



NASA CR-
ERIM 193400-5-P

Annual Report

REMOTE SENSING IN MICHIGAN FOR LAND RESOURCE MANAGEMENT

1 June 1973 Through 31 May 1974

D. S. LOWE, et al.
Infrared and Optics Division

SEPTEMBER 1974

(NASA-CR-140115)	REMOTE SENSING IN	N74-33857
MICHIGAN FOR LAND RESOURCE MANAGEMENT		
Annual Report, 1 Jun. 1973 - 31 May		
1974 (Environmental Research Inst. of		Unclas
Michigan) 58 p HC \$6.00	CSSL 08B G3/13	49285

Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Office of University Affairs, Washington, D.C.
Grant NGR 23-005-552
Mr. Joseph A. Vitale, Technical Monitor



NOTICES

Sponsorship. The work reported herein was conducted by the Environmental Research Institute of Michigan for the National Aeronautics and Space Administration, Office of University Affairs, Washington, D. C., under Grant NGR 23-005-552. Mr. Joseph A. Vitale is Technical Monitor. Contracts and grants to the Institute for the support of sponsored research are administered through the Office of Contracts Administration.

Disclaimers. This report was prepared as an account of Government-sponsored work. Neither the United States, nor the National Aeronautics and Space Administration (NASA), nor any person acting on behalf of NASA:

- (A) Makes any warranty or representation, expressed or implied with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or
- (B) Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used above, "person acting on behalf of NASA" includes any employee or contractor of NASA, or employee of such contractor, to the extent that such employee or contractor of NASA or employee of such contractor prepares, disseminates, or provides access to any information pursuant to his employment or contract with NASA, or his employment with such contractor.

Availability Notice. Requests for copies of this report should be referred to:

National Aeronautics and Space Administration
Scientific and Technical Information Facility
P. O. Box 33
College Park, Maryland 20740

Final Disposition. After this document has served its purpose, it may be destroyed. Please do not return it to the Environmental Research Institute of Michigan.

Technical Report Documentation Page

1. Report No. NASA CR-	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle REMOTE SENSING IN MICHIGAN FOR LAND RESOURCE MANAGEMENT		5. Report Date September 1974	6. Performing Organization Code
		8. Performing Organization Report No. 193400-5-P	
7. Author(s) D. S. Lowe, L. B. Istvan, N. E. Roller, I. J. Sattinger, A. N. Sellman, and T. W. Wagner		10. Work Unit No. (TRAIS)	
9. Performing Organization Name and Address Environmental Research Institute of Michigan Infrared and Optics Division P. O. Box 618 Ann Arbor, MI 48107		11. Contract or Grant No. Grant NGR 23-005-552	
		13. Type of Report and Period Covered Annual Report 1 June 1973 through 31 May 1974	
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Office of University Affairs Washington, D.C. 20546		14. Sponsoring Agency Code	
15. Supplementary Notes Mr. Joseph A. Vitale is Technical Monitor for NASA.			
16. Abstract <p>The Environmental Research Institute of Michigan is conducting a program whose goal is the large-scale adoption, by both public agencies and private interests in Michigan, of NASA earth-resource survey technology as an important aid in the solution of current problems in resource management and environmental protection. During the period from June 1973 to June 1974, remote sensing techniques to aid Michigan government agencies were applied in the following activities:</p> <ol style="list-style-type: none"> (1) Land use inventory and management (2) Great Lakes shorelands protection and management (3) Wetlands protection and management (4) Soil survey <p>In addition to these major tasks, the project disseminated information on remote sensing technology and provided advice and assistance to a number of users in Michigan.</p>			
17. Key Words Remote sensing Michigan Land resource management Coastal zone management		18. Distribution Statement Initial distribution is listed at the end of this document.	
19. Security Classif. (of this report) UNCLASSIFIED	20. Security Classif. (of this page) UNCLASSIFIED	21. No. of Pages 59	22. Price

PREFACE

This project was performed for the Office of University Affairs, National Aeronautics and Space Administration, by the Environmental Research Institute of Michigan (ERIM) in cooperation with Michigan State University (MSU). The Environmental Research Institute of Michigan, a non-profit corporation, was established on 1 January 1973 as successor to the Willow Run Laboratories of The University of Michigan. This report covers work performed from 1 June 1973 through 1 June 1974; it is one of a series presenting the results of the program.

The goal of this project is to develop and apply earth resource survey technology to problems in land and water resource management of current concern to public agencies. Successful introduction of the technology calls for parallel efforts to:

- provide potential user agencies with the necessary evidence of the value of remote sensing technology for their purposes,
- develop the necessary scientific and technical background within the agencies to take full advantage of remote sensing information, and
- provide the necessary remote sensing services and facilities to support a statewide remote-sensing capability.

The investigations described herein were carried out under NASA Grant NGR 23-005-552. Joseph A. Vitale, Chief, Engineering Design Branch, Office of University Affairs, acted as Technical Monitor. The work was performed under the direction of Donald S. Lowe, Deputy Director of the Infrared and Optics Division at ERIM. The program was coordinated with a similar one conducted by Michigan State University under a separate grant. At MSU, direction was provided by Myles G. Boylan, Director of the School of Urban Planning and Landscape Architecture, and Dr. Raymond D. Vlasin, Chairman of the Department of Resource Development.

Project staff members at the Environmental Research Institute of Michigan who participated in this program are listed below. Spheres of responsibility are as indicated; specific task assignments are given in parentheses.

PRECEDING PAGE BLANK NOT FILMED

Richard R. Legault, Director, Infrared and Optics Division
Donald S. Lowe, Deputy Director, Infrared and Optics Division
Fabian C. Polcyn, Head, Technology Applications Group
Laurence B. Istvan, Research Assistant (Great Lakes shorelands)
Norman E. G. Roller, Research Associate (wetlands)
Irvin J. Sattinger, Research Engineer (land use)
A. N. (Buzz) Sellman, Assistant Research Engineer (land use)
Thomas W. Wagner, Assistant Research Engineer (soil survey)

CONTENTS

1. SUMMARY	7
2. INTRODUCTION	9
2.1 Consultation Activities with the State Government	9
2.2 Land Use Inventory and Management	10
2.3 Great Lakes Shoreland Management	11
2.4 State Protection and Managements of Wetlands	12
2.5 Habitat Management at Pointe Mouillee	13
2.6 Soil Survey	14
2.7 Assistance to Users of Remote Sensing	14
2.8 Information Dissemination	15
3. CONSULTATION AGREEMENT WITH THE STATE GOVERNMENT	16
4. LAND USE INVENTORY AND MANAGEMENT	18
4.1 Development of Land Use Classification System	18
4.2 Preparation of State-wide Maps	19
4.3 Transportation Analysis Modeling	20
4.4 Land Use Map of Wexford County	22
4.5 Land Use Analysis in Southeastern Michigan	23
5. GREAT LAKES SHORELAND MANAGEMENT	24
5.1 Flight Planning and Execution	25
5.2 Measurement of Beach Recession Rates	26
5.3 Shoreline Protection Measures	29
5.4 Power Plant Discharges into the Aquatic Environment	29
5.5 Port Development	32
5.6 Continuing Program	35
6. PROTECTION AND MANAGEMENT OF WETLANDS	36
6.1 Objectives	36
6.2 Wetland Inventory	37
6.3 Acquisition of St. John's Marsh	39
7. SOIL SURVEY	42
7.1 Preliminary Planning of Survey Methods	42
7.2 Operational Demonstration	43
8. ASSISTANCE TO USERS OF REMOTE SENSING	46
9. INFORMATION DISSEMINATION	48
Appendix A: AGREEMENT WITH DEPARTMENT OF MANAGEMENT AND BUDGET	51
Appendix B: "GOVERNOR GETS SPACE PICTURE" (NEWSPAPER ARTICLE)	54
Appendix C: "PLAN TO SAVE MARSH" (NEWSPAPER ARTICLE)	56
Appendix D: "SHORELINE DAMAGE STUDIED" (NEWSPAPER ARTICLE)	56
REFERENCES	57
DISTRIBUTION LIST	59

FIGURES

1. Highway Corridor Selection	21
2. Michigan Shoreline Covered by Flight Mission X252M, April—May 1974	27
3. Little Lake Harbor, 7 May 1974	30
4. Ludington Pump Storage Plant, 24 April 1974	31
5. Portion of Saginaw Bay, 7 May 1974	33
6. Port Facilities on Detroit River, 10 April 1974	34
7. Portion of St. John's Marsh, 10 April 1974	40
8. Enhanced Images for Soil Survey	44

REMOTE SENSING IN MICHIGAN FOR LAND RESOURCE MANAGEMENT

1

SUMMARY

Since September 1971, the Environmental Research Institute of Michigan has been conducting a program under a grant from the NASA Office of University Affairs whose goal is to demonstrate applications of remote sensing technology originally developed with support from NASA and other sources. Through these demonstrations for both small and large users, the program is leading to the large scale adoption of this technology by both public agencies and private interests in Michigan as an important aid in the protection and management of Michigan's land and water resources.

Through an agreement with the Michigan Department of Management and Budget, a series of meetings were arranged with management personnel of ten major departments of the state government who have the responsibility for policy formulation and project planning and authorization. The meetings proved to be an effective means for bringing to the attention of top management personnel the possibilities for using remote sensing methods to provide information needed for decision making. These direct contacts with state agency management personnel were supplemented by many specific opportunities to provide advice and assistance to current and prospective users of remote sensing and to disseminate information on remote sensing technology.

The project continued its large-scale involvement in work related to land use inventory for regulation and management. The project directly or indirectly participated in committee work leading to the adoption of a land use classification system, in preparing ERTS photomosaics and a seven-category land use map of the entire State of Michigan, in continuing the application of methods of using ERTS data for transportation analysis, and in working with the Southeast Michigan Council of Governments in their adoption of remote sensing to aid the solution of land use problems in the Greater Detroit area.

A major achievement during the year was the planning and execution of an extensive flight mission by the ERIM C-47 aircraft in which color photography and multispectral scanner imagery were obtained for 3000 km of Great Lakes shorelands. This remote sensing imagery has already been applied to problems of beach erosion protection, harbor maintenance, port development, and protection of wetlands. Many additional uses are in prospect for inventory, protection, and management of shoreland areas threatened by erosion, flooding, and uncontrolled development.

During this current performance period, work previously completed jointly by ERIM and Michigan State University in environmental assessment of the Pointe Mouillee State Game Area provided information and recommendations which supported the decision by the Michigan Department of Natural Resources and the U.S. Army Corps of Engineers to construct a barrier dike offshore of Pointe Mouillee. This dike will serve both as a site for dumping dredged materials and as a means for protecting Pointe Mouillee marshlands from further damage by Lake Erie storms.

Important new applications have been initiated to enable government agencies to adopt operational remote sensing methods for performing an urgently needed inventory of Michigan's wetlands and for improving the efficiency and accuracy of existing soil survey procedures.

INTRODUCTION

During the past year, the Environmental Research Institute of Michigan increased both the intensity and breadth of its program to advance the application of remote sensing methods. Through the parallel efforts of ERIM and Michigan State University, technical and management personnel in most of the major Michigan-based agencies have been made aware of the capabilities of remote sensing technology and have given careful thought to the possible application of this technology to their own problem areas.

At the state level, ERIM personnel worked with the Departments of Management and Budget, Natural Resources, State Highways and Transportation, and Commerce. In addition, discussions were held with other Departments for the purpose of exploring possible applications of remote sensing.

Flight missions along major sections of the Great Lakes shoreline of Michigan, and the continuing acquisition of ERTS-1 and Skylab data, provide much additional remote sensing imagery needed for future effective use of NASA technology in Michigan.

Significant technical results have been achieved in a number of application areas and subsequent government actions have been based on these results. This section summarizes these accomplishments, with specific results and actions underlined for emphasis. The remainder of the report describes each area of remote sensing activity in further detail.

2.1 CONSULTATION ACTIVITIES WITH THE STATE GOVERNMENT

In cooperation with the Michigan Department of Management and Budget, a formal agreement has been reached whereby an ERIM representative has been given office space in the Office of Intergovernmental Relations and afforded political support to inform and educate top-level management in all departments of State Government on the potentials of remote sensing. This arrangement allows continuing contact with agency personnel who are responsible for making policy decisions and determining operational procedures, including those pertaining to the use of remote sensing. The objective of this activity is to establish remote sensing as a standard operational tool in state agency activities through contact and coordination at top management levels.

Meetings have been held with the Departments of Agriculture, Commerce, Management and Budget, Labor, Military Affairs, Natural Resources, Public Health, Social Services, State Highways and Transportation, and State Police. As a result of these meetings, three specific applications of particular interest for further investigation have so far been identified:

- (1) State-wide wetlands mapping using ERTS and RB-57 data

- (2) A computerized state information system with ERTS providing high resolution, geobased, thematic data
- (3) Use of ERTS classification data for environmental and technical assessment of the U.S. Navy's Project SANGUINE antenna

Programs for both the wetlands mapping and the state-wide information system are to be undertaken as part of our effort during FY 75 (see Sections 2.2 and 2.4). The future direction of Project SANGUINE is being reviewed by the Navy and is thus not an issue at the present time.

2.2 LAND USE INVENTORY AND MANAGEMENT

ERIM has been working closely with the Michigan Office of Land Use to initiate and use optimum types of remote sensing data, land classification and referencing systems, and computer-based systems for supplying land use information needed by government agencies for management and decision-making.

I. J. Sattinger is the ERIM representative on the Land Use Classification Committee set up by OLU to develop and disseminate a four-level classification system for uniform use by state and local agencies. ERIM has emphasized the capabilities of automatic data processing—specifically, the use of extensive coverage satellite data. Michigan State University has also participated in the effort, emphasizing manual interpretation of aerial photography and demonstrating the application of this method in smaller area projects. Together, ERIM and MSU have helped work remote sensing into the overall program as an integral part of the data gathering scheme.

Results of the committee effort include:

- A state land use plan which the OLU has now submitted to the Governor for his approval
- Adoption and dissemination of a four-level land classification system

ERIM, with support from State funding, has also prepared:

- Color and black-and-white ERTS photomosaics of the entire State of Michigan
- A seven-category land use map derived from conventional information sources and ERTS-1 photointerpretation

In a closely-related effort, ERIM has demonstrated the use of computer-processed ERTS-1 data to provide land use and land cover information needed in a computer-based Transportation Analysis Model developed by the Michigan Department of State Highways and Transportation for traffic prediction, highway corridor selection, and other highway planning purposes. For

this purpose we utilized processed data on the Hiawatha National Forest — obtained in previous work under the NASA grant and as reported in our last yearly report [1]. ERIM capabilities in computer programming and analysis were also utilized to assist in merging the land cover data with data from other sources in a geographically referenced form [2]. MDSH is now in position to use this technique for existing highway corridor problems.

In order to establish land cover mapping capabilities for the state system in a different geographic area, ERIM is processing ERTS-1 data to prepare an up-to-date land cover map of Wexford County, Michigan. This area was chosen, in part, because of a request by the county planning commission for up-to-date land cover information which it needs for planning future growth and development within the county.

The Southeast Michigan Council of Governments is actively developing uses of remote sensing data to meet its needs. With assistance from ERIM, SEMCOG obtained and used HUD funds to investigate practical uses of remote sensing. One application of current importance is the preparation and use of a computerized regional growth model for the seven-county SEMCOG region to be used for planning and controlling the amount and location of future growth in the area. ERIM recommended and successfully demonstrated the use of existing NASA high-altitude photography acquired during the period from 1969 to 1973 as the best procedure for providing the inputs needed for this model. These inputs include a land use inventory and summary measurements of areas devoted to different types of land use. As a result of this demonstration, SEMCOG requested—and is now reviewing—a proposal to fund ERIM to prepare an inventory and make area measurements for the entire region.

2.3 GREAT LAKES SHORELAND MANAGEMENT

The objectives of this task are twofold: to aid local and state agencies in making shoreline zoning and development decisions using remotely sensed information; and to have the Michigan Department of Natural Resources make remote sensing imagery the basis for major management decisions governing the state's entire 3700 km of shoreline.

This task was initiated in previous years in response to the recognized need for effective methods of assessing shoreline problems and carrying out remedial action. To meet this need, ERIM requested that NASA authorize flight missions along critical sections of the Michigan shoreline.

Since approval early in 1974 of C-47 flight missions, the ERIM staff has been active in planning for and executing the flights and in organizing the coordinated program between ERIM and the government agencies to make full use of the data. The planning operation included personnel from many divisions of DNR, as well as other agencies and Michigan State University. These people recommended specifications of minimum data requirements, shoreline areas of

special interest, and desired informational output. The final flight plans thus represented an optimization of the needs of each of the various users.

The C-47 flight missions were completed during April and May 1974. Preliminary examination of the data products indicates that color aerial photography and multispectral scanner data of excellent quality have been obtained for 3000 km of shoreline, and that the major part of the data meets the requirements for planned applications.

A comprehensive plan for the utilization of the data is being developed, with ERIM acting to coordinate the needs and proposed tasks to be undertaken by DNR, MSU, and ERIM. Several results have already been achieved as reported below.

ERIM is supplying black-and-white prints of the photography to the Water Development Services Division of DNR, and assisting them in making urgently needed beach erosion measurements. This includes both development and demonstration of quick and efficient techniques for making the measurements. These measurements are immediately made available to local zoning officials and developers, who have been calling DNR daily to obtain them. Based on this information, zoning and building decisions are currently being made, and will continue to be made through 1975.

In addition, the Detroit District of the Army Corps of Engineers has purchased from ERIM color prints of approximately 20 harbors along the Michigan shoreline. These prints will be used to aid in construction planning activities and permit reviews. The Chicago Division Office of the Corps is also arranging with NASA/JSC to obtain copies of the entire flight imagery to supplement their coverage of the rest of the Great Lakes shoreline.

The Wayne County Planning Commission and the Detroit Port Authority have also purchased copies of the 1974 photography to aid these agencies in making economic and technical studies of Detroit port modification and expansion.

Many additional uses of the shoreline imagery are being planned for the following year.

2.4 STATE PROTECTION AND MANagements OF WETLANDS

During the current year, initial work has been performed to specify the requirements and methods for a state-wide wetlands mapping program. The main part of this program is to be performed during 1974-75.

The objective of the wetlands program is to use remote sensing methods to establish a state-wide inventory of wetlands. The state-wide inventory could also serve as a midwestern and northeastern regional model for the proposed national inventory scheduled to be initiated by the U.S. Department of the Interior in 1975.

The first application of wetland inventory methods will be in preparing an environmental assessment of the inventory test area, St. John's Marsh, as a requirement for obtaining legislative approval and funding for its public acquisition.

A series of discussions have been held with the Wildlife and Water Development Services Division of DNR to determine the informational requirements of DNR for both a useful state-wide wetlands inventory, and the environmental assessment of St. John's Marsh. Remote sensing data were collected on the marsh area as part of the shoreline flight program.

For the state-wide project, methods of using ERTS data in a multistage inventory are being examined. This work includes selection of optimum combinations of acquisition dates for wetlands discrimination, based on ERIM signature analysis work under separate (NASA) contracts.

Historical aerial photography will be used to identify cause-effect relationships in wetlands changes and to prepare the environmental assessment of the St. John's Marsh. This method has been previously documented (in our work at Pointe Mouillee [3] and elsewhere) and, as a result of ERIM's recommendation, is now being emphasized by the Wildlife Division for future analysis, assessment, and management of wetland areas.

2.5 HABITAT MANAGEMENT AT POINTE MOUILLEE

The effort carried out at the Pointe Mouillee State Game Area in previous years has continued to be of benefit. The technical report on our work [3] was published after thorough review with Jim Foote (a biologist at Pointe Mouillee), the Hydrologic Survey Division, the Wildlife Division, the Region III Office of the Michigan Department of National Resources, and the Army Corps of Engineers.

These review processes have thus far yielded the following results:

(1) The Corps of Engineers and DNR, acting jointly, have formally adopted a plan to construct a large barrier dike offshore from the game area. Information from the ERIM-MSU project was used in the formulation of this plan, and specifically in the public hearings on and writing of the recently approved Environmental Impact Statement.

(2) DNR has proceeded to purchase the lands bordering the game area to the west, as recommended by the ERIM study.

(3) DNR has also adopted the study recommendations to further marsh management in the newly acquired areas by establishing water-level control capabilities utilizing existing dikes and natural features. This project has been assigned a high priority and funds for it are now being allocated.

2.6 SOIL SURVEY

In cooperation with field personnel of the USDA Soil Conservation Service (SCS) and the Michigan Agricultural Experiment Station, ERIM is working to improve the accuracy and timeliness of soil mapping using modern remote sensing techniques. Recent evaluation of existing multispectral data of Washtenaw County (collected under other programs) provides the basis for processing and interpretation of new data of Jackson County, collected in April 1974. Results of this cooperative effort will help determine the utility of these data for application to the ongoing National Cooperative Soil Survey Program in the State of Michigan. This program involves federal, state, county, and local units of government.

Evaluation of processed images for selected areas of Washtenaw County clearly shows the advantage of collecting appropriate remote sensor data at the right time of year. The results of the current year's effort are contained in Reference [4], submitted to SCS and the Agricultural Experiment Station.

These results and recommendations are being applied to a working demonstration of the use of modern imagery in the current Jackson County soil survey. Remote sensor data were obtained from a 4 by 42 km portion of Jackson County. The excellent 9-inch photography which was obtained at that time is already being used by the field mapping party. Multispectral imagery specially processed for soil mapping will be available to the field party in July 1974. The results of this effort, if successful, will aid in the demanding and important task of providing detailed soil information for a wide variety of users.

2.7 ASSISTANCE TO USERS OF REMOTE SENSING

In addition to its major project activities, ERIM has offered advice and assistance to many current and prospective users of remote sensing. Contact was usually initiated by the user, and in several cases imagery or analyses were supplied by ERIM. Among the opportunities for providing such advice or assistance during the year were the following:

- Environmental analysis of utility sites for Consumers Power Co. and Commonwealth Associates, Inc.
- Participation in public hearings on wilderness proposals for the Sleeping Bear Dunes National Lakeshore
- Providing RB-57 photography for the celebration of the 50th anniversary of the General Motors Proving Grounds
- Bank marketing studies by the Manufacturers National Bank of Detroit
- Assistance to the Creeksheds Project of the Huron River Watershed Council
- Assistance to the Geography Department of Eastern Michigan University

2.8 INFORMATION DISSEMINATION

During the year, the project continued its program of widespread dissemination of information on remote sensing methods and applications. Information was made available by means of classroom lectures, presentation of papers at seminars and symposia, news releases and displays. Many individual groups from various state and local agencies have visited ERIM laboratories for briefings on problems of concern to them. Discussions have been held with state legislators from a number of districts and NASA imagery of particular interest has been made available. Altogether, during the year, we have taken advantage of more than 30 such opportunities to disseminate information on the project's goals and activities.

CONSULTATION AGREEMENT WITH THE STATE GOVERNMENT

Under grants from the Office of University Affairs, ERIM and MSU have conducted a number of successful pilot demonstration projects in which remote sensing was used to provide information needed by state officials. These projects were conducted in cooperation with state employees at the working level who are addressing specific problems facing them. Since the cooperating agents have limited areas of responsibility, the impact of our work would be quite localized unless it is given full visibility and support by top-management. Our project has made many contacts at policy and management levels during the planning and performance of these tasks and reviewing the results. However, there is a clear need for a continuous and concentrated program of making such contacts.

To achieve this result, a formal agreement was reached with the Michigan Department of Management and Budget (DMB) whereby the Office of Intergovernmental Relations has provided ERIM with the political support to contact all departments of state government at the higher levels where project planning and funding are approved and legislation is recommended (see Appendix A). This arrangement also provides an ERIM representative with an office in Lansing at the Office of Intergovernmental Relations. Afforded this opportunity, we are in a good position to further the objective of establishing remote sensing as a standard operational tool in state agency activities.

A specific purpose is served in having the Department of Management and Budget designated as the agency to work with NASA's Office of University Affairs program. Since any one of the individual departments has limited resources, large-scale adoption of remote sensing by the state will require interest by each department as well as a pooling of resources. By working through DMB, an agency which does not have an operational mission but rather a coordinating function, we can better secure the broad support needed. Prior to a reorganization of the state executive branch in 1965, over 250 individual departments, offices, commissions, boards and authorities reported directly to the governor. The reorganization reduced this to 19, while making DMB responsible for setting policy and advising the governor on overall organizational structure, budgets and programs.

Through the arrangement with DMB, Donald Lowe has conducted a series of meetings to brief top management personnel on remote sensing technology and applications and to identify possible projects or programs where remote sensing could be used effectively. Meetings have been held with the departments of Agriculture, Commerce, Management and Budget, Labor, Military Affairs, Natural Resources, Public Health, Social Services, State Highways and Transportation, and State Police. Areas of interest to the individual departments have been identified.

Two specific applications of particular interest for further investigation are a computer-based state-wide information system using ERTS data, and state-wide wetlands mapping. Programs for both of these applications are currently being worked on, as discussed in Sections 4 and 6.

Interest was also shown in performing environmental and technical studies related to the possibility that a 100 by 100 km area in Northern Michigan would be chosen as the site for the U.S. Navy's Project SANGUINE, a buried extra-low-frequency antenna. However, the future direction of Project SANGUINE is now being reviewed by the Navy and is thus not an active issue within the state at the present time.

ERIM will continue to take advantage of this arrangement for thoroughly informing a large number of top management personnel of the State on the capability and potential of remote sensing and in working with them to define and recommend major remote sensing programs which effectively coordinate the information needs of several Departments. ERIM will assist the State in conducting one or more of these coordinated remote sensing programs, where this activity is appropriate and within available project resources.

LAND USE INVENTORY AND MANAGEMENT

The State of Michigan is establishing a program to deal with land use/land resource issues on a comprehensive basis. The state's goal in this program is to protect its natural resources from uncontrolled land development and its air and water from pollution. Legislation already in existence is directed toward these goals and other legislation being considered for adoption at both state and federal levels would further enhance Michigan's program. The most recent example of this is Public Act 4244 (Farmland and Open Space Preservation Act), which directs the Office of Land Use to "prepare a report and make recommendations to the legislature for a state plan for preserving open space lands, agricultural and horticultural lands, unique or critical land areas, recreation lands and historic lands."

ERIM is engaged in a number of activities which contribute significantly to the State's objectives by providing the background needed to assess the use of NASA technology in support of these responsibilities. The activity was initiated under this project in 1972 and subsequently led to additional work performed under State support. Earlier results of the work are reported in the first and second annual reports [5, 1]. These earlier results included the definition of methods of mapping land use and land use change needed for developing a statewide information base and the preparation of a four-category statewide land use map to provide an initial input to the needed information base.

ERIM's effort in support of Michigan's objectives in the area of land regulation has continued during the current year. This work has been done in close cooperation with the Office of Land Use of DNR. Continuing support for this effort has been provided through the NASA Grant, but additional closely related activities are supported by other sources.

4.1 DEVELOPMENT OF LAND USE CLASSIFICATION SYSTEM

Sattinger is a member of the Land Use Classification Committee, one of three committees set up by the Office of Land Use in the Department of Natural Resources to furnish technical guidance for the state's expanding responsibilities in land use regulation. The Land Use Classification Committee has prepared a consistent and comprehensive land use classification system to be generally adopted by all state agencies and local agencies in Michigan. In setting up this system, the Committee took account of both the ultimate use of the resulting land use information and the opportunities for economical and rapid collection of such information from NASA and other remote sensing data sources. The Committee's report on a recommended classification system was submitted to the Office of Land Use in March, 1974 [6].

ERTS data constitute one of the important sources of information which can be used in land use inventory over large areas. ERIM is applying its experience with analysis and interpretation of ERTS data to assess the utility of ERTS data for the land use classification process. The assessment indicates that computer-processed ERTS data would be able to provide most categories of land use and land cover at Levels I and II with resolution as good as 0.5 hectare. The storage of processed ERTS data on computer-compatible tape in direct correlation with geographic location makes it potentially very useful as a part of any land use classification and referencing system. This information on ERTS capability will continue to be used by the land use classification committee in further planning of state-wide inventory information systems. Meanwhile, ERIM will continue to improve ERTS capabilities for this purpose through specific applications, such as providing data for a Transportation Analysis Model and mapping Wexford County.

4.2 PREPARATION OF STATE-WIDE MAPS

Additions to the State's information base have been prepared taking advantage of the up-to-date coverage provided by the ERTS-1 satellite system.

As a part of other projects which were initially stimulated by our efforts under the NASA Grant, we have prepared a set of 1:500,000 photomosaics of the entire State of Michigan from available ERTS-1 photos. One of these products recently completed is a color-infrared mosaic of the entire State, prepared from Bands 4, 5, and 7 of the ERTS-1 coverage. Another product is a mosaic made from Band 7, which accurately displays the water/land boundaries and some associated wetland areas for the entire state.

From the same ERTS-1 photos of Michigan we have also derived an improved state land use map containing more detail than the one originally prepared. Rather than giving only four categories, this map shows the distribution in Michigan of seven land types (urban, forest, agriculture, wetlands, brushlands, barren, and water).

These products have been furnished to the Office of Land Use of DNR. This office will incorporate them with land use and land cover information obtained from other data sources. In addition, the NASA Grant project has encouraged ERIM's administration to use these products, primarily prepared under other projects, to effectively inform government officials, in both the legislative and executive branches, of NASA's role in dealing with earth-resources problems on both a local and national level.

Following the lead of the NASA Grant objectives, the ERIM administration provided the support for taking several steps to bring NASA technology to the attention of government officials. On April 17, 1974, a 1:1,000,000 copy of the color IR mosaic of Michigan was presented to Governor Milliken by President William M. Brown and Donald S. Lowe of ERIM. (See

Appendix B.) The Governor expressed an interest in pursuing ways in which Michigan agencies might continue to benefit from NASA's Earth Resources Program. ERIM's consultation agreement with the State Government, which is administered through the Department of Management and Budget, thus provides a mechanism for accomplishing this function. Copies of the color photomosaic, as well as similar NASA imagery, are also being distributed to influential state-government officials in both the legislative and executive branches. A large color infrared photomosaic of Michigan (1:500,000) has been framed and mounted in the capitol building in Lansing.

4.3 TRANSPORTATION ANALYSIS MODELING

We are continuing to work with the Transportation Analysis Unit of the Michigan Department of State Highways to develop the use of ERTS-1 tapes as a source of land use information for their Transportation Analysis Model [1, 7].

The Highway Data File already includes a wide variety of information on public and private facilities — e.g., hospitals, parks, sewage treatment plants, snowmobile trails, and considerable socio-economic data from census enumerations. The primary shortcoming of the data file which limits the scope of its analytic value is the lack of land use/land resource data.

Highway Department staff were assigned to the specific task of merging ERTS recognition tapes supplied by ERIM into their Data File, and ERIM provided technical support to their programmers to effect the merging operation. This joint effort has accomplished the following:

- (1) Successfully converted the ERTS recognition data format to the Highway Department's computer system (Burroughs 5500).
- (2) Inserted the land use data into the corridor location model.
- (3) Generated from the model, a first-run sensitivity map which represents a solution of the highway corridor location problem based on land use parameters.

The highway corridor selection process uses a computer-based procedure which selects the optimum route for the highway, such as one that passes close to urban areas yet avoids water bodies and forested areas while keeping the total path distance as short as possible. The Highway Department has demonstrated this selection process for a section of land being considered as a highway corridor. Figure 1 shows, for demonstration purposes, the computer output of a simulation of the corridor selection process.

Because of the successes achieved to date by this procedure, the director of the Transportation Analysis Unit, Mr. Richard Esch, is enthusiastic about its potential and is continuing to assign manpower and time to the project. Reference [2] reaches the following conclusions concerning potential use of the method.

-94	-94	-94	-94	-94	-94	-94	-51	0	0	-36	0	0	
-100	-100	-100	-100	-74	-98	-100	-100	-26	0	-37	0	0	
-100	-100	-100	-100	-79	-83	-100	-100	-99	-85	-3	0	0	
-100	-100	-100	-100	-100	-100	-100	-100	-99	-100	-100	-20	0	0
-100	-100	-100	-100	-91	-84	-97	-91	-100	-100	-56	0	0	
-100	-98	-42	-13	-1	0	-2	-86	-100	-100	-84	-2	0	
-100	-54	2	0	0	0	0	-2	-30	-88	-100	-97	-40	
-100	-26	2	0	0	0	6	5	2	6	-20	-27	-2	
-100	-38	6	7	5	8	12	4	0	1	4	2	5	
-58	-9	2	1	7	0	11	5	0	0	1	0	0	
2	1	0	0	1	0	0	1	0	2	0	1	0	
-26	-25	0	0	0	0	1	12	0	-1	-16	-9	0	
-98	-45	0	0	0	0	0	0	2	6	0	-1	0	
-53	-2	0	0	0	0	0	2	2	6	6	2	2	
-5	2	0	0	0	1	5	0	2	9	17	5	2	
0	2	0	0	0	3	0	2	9	1	-1	5	17	
0	6	0	0	0	0	0	2	2	16	19	23	4	
5	0	-1	0	0	-4	-2	13	16	13	2	0	8	
34	3	-12	0	0	0	0	2	9	-1	1	1	-3	
31	20	-32	-1	1	0	0	0	1	-14	-38	-2	0	
18	-2	-13	0	0	-25	0	1	5	-16	-37	0	0	
9	-10	-20	1	-2	2	11	1	0	0	1	2	1	
8	2	-48	7	0	4	59	35	-7	0	0	0	2	
6	22	-48	-3	2	4	12	13	-9	-7	1	-2	-12	
33	49	11	-71	-1	2	6	2	-2	0	-38	-1	0	

FIGURE 1. HIGHWAY CORRIDOR SELECTION. This highway corridor near Munising was selected by computer to pass through the 57-hectare cells with the most positive ratings, corresponding to highest percentage of urban area and/or lowest percentage of surface water. The selection process gives equal weight to minimizing route length. The land cover data used in the corridor selection model for this 180 sq km area were provided by computer-processed ERTS-1 tapes.

"The automated environmental sensitivity-mapping program . . . offers the potential of producing environmental sensitivity maps automatically for use as a 'first-cut' tool, that is, as a device for ruling out unfeasible corridors. It spotlights the ability of the Statewide transportation modeling system to progress from satellite data to forecasts of travel, socio-economic, and environmental impact measurements in an efficient, consistent manner.

"Furthermore, the mapping process lends itself to effective stimulation of public involvement in transportation planning. Since its output is pictorial, it can translate the opinions, goals, and objectives of the residents of a region into a map of sensitive areas. People can thus see the effects of their opinions on the location of a proposed highway; environmental analysts can restrict their attention to feasible corridors only, thus possibly eliminating unnecessary work."

This may be the first application in which ERTS data has been incorporated into the computer model of a user agency not directly associated with an ERTS investigation. The same basic approach can be used for many applications other than highway corridor selection, several of which are now being planned.

4.4 LAND USE MAP OF WEXFORD COUNTY

A good opportunity to demonstrate the use of ERTS data for planning and management purposes at the county level was made available through contacts with officials of Wexford County. On 9 August 1973, a Traverse City meeting was held by the Northwest Michigan Regional Planning and Development Commission to brief regional and local officials on the capabilities and applications of remote sensing. Attendees from ERIM included Lowe, Sattinger, Polcyn, and Sellman. The meeting was also attended by faculty and research staff from MSU. The discussion covered a number of regional problems which might be addressed by remote sensing. As a follow-up to the meeting, ERIM received a letter from Ed Millar, Planning Coordinator for Wexford County, describing several current problems of concern to the Planning Commission. As a result of subsequent discussions with ERIM staff, Mr. Millar decided that an up-to-date land use map of Wexford County would enable his office to conduct detailed studies of the county for planning of future growth and development. Contacts by the Planning Commission with the Congressional Representatives for Wexford County, Guy VanderJagt and Elford A. Cederberg, resulted in their also showing interest in this ERTS application.

Accordingly, ERTS-1 coverage of Northwest Michigan is being computer-processed to prepare the Wexford County land use map. A preliminary map has been completed using ERTS-1 data acquired on 9 June 1973. In order to provide adequate discrimination of various types of land use, additional coverage at a different season will be required. To accomplish this, the preliminary map is to be improved by processing a magnetic tape of ERTS-1 data acquired in January 1973.

4.5 LAND USE ANALYSIS IN SOUTHEASTERN MICHIGAN

The Southeast Michigan Council of Governments (SEMCOG) has responsibility for the coordination of many programs of local governments in the seven-county region comprising Southeast Michigan. One of its major responsibilities is the development and coordination of land use planning for the region. Don Lowe, Buzz Sellman and other members of the ERIM staff have made a number of contacts with members of the SEMCOG staff to develop their interest in using remote sensing methods to accomplish much of the data collection and analysis needed for planning and decision-making purposes.

These early contacts led SEMCOG to request funds from HUD to make a detailed investigation into the possible uses of remote sensing to meet SEMCOG responsibilities. After SEMCOG received these funds, we worked in close cooperation with Don Belanger, who had direct responsibility for the investigation. Through briefings and informal technical advice, we have assisted the SEMCOG staff in becoming very familiar with remote sensing capabilities.

Early in 1974, we were asked to review a land use inventory project for the SEMCOG region. A land use analysis for the entire seven-county region is required for a computerized regional growth model, and summary acreages of land use for the years 1970 and 1975 must be determined as the "land components" part of the model.

SEMCOG must go to considerable expense merely to convert highway photography to the proper scale and format for photo-interpretation purposes. Suggesting that the NASA high-altitude photography obtained at several times during the period from 1969 to 1973 was an excellent alternative, we prepared an inventory based on their specifications for four of the 1500 zones comprising the SEMCOG region. SEMCOG officials were very much pleased with the results, and since they needed specialized assistance in photo interpretation, they invited ERIM to submit a proposal to prepare a land components inventory for the entire SEMCOG region. This proposal has been submitted and is currently under review.

Results of our analysis of certain areas in Southeast Michigan are cited by the State of Michigan in its presentation of program policy guidelines for 1975-76 [8]. These guidelines provide the framework for the consideration of alternative program means for assisting the state in meeting its goals and objectives. Selected priority issues and concerns are also identified from the perspective of the state as a whole. Specific NASA imagery and data provided by ERIM were presented in the document on changing land use in the Livonia/Farmington area of Wayne and Oakland Counties and on loss of wildlife habitat at Pointe Mouillee. This information was used to identify and illustrate major issues which the state must face with respect to increasing pressures on its available land resources from rapid urban development and the destructive forces of nature.

GREAT LAKES SHORELAND MANAGEMENT

The State of Michigan has over 3700 km of Great Lakes shoreline along its mainland. These shorelands have inestimable ecological, economic, and aesthetic value to the State and its people. However, the Great Lakes shoreline is beset by major problems, including:

- Beach erosion and resulting destruction of property and structures
- Flooding and storm-threatened areas
- Encroachment of residential and industrial development on wetland and other environmentally sensitive areas
- Pollution of near-shore waters

Hence, in order to preserve the intrinsic value of the shorelands, the state government has attached high priority to their management [9].

The Michigan Department of Natural Resources (DNR) has been designated as the lead agency for this purpose. It obtains its mandate from the Michigan Shorelands Protection and Management Act of 1970, which also gives zoning and regulatory responsibility to the local governments within bounds set by DNR. Under the Michigan Shorelands Protection and Management Act, DNR is legally required to delineate, evaluate, and institute management plans (covering limits on development and use, necessary protective structures, and recommendations for state acquisition) for (1) all high-risk erosion areas along 1100 km of shoreline, including threatened structures in these areas; and (2) environmental areas along 800 km of shoreline. For all shorelands within their jurisdiction, local zoning boards are required to prepare ordinances which meet DNR requirements for management and set limits on development in high-risk erosion areas and environmental areas. If local boards fail to take the proper zoning action, responsibility passes to DNR to evaluate and approve all development plans within the designated areas.

Currently being considered is an amendment to this act which would include floodland (along with erosion and environmental areas) as areas to be protected and managed. If this amendment passes, the requirements discussed above would apply as well to over 450 km of floodland paralleling the shoreline.

In addition to its responsibilities under the 1970 Michigan Act, the Department of Natural Resources has been assigned to oversee Michigan's compliance with the U.S. Coastal Zone Management Act of 1972. Under this act (administered by NOAA) management plans must be prepared and instituted for the entire coastal zone, consonant with national, regional, state and local goals. This act basically gives federal support to the actions previously begun under the State legislation. In 1974 Michigan applied for and has been awarded a grant of \$330,000 federal funds supplemented by half such an amount in matching state funds for this purpose.

5.1 FLIGHT PLANNING AND EXECUTION

To identify problem areas along the shoreline, plan appropriate remedial action, and execute or enforce the required action, a fund of basic information is needed. Because of the magnitude of the area under study, it became obvious that a strong emphasis and reliance should be placed on remote sensing data. The project therefore directed a significant part of its activity during the current year to obtaining the remote sensing data needed by the state to meet its major responsibilities for Great Lakes shorelands protection and management.

ERIM staff members, as early as 1971, began discussions with supervisory and technical personnel of various units within the Michigan Department of Natural Resources concerning problems of shorelands management. During this early period, ERIM was funded by the Water Development Services Division to conduct a pilot project using current and historical aerial photography to measure beach erosion rates. This preliminary study indicated that while the general method was sound, several technical and definitional problems with the measurement technique existed. ERIM and DNR personnel have been working together to solve these difficulties, because of the DNR determination that remote sensing is the only feasible way to make the necessary analyses for such an extensive undertaking. Many other specific uses for remote sensing were also discussed.

To provide a data base for demonstration purposes in high-priority areas, ERIM requested NASA to authorize a 160 km shoreline flight. Then, on the premise that the utility of remote sensing for managing the shoreline would be demonstrated, we also requested a follow-up flight of the entire shoreline, with the State of Michigan providing the resources for data processing and information extraction. Although such a 160 km demonstration flight had been cancelled on two previous occasions, approval was finally obtained early in 1974 for a flight program covering most of Michigan's 3700 km of shoreline. Because of the scope of this data collection undertaking, the ERIM staff has been extremely active in planning for and executing the flights as well as in organizing the coordinated program between ERIM and the State agencies to make full use of the data as soon as they became available.

In order to plan a multidisciplinary shoreline remote sensing program, ERIM received recommendations of minimum data requirements, of shoreline areas of special interest, and of desired information outputs from several sources, including the DNR's Water Development Services Division, their Wildlife Division, the Detroit District of the Army Corps of Engineers, and Michigan State University. From these requirements, ERIM specified the flight altitude, route, data collection procedures, and time schedule as well as the film, filter, scanner spectral bands and other factors needed to assure a successful flight program. These specifications optimally balanced the needs of each of the various users.

The data flights were made during April and May 1974. Color and color-infrared photography and MSS data for at least 3000 km of the most critical sections of shoreline have been collected (see Figure 2). This extensive data collection effort provides a comprehensive data base which not only will have many immediate uses but will also continue to be available as an information resource for many years to come. Although aerial photography has been collected over some of these areas in the past, the current remote sensing data has special features that greatly enhance its usefulness. Of major value is the uniform coverage of large stretches of shoreline, rather than small isolated sections. The color aerial photography, at scales of 1:10,000 or 1:16,000, provides data with excellent resolution. The SO-397 color film also greatly increases the interpretability for land and water features as compared to black-and-white photography. Moreover, the scanner imagery can be subjected to automatic interpretation for identification and enhancement of special features of land and water areas, including applications of thermal mapping.

To make maximum use of this newly available data base, ERIM is actively cooperating with the state and local government agencies. Our discussions with these people have defined effective methods of applying the data to specific types of problems. As a result, we find that agency personnel are using the data as soon as it becomes available. Basically, ERIM's objective is to demonstrate that remote sensing is an effective means of providing data required by various users and defining the methodology required to extract the information.

There have already been some applications of the data, which are discussed in the remainder of this section. Most of the effort will be carried out during the coming year, including a continuation of the current applications and other uses, as will be mentioned later in Section 5.6.

5.2 MEASUREMENT OF BEACH RECESSION RATES

Of the 3700 km of Michigan's mainland shoreline, over 1100 km have been determined to be in a high-risk erosion condition. Upon request, DNR must provide recession rate data to 226 local units of government who must establish setback lines by spot zoning in high-risk erosion areas. DNR is also required to provide shore erosion rates to approximately 500 owners of some 350 km of eroding, unplatted and undeveloped property. In addition, DNR is frequently requested to provide to local agencies and the public, recession rate information for already developed areas.

The Water Development Services Division is now using the 1974 photography to delineate high-risk erosion areas and determine beach recession rates within these areas; one of the first applications was for portions of Emmet County shoreline. ERIM is supplying DNR with black-and-white positive prints of the 9-inch color imagery for this purpose. Because the need for beach erosion measurements is urgent, these prints are being immediately made available to local



*These segments were at flight altitudes of 2040m. Other flight segments were at 1530m.

FIGURE 2. MICHIGAN SHORELINE COVERED BY FLIGHT MISSION X252M, APRIL-MAY 1974

zoning officials and developers. Zoning and building decisions are currently being based on this information. The ERIM staff will follow up these local decisions and report them in an account of next year's efforts.

As indicated previously, this beach recession rate effort has been active for some time. In 1971, the Water Resources Division of DNR requested ERIM to explore with them the possibilities of establishing a partially or fully automated procedure for determining beach line recession rates along the Michigan shoreline. Technical personnel at ERIM, in consultation with DNR personnel, recommended a method in which a trained photointerpreter uses standard aerial photography obtained on two different dates to measure changes in the beach shoreline, recording the results by a computer calculation method tied into a high precision grid measurement device.

This method was tested in the summer of 1972 on photography of selected areas chosen by the DNR. While the results of the test highlighted the advantages of the machine precision measurements and the computer calculation techniques, they also pointed out problems which lead to ambiguities or errors in some of the calculated recession rates.

The first of these problems concerned the definition of beach recession and the selection of criteria for determining erosional effects. Agreement on the criteria for identifying the point of the beach for measurement (i.e., waterline, foot of bluff, top of bluff, or farthest extent of permanent vegetation) had to be reached before meaningful determinations of recession could be made.

A second difficulty encountered was in the quality and comparability of the photography. The span of years between two images of the same area ranged from 15 to 30 years. Photographic scale ranged from 1:8000 to 1:40,000. These differences hampered accurate interpretation of the photographs, and in some cases indicated a net accretion or recession of the beach opposite in trend to that presently occurring. This problem has now been alleviated by the collection of shoreline photography at a uniform scale large enough to allow accurate determination of beach characteristics.

A third difficulty, currently being resolved, lies in making the necessary photogrammetric corrections (for parallax displacement, tilt, etc.) to enable high-accuracy measurements.

As this report goes to press, the pilot efforts in high priority areas are just being completed, and state agencies are making preparations for the full-scale measurement of recession rates along the entire shoreline.

5.3 SHORELINE PROTECTION MEASURES

Aerial photography of the Michigan shoreline is of direct use to the Detroit District of the Corps of Engineers in connection with its construction and permit operations. The District has purchased color negatives and prints providing photographic coverage of approximately 20 major harbors on Lake Michigan, Lake Superior and Lake Huron (see Figure 3) as well as black-and-white negatives of the Lake Michigan shoreline from the RB-57 flights of 1969 and 1970. This up-to-date and historical coverage is helping District engineers understand physical changes occurring in the vicinity of these 20 harbors as well as in planning or approving remedial measures to alleviate resulting problems.

Specific purposes for which the ERIM-furnished remote sensing data will be used by the Detroit District include the following:

- Planning dredging operations in harbors to eliminate shoaling resulting from sediment transport and deposition.
- Evaluating the adverse effects of federal harbor installations on shoreline erosion. (Under the Rivers and Harbors Act of 1968, the federal government is responsible for monitoring the occurrence of such adverse effects and for correcting the resulting damage.)
- Installing and maintaining protective structures to minimize beach erosion at critical points.
- Locating offshore sand and planning for its use to make up sand deficiencies resulting from the installation of shoreline structures. At Grand Haven, for example, sand erosion in the vicinity of the water intakes is endangering the municipal water supply.

This aerial photography will allow the engineers to estimate the rate and direction of sediment transport by observing such phenomena as wave action, coastal jet patterns, river and industrial outflows, water circulation, bottom depth, wind patterns, and the effects of man-made structures. (See Figure 4.)

The Chicago Division Office of the Corps of Engineers is also interested in the 1974 imagery. This office is taking steps to obtain copies of the photography for those sections of shoreline in which it has particular responsibilities, and to supplement its own coverage of the Great Lakes.

5.4 POWER PLANT DISCHARGES INTO THE AQUATIC ENVIRONMENT

Temperature is an important environmental parameter which has a bearing on virtually all chemical, physical, and biological processes. In consequence, information regarding the thermal loading introduced by power plants into the public waters of the State is of interest to the Michigan Water Resources Commission. As in the case of other effluent discharges, monitoring must be performed on a routine basis to determine compliance with established standards.



FIGURE 3. LITTLE LAKE HARBOR, 7 MAY 1974. Since its original construction on the south shore of Lake Superior, shoaling problems have been experienced at Little Lake Harbor. This photograph, providing the first good vertical view of the harbor since 1964, clearly shows the transport of material from the east and the continuous nature of harbor mouth shoaling effects from the sandbar outside the harbor. The resulting sediment transport patterns produce rapid shoaling in the mouth of the harbor, making it difficult to maintain the desired 4m depth. This photograph is expected to be very useful for a design-deficiency study scheduled to begin in FY 75. (Original in color.)



FIGURE 4. LUDINGTON PUMP STORAGE PLANT, 24 APRIL 1974. The Ludington Pump Storage Plant acts as an energy storage system by alternately transferring large amounts of water between Lake Michigan and the elevated reservoir at the right. The large structure and the intake or discharge of water can substantially alter the lake circulation patterns, which are predominantly northward during the summer. Continued monitoring of the effect of the plant on these patterns is important to determine the degree to which they cut off littoral transport of material and contribute to shore erosion in the vicinity of Ludington, a few kilometers to the north. (Original in color.)

The Michigan shoreline flight program collected remote sensing data in the vicinity of several major power plants. (See Figure 5.) The availability of the data has been called to the attention of the Water Resources Commission staff and discussions initiated regarding the processing of the data to show: (1) temperature distribution and (2) surface areas corresponding to each temperature interval displayed. Cost data for the performance of this work have been submitted to the Water Resources Commission and are now under review.

5.5 PORT DEVELOPMENT

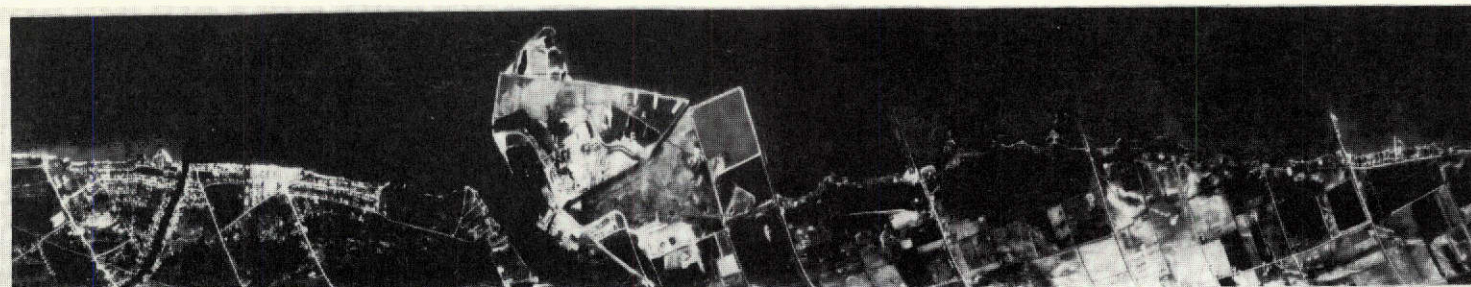
The Michigan Department of Commerce has initiated a program for a state-wide study of Great Lakes port facilities, with a view toward recommending and carrying out programs of port modernization and expansion. Buzz Sellman attended a meeting held by the Department in May 1974, at which it was decided to concentrate first efforts on the Detroit Port.

The port studies are concerned with the economic justification for modernizing and expanding existing port facilities. (See Figure 6.) These improvements might take the form of installing facilities for handling containerized cargo, or expanding docks and truck terminals. Up-to-date information provided by remote sensing is needed for studying the influence of current shoreland use on the development of these port facilities.

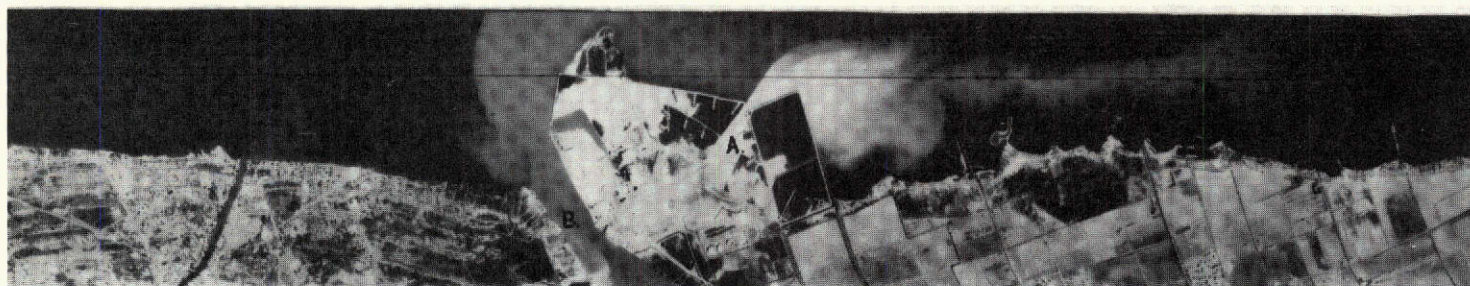
The Detroit-Wayne County Port Authority staff is now conducting a preliminary review of Detroit port operations and preparing recommendations for expanding and improving port activities. Following a briefing at ERIM for the Port Authority staff and the Wayne County Planning Commission, the Planning Commission purchased copies of photography (including lower Lake St. Clair, the Detroit River, and upper Lake Erie). ERIM staff also prepared strip mosaics of the shoreline photography for use by the Port Authority staff. As a result of this initial demonstration, these agencies found photointerpretation to be an effective method of identifying unused areas which can serve as future sites for port expansion or construction.

Following this preliminary work, in a meeting convened by Mr. Norton Berman, Deputy Director of the Dept. of Commerce, and attended by the Wayne County Planning Commission, City of Detroit, and Detroit Port Authority, it was decided to prepare a formal proposal to the State Legislature requesting funds for detailed planning of a Riverfront Development Project. ERIM, because it had successfully demonstrated the utility of the shoreline photography, was asked to participate in proposal preparation. State approval of funding for this project planning effort will require additional use of remote sensing data.

The Port Authority of the City of Monroe has also recently purchased, from ERIM, RB-57 imagery of the Monroe port. They will utilize the imagery to demonstrate the location and other advantageous aspects of their city in an effort to influence industrial concerns to settle there.



0.48-0.53 μ m



9.0-11.4 μ m

FIGURE 5. PORTION OF SAGINAW BAY, 7 MAY 1974. The lower display shows the thermal discharge into the bay from two power plants (Pt. A) together with the thermal loading from the Saginaw River (Pt. B). The elevation in temperature evident in the case of the Saginaw River is caused by both natural processes and various industrial uses of the river water at upstream locations.



FIGURE 6. PORT FACILITIES ON DETROIT RIVER, 10 APRIL 1974. State and local agencies are cooperating in planning for modernization and expansion of existing port facilities as well as construction of new facilities. Up-to-date aerial photography such as this is needed to study land use along the shore and to identify unused areas suitable for port expansion or construction. Clearly indicated is the Ambassador Bridge connecting the U.S. (left) with Canada. (Original in color.)

5.6 CONTINUING PROGRAM

Some early results of using the remote sensing data base for beach erosion protection, harbor maintenance, and port studies have been described in this section. During the coming year, ERIM will continue to demonstrate remote sensing methods which government agencies can use for these and other purposes relating to shorelands management and protection.

Additional uses being considered by these government agencies include the following:

- Updating the use and development inventory of existing shorelands
- Determining the number and location of dwellings or other structures in danger of being damaged or destroyed by shore erosion
- Identifying flood risk areas, especially those subject to development, to permit planning protective measures
- Documentation of the location and extent of unique natural, cultural, scenic, historic, and aesthetic areas in order to regulate the development and use of these areas. (Section 6 discusses the delineation and classification of coastal wetlands, which constitute a major type of environmental area.)

PROTECTION AND MANAGEMENT OF WETLANDS

Michigan's wetlands function importantly in providing suitable habitat for many forms of wildlife, as a basis for Michigan's rapidly increasing tourism and outdoor recreation industry, as sources of agricultural and timber products, and in maintaining the quantity and quality of water resources. The pressures of increasing population and a higher standard of living have had a more serious effect on wetlands than on other types of undeveloped wildland. It is essential that the state develop and enforce rational policies regulating the use and modification of wetland areas.

Governor Milliken, by Executive Order 1973-2, assigned to the Department of Natural Resources Commission the task of assembling a land-use plan for the State of Michigan and preparing legislative proposals to implement the plan. As DNR Director, the late A. Gene Gazlay established the Office of Land Use to carry out the mandate. Subsequently, a specific recommendation for preservation of wetlands was included in the Governor's special message to the Legislature on 6 November 1973.

In a letter to ERIM dated 19 December 1973, Director Gazlay described the urgent need for rapid and economical methods of collecting wetlands inventory information. Such inventories are needed at 5 to 10 year intervals to provide up-to-date information on the quantity, quality, and distribution of wetlands. Policy-makers and land and wildlife management personnel use this information for a number of purposes:

- (1) In adopting and enforcing a state policy for the protection and management of wetlands
- (2) In providing information to local units of government who must implement this policy at the local level through the adoption of zoning ordinances and other protective measures
- (3) In identifying wetland areas suitable for purchase or lease in a public acquisition program
- (4) To base management of wetlands on the relationships of number and quality of wetlands to the waterfowl and other wildlife they can support

6.1 OBJECTIVES

The major objective of this task is to assist the State of Michigan in meeting its responsibilities for protection and management of its valuable wetland areas. This is to be done through the adoption of a cost-effective remote sensing method for state-wide inventory of wetlands needed for government decisions on public acquisition and zoning restrictions.

To confirm the effectiveness of the techniques selected to accomplish this overall objective, the project is aiding the state in preparing an environmental assessment of St. John's Marsh, near the delta of the St. Clair River. This assessment is needed by the state in order to obtain

legislative approval and funding for public acquisition of the Marsh, currently under pressure from encroaching urbanization. (See Appendix C.) Marsh area analysis and assessment will also provide the means for demonstrating to the State the utility of a multistage method for conducting a state-wide wetland inventory.

6.2 WETLAND INVENTORY

Specific remote sensing techniques for wetlands mapping have already been developed under other projects, but an optimum combination of these techniques must now be selected and applied to prepare a state-wide inventory of wetlands. This previous work indicates that economical, accurate mapping of wetlands at the level of significance required by DNR necessitates the use of a multi-stage sample survey system, combining computer-processed ERTS data with the results of manual interpretation of larger-scale aerial photography or aircraft scanner data. Preliminary investigations into the feasibility of this approach have been performed by Norman Roller of ERIM, in close cooperation with Gerald Martz, Supervisor, Waterfowl and Wetlands Research Unit, Rose Lake Wildlife Research Center of DNR, and in consultation with William Marks, Chief of the Water Development Services Division of DNR.

Computer-compatible multispectral data collected by ERTS-1 over the entire state during the past two years provide a uniform data base capable of serving as the basic source for a state-wide inventory. Evaluation and recommendations on the use of ERTS data for this purpose can be based on the results of ERTS studies being conducted for NASA under Contract NAS5-21783 [10]. Task V of this contract is directly concerned with the use of ERTS data for wetland mapping and studies of an area typical of inland wetlands in Southern Michigan have already been made. The test area, located in Livingston and Washtenaw Counties, includes the E. S. George Reserve—a wildlife and forest research area owned by The University of Michigan. Single and multi-date analyses of computer-processed ERTS-MSS data have shown an ability for accurate mapping of temporary and permanent surface water covering areas greater than 1 hectare, combined with an ability to detect significant types of wetland vegetation. Through computer processing of ERTS imagery for late March and early June, we successfully identified such varieties of land cover as marsh, shrub swamp, lowland forest, upland forest, and varying mixtures of tree cover over grass. The studies indicate that by an extension of these methods, all eight categories of wetland areas which Reference [11] lists as occurring in Michigan can be successfully recognized.

This ERTS project, still continuing, has the objective of better defining the conditions for optimum recognition and mapping. We are determining the best single or multiple dates of ERTS data acquisition and the optimum spectral bands for discrimination of wetland types. Also being perfected are methods of geographically registering data collected on two or more

dates. As these results are obtained from the ERTS project, they are discussed with DNR staff members and are being directly used in formulating recommendations for a state-wide wetlands mapping program. Experience gained with the inventory of waterfowl habitat under the Pointe Mouillee study [3] are also directly applicable in recommending methods of using aerial photography in the multi-stage sampling procedures for state-wide inventory.

Michigan wetlands fall into three basic categories: northern inland wetlands, southern inland wetlands, and coastal wetlands. The ERTS investigation discussed above has concentrated on the mapping of inland wetlands, but we must extend this procedure to coastal wetlands. Under the wetlands task, this extension is being accomplished by using a combination of ERTS and aircraft data to map a particular wetland area to be considered for possible public acquisition in the near future. The area selected is the St. John's Marsh, located on the mainland just north of the St. Clair River delta.

In order to demonstrate multi-stage sampling methods for this test area, suitable ERTS-1 data for one or more dates will be computer-processed to produce the first level of wetland enumeration. The aerial photography will provide the higher resolution recognition and mapping which will be used in an operational system to sample the wetland regions detected by ERTS-1. The demonstration will measure and record terrain features identified as key variables indicative of wetland condition; results will include: (1) total numbers, by type, of wetland areas greater than some specified size; (2) total surface acreage of wetlands, by type; (3) individual wetland shoreline length; (4) annual water permanence; (5) associated upland vegetation; and (6) evidence of human intrusion. Such a demonstration will also indicate the degree to which even greater reliance can be placed on ERTS data in inventory updating (as distinguished from the original inventory).

The optimum mix of sensor system and survey strategy that will be defined from this investigation of the coastal wetland situation will further aid the DNR in seeking legislative support and management planning for a new state wetlands inventory. Based on preliminary results of the methods we are investigating, Mr. William Marks, Chief of the Water Development Services Division (DNR), has recommended that ERIM discuss the potential of this technique and its possible implementation with Mr. Ray Smit, a member of the Michigan House of Representatives and a supporter of wetland preservation measures.

There is also every indication that this method of wetlands inventory could serve as a mid-western and northeastern regional model for the proposed national inventory scheduled to be initiated in 1975 by the Bureau of Sport Fisheries and Wildlife of the U. S. Department of Interior.

6.3 ACQUISITION OF ST. JOHN'S MARSH

St. John's Marsh, located adjacent to the St. Clair River Delta, is a privately owned area that each year hosts one of the largest concentrations of migratory waterfowl to be found in the northern regions of the Mississippi Flyway. But commercial housing developments now encroaching upon most of the adjacent marshlands that once surrounded St. John's Marsh are relentlessly destroying the value of this area for waterfowl use and environmental protection (Figure 7). Both the Wildlife Division and the Water Services Development Division believe that purchase of the remaining portion of this vital ecosystem is imperative to provide for its adequate protection and ensure its continued existence. Before this action can take place, however, the DNR must justify the purchase by preparing an environmental assessment of the Marsh to substantiate claims regarding the utility and uniqueness of the area.

To help in this assessment task, we are currently analyzing 1:10,000-scale color aerial photography (collected in April 1974) as well as five dates of 1:20,000-scale USDA-ASCS black-and-white historical aerial photography. Our aim is to inventory the existing habitat and marsh vegetation cover types, then determine the effects of historical land-use practices and environmental conditions in the surrounding area to show their role in creating the current condition of St. John's Marsh. This information will then be correlated with DNR's records of waterfowl productivity and migratory use for this area to determine the cause-effect relationships between the loss of habitat quality and such detrimental influences as human intrusion, effects of high water, drainage, and cutting of marsh vegetation for hay. This information will form the basis of the required environmental assessment.

DNR will base its justification for public acquisition of the area on a technical report to be submitted by ERIM. In it, we will also recommend specific multi-stage sampling procedures for preparation of the needed state-wide inventory. Report copies will be transmitted to the Office of University Affairs and followed by a synopsis of resulting DNR decisions and actions.

With the case for wetlands acquisition thus documented, two sources of support for the concept will be sought. First, within the structure of the state government the deleterious cause-effect relationships affecting wetland ecosystems under private ownership in this part of the state will be cited to the State Legislature by the DNR as justification for funding a public acquisition of the St. John's Marsh. DNR will request the State Legislature to make a special appropriation of \$1,200,000 which will be matched with Federal monies from the Land and Water Funds. Secondly, private citizens will use this same information to influence local members of the legislature to support the DNR request. Specific local action groups expected to use information generated by this task to lend credence to their position include (1) the Lake St. Clair Advisory Committee, (2) the Michigan Duck Hunters Association, (3) the Colony Park Home Owners Association, (4) the Michigan Chapter of the Audubon Society, and (5) outdoor editors of Detroit and local newspapers.

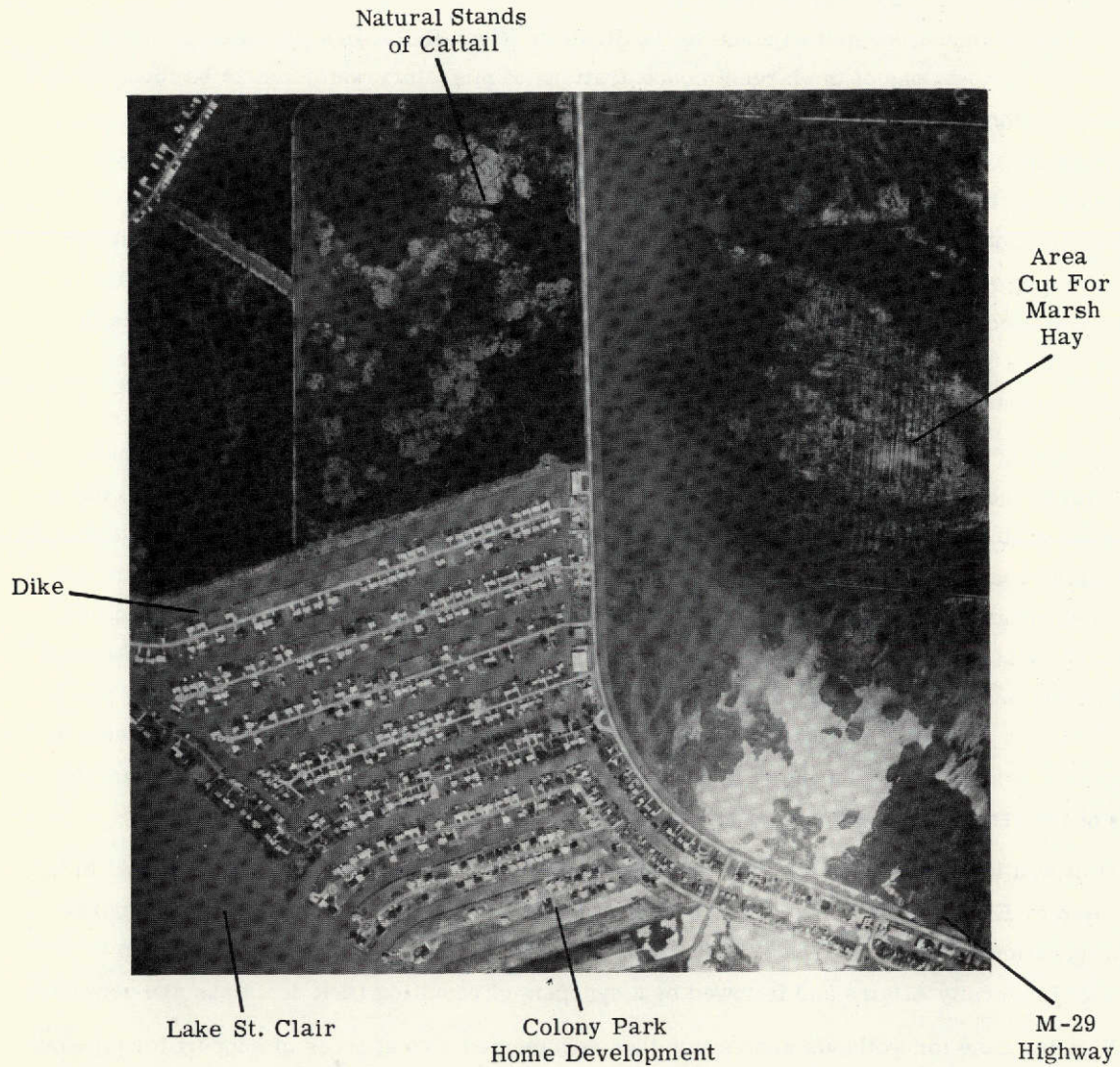


FIGURE 7. PORTION OF ST. JOHN'S MARSH, 10 APRIL 1974. Expansion of residential areas poses a serious threat to the environmental value of St. John's Marsh as a waterfowl and fish habitat. The remaining sections of marsh shown in this photograph will soon disappear if existing realty development plans are carried out. The alternative of public acquisition of these marshlands by the Michigan Department of Natural Resources can preserve this vital wetland ecosystem. (Original in color.)

As noted above, historical aerial photography has been used to identify cause-effect relationships in wetland changes in St. John's Marsh. As a result of ERIM's use of historical photography in wetland assessment, this approach is now being emphasized by the Wildlife Division for future analysis, assessment, and management of wetland areas.

SOIL SURVEY

In conducting operational soil surveys, emphasis is placed on the speed, economy, and accuracy with which the survey can be completed. Previous studies at ERIM indicate that multispectral scanner data can be of substantial value for this purpose. Initial efforts to obtain useful soil information were undertaken as part of the M-14 Highway Impact Study [12, 13]. Subsequently other, more promising, techniques were documented in a paper sponsored by the Office of University Affairs, NASA [14]. This past experience demonstrates that multispectral scanner data can be used for indicating some characteristics of individual soils and for delineating boundaries of individual soil mapping units. In soil surveys, use of this capability as a complement to aerial photography, which is already in operational use, would increase both the accuracy and efficiency with which field survey teams can select and check ground samples. Currently, improper selection of sampling points adversely affects the cost and reliability of the resulting soil survey. In discussing these concepts of scanner data application with the USDA Soil Conservation Service (SCS) and the Michigan Agricultural Experiment Station (MSU), ERIM found agreement that the proposed techniques should be applied in an ongoing soil survey.

A task was therefore initiated during the current year to apply remote sensing techniques to the soil survey procedures presently used in Michigan by SCS and MSU. The goal of this task is to obtain the widespread adoption of specialized remote sensing techniques as a means of improving the speed, economy, and accuracy of operational soil surveys. Rodney Harner, State Soil Scientist of SCS, has indicated that if this project is successful, it will provide the justification for SCS to incorporate this technology in its ongoing and future survey programs in 60 Michigan counties.

This application of remote sensing is to be fully demonstrated in the National Cooperative Soil Survey begun in Jackson County in the fall of 1973. Cooperating agencies include state, county, city, and township units, with the Soil Conservation Service acting as the principal mapping agency.

7.1 PRELIMINARY PLANNING OF SURVEY METHODS

Work during the current year has been directed toward obtaining results from preliminary data collection and analysis on which to base the operational demonstration. For this purpose, we processed four flight lines of multispectral data from two previously mapped test sites in Washtenaw County. One of these test sites was the M-14 Freeway Test Site, the other an area in Sharon Township. Both of these sites have a great deal of soil information available from other programs. Our preliminary evaluation was based in part on the signature analysis of 30 significant classes of vegetation and soil types found at the two test sites. Images prepared

from various single bands or from ratios of two bands taken at various dates were also examined by ERIM and MSU staff members to confirm the interpretability of various surface types as indicated by the signature analysis. (See Figure 8.) As discussed below, the results of this preliminary planning were used to recommend optimum spectral bands and processing methods for the subsequent soil survey operation in Jackson County.

It was found that no single date of data collection provides maximum discrimination of all features of interest in a soil survey. In agricultural areas, data collected in May or June show maximum bare soil exposure resulting from field cultivation and good separation of bare and vegetated areas. The data collected over Jackson County, obtained in April, meet the requirement of showing deciduous trees in leaf-off condition. This is most appropriate for the Jackson County area, which is heavily wooded.

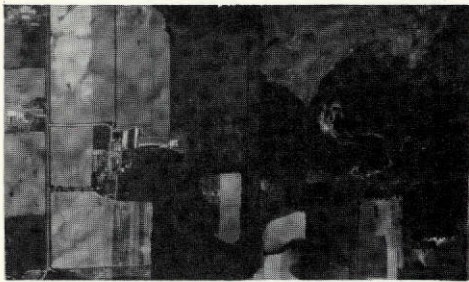
For field operations, a three-color image is to be prepared showing surface water in blue, vegetation in green, and bare soil and roads in red. The image will be printed in a subdued matte finish for easy field annotation at a scale of 1:20,000, corresponding to that of aerial photography.

The surface water will be mapped by use of the 1.5-1.8 μm band. Vegetation will be separated from other surface types and mapped in continuous tone by processing the ratio of the near-infrared band to the red band, $(0.67-0.94)/(0.62-0.70 \mu\text{m})$. The variations in continuous tone separate various major classes of vegetation. Bare soil and roads will be separated from other surface types and mapped in continuous tone, using either one or more bands in the visible spectrum (0.40-0.48 μm to 0.62-0.70 μm) or a thermal-infrared band (9.2-11.7 μm). The variations in continuous tone tend to be correlated with soil natural drainage or soil texture.

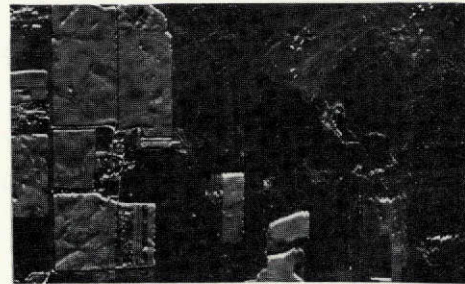
7.2 OPERATIONAL DEMONSTRATION

We began the application of remote sensing methods to an ongoing soil survey by obtaining remote sensing imagery in aerial flights over Jackson County in April 1974. Excellent 23cm \times 23cm aerial color photography resulted for a 4 km \times 42 km strip across Jackson County; it has been inspected by the field party chief and is being used in field mapping. Beginning in June, ratio processing of aircraft multispectral data will be accomplished. These data are to be processed to enhance soil and terrain differences determined to be most useful for soil surveys. Soil differences will include those of color (Munsell hue) and natural drainage. Terrain differences to be enhanced will include vegetation density and vigor, natural drainage patterns, and surface features (roads, buildings, water).

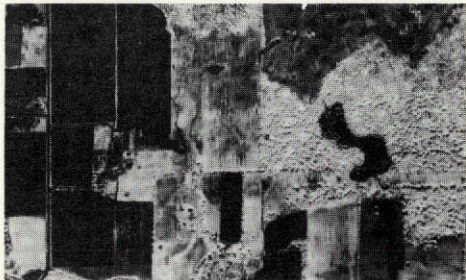
T. Wagner of ERIM, D. Mokma of MSU, and R. Ingel of SCS will cooperate in evaluating the processed imagery. Detailed interpretation and extensive field checking will be accomplished



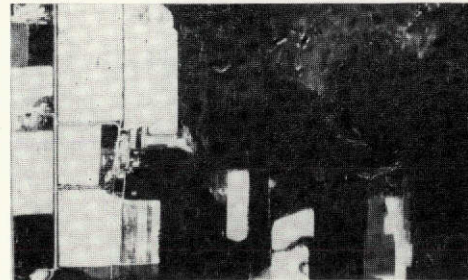
Green
Violet



Red
Green



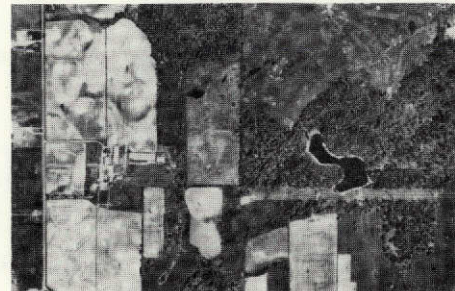
Near-IR
Red



Mid-IR
Near-IR



Thermal-IR
Near-IR



Aerial Photo
(May 21, 1969)

FIGURE 8. ENHANCED IMAGES FOR SOIL SURVEY. These enhanced images were obtained by ratio processing of multispectral scanner data collected on 5 June 1972 over the M-14 Freeway Test Site near Ann Arbor, Michigan. The green/violet and the red/green ratio images differentiate vegetation (relatively dark) from bare areas (relatively light). The near-IR/red ratio is useful for discriminating among classes of vegetations, while the thermal-IR/near-IR ratio maintains the most contrast for bare areas. These image enhancement methods are now being applied in the soil survey for neighboring Jackson County.

during July 1974. Following this preliminary work, the resulting data will be used by the SCS field mapping party to improve the efficiency and accuracy of ground sampling procedures.

At the conclusion of the work, a technical report will be prepared to illustrate the capability of processed scanner imagery for delineating soil types and to analyze the cost-effectiveness of the technique in operational soil surveys. This information will provide the basis for planning future applications of remote sensing in soil survey work in Michigan.

ASSISTANCE TO USERS OF REMOTE SENSING

In the course of the year, ERIM has offered advice and assistance to many current and prospective users of remote sensing data. These users have included private corporations as well as local agencies, both governmental and non-governmental. With contact normally initiated by the user, ERIM in several cases supplied imagery or analysis services. The more important of these contacts are summarized below.

Environmental Analysis of Utility Sites. Consumers Power Co. of Jackson, Michigan needed some remote sensing data for analysis of certain environmental problems and contacted ERIM as a likely source. They subsequently purchased remote sensing data products for evaluation of several sites.

One such product was a computer tape of ERTS imagery that ERIM processed to prepare a land cover inventory of an area measuring about 95 km² in size near St. Johns, Michigan, north of Lansing. This inventory was used to evaluate the area for possible acquisition as a cooling pond reservoir. Such a reservoir is needed as an environmentally acceptable method of dissipating waste heat.

Consumers Power also purchased enlargements of RB-57 photography for three areas in Southern Michigan they were considering as sites for power transmission corridors. Based on the resulting photographs, the MSU Department of Fisheries and Wildlife of Michigan State University performed environmental impact analyses of these areas.

Commonwealth Associates, Inc., of Jackson, Michigan, is one of the major firms who prepare environmental impact assessments for power plant installations, cooling water ponds or discharges, and electric transmission line construction for utility companies. ERIM has held a series of informational meetings with their staff members to define potential uses of various forms of remote sensing for these purposes. Among the remote sensing products found applicable to the company's environmental assessment activities are: scanner mapping of water circulation patterns and aquatic vegetation, evaluation of environmental areas, and the use of ERTS imagery to establish a data base for corridor selection. We are now prepared to work with Commonwealth Associates when a specific need for these products arises under one of their utility company contracts.

Sleeping Bear Dunes National Lakeshore. Two ERIM staff members, Virginia Prentice and Norman Roller, participated in a public hearing held 12 July 1974 on wilderness proposals for the Sleeping Bear Dunes National Lakeshore. For illustrative purposes, they supplied the National Park Service with Skylab photographic coverage of the area obtained in September 1973. This S-190B photography has been retained at the Sleeping Bear Dunes Headquarters Area and will be used for interpretive purposes.

General Motors Proving Grounds. Officials at the General Motors Proving Grounds purchased 100 copies of RB-57 photography of the Proving Grounds and surrounding area near Milford, Michigan for framing in connection with the celebration of its 50th anniversary. The wide distribution of this NASA photography was of substantial public relations benefit.

Bank Marketing Studies. As an outgrowth of our ongoing work with them, SEMCOG recommended ERIM to Manufacturers National Bank of Detroit as a source of guidance in the use of remote sensing for marketing studies. Meetings with bank officials were held to define potential uses of remote sensing in this field. NASA high-altitude photography was identified as the most useful product available for these purposes. The bank has since purchased copies of imagery over the Oakland County area for the identification of branch bank sites and analysis of urban growth and resulting market potentials.

Huron River Watershed Council. The Creeksheds Project, supported in part by funds from the U.S. Department of the Interior, aims to develop improved strategies for creekshed protection in urban, rural, and fringe areas. ERIM has advised project personnel regarding suitable uses of remote sensing for land use mapping and supplied existing RB-57 photography of several creekshed areas in the Huron River basin selected for project study. We will continue to follow the work of the Project and offer advice where needed.

Eastern Michigan University. Eugene Jaworski and Nicholas Raphael of the EMU Geography Department are conducting a study to determine the extent of damage to marsh areas along the Great Lakes shoreline resulting from residential development and industrial activities. (See Appendix D.) ERIM has provided advice based on past experience in using remote sensing data for this purpose and has made available low-altitude photography of Lake Erie shoreline areas in which EMU is concentrating their investigation.

INFORMATION DISSEMINATION

During the year, the project continued its program of widespread dissemination of information on remote sensing methods and applications. Information was made available by means of classroom lectures, presentation of papers at seminars and symposia, news releases, and displays. Many individual groups from various state and local agencies have visited ERIM laboratories for briefings on problems of particular interest to them. Discussions have been held with state legislators from a number of districts, and NASA imagery has been made available to them. The most significant informational activities are discussed below.

Conference on ERTS in Michigan. ERIM staff members participated in the Conference on ERTS in Michigan held on 7 June 1974 in Ann Arbor by the Michigan Section of the American Institute of Aeronautics and Astronautics. This conference was attended by more than 100 people representing government, industry, and universities in Michigan.

The keynote address for the conference was given by Congressional Representative Marvin L. Esch of the Michigan Second District. ERIM participated in the program by setting up a display of recent ERTS results and by making the following presentations:

- B. Sellman, "Remote Sensing and Resource Analysis: An Overview for the State of Michigan."
- C. T. Wezernak, "Limnological Studies in Michigan."
- L. B. Istvan, "Inventory and Analysis of the Coastal Zone."
- D. S. Lowe, et al., "Panel Discussion on Future Prospects for ERTS Applications in Michigan."

Cornell University Seminar. Donald Lowe, Robert Vincent and Thomas Wagner participated in a Seminar in Remote Sensing held by the School of Civil and Environmental Engineering of Cornell University in 1973-74. The following presentations were made:

- R. K. Vincent, "Spectral Ratio Imaging Methods for Geological Remote Sensing from Aircraft and Satellites," December 1973.
- T. W. Wagner, "The Multispectral Environment," February 1974.
- D. S. Lowe, "Multispectral Scanners: Design, Capabilities and Limitations," February 1974.

Assistance to Public Schools and Colleges. Examples of Skylab, ERTS, and RB-57 photography were provided to the Instructional Media Division of the Ann Arbor Public Schools for use in developing an environmental studies kit.

Various ERIM staff members have lectured on remote sensing at individual classes held at The University of Michigan, Eastern Michigan University, and Oakland Community College.

In addition, we are cooperating with the Geography Department at Eastern Michigan University in its instructional and research program by providing remote sensing imagery and advice on its utilization.

Participation in the Ninth International Symposium on Remote Sensing of Environment.

Recent results of work performed under the NASA Grant were the subject of two papers presented at the Ninth Remote Sensing Symposium held in Ann Arbor on 15-19 April 1974.

R. E. Esch and Buzz Sellman, "The Role of ERTS-1 Processed Data for Transportation Planning in Michigan."

S. W. Schar, W. R. Enslin, I. J. Sattinger, J. G. Robinson, R. S. Fellows, K. R. Hosford and J. H. Raad, "Resource Analysis Applications in Michigan."

Presentation to Department of Natural Resources Staff. Buzz Sellman was invited by the DNR Office of Land Use to talk to an audience of DNR personnel concerning the use of NASA high-altitude photography for various applications. Sellman discussed the availability and use of existing photography, and the future use of high-altitude aircraft data to be collected by NASA over portions of the Upper Peninsula during the summer of 1974.

Great Lakes Basin Commission Publication. At the request of the Great Lakes Basin Commission, a short technical article was prepared for inclusion in the September 1973 issue of its publication, Communicator. This article, "A New Dimension in Remote Sensing" by Fabian Polcyn, describes potential uses of ERTS data for regional studies of the Great Lakes Basin.

Presentation to Saline Area Regional Planners. At the invitation of the Washtenaw County Metropolitan Planning Commission, Buzz Sellman gave a presentation in May 1974 for the Saline Area Regional Planners. He described current remote sensing activities in Southeast Michigan and suggested ways in which ERIM is prepared to work with local agencies to make effective use of available remote sensing methods and data.

Television News Broadcasts. The NASA Earth Resources Technology program was covered in short news features on Detroit Station WXYZ in August 1973 (at the time of a Skylab overpass) and on Detroit Station WJBK in June 1974. I. J. Sattinger was interviewed in these features, both of which emphasized the use of Skylab and ERTS imagery of Southeast Michigan.

Remote Sensing Displays. Displays, slides, and other educational material on remote sensing resulting from the project's activities are made available to government agencies and scientific societies for appropriate purposes. Recent examples of cooperation include supplying such materials to:

- The Great Lakes Basin Commission
- The Grosse Ile Laboratory of the Environmental Protection Agency
- Ninth Remote Sensing Symposium in Ann Arbor, Michigan, April 1974
- International Exposition and Seminar on Water Resources Instrumentation of the International Water Resources Association, 4-6 June 1974, Chicago
- Annual meeting of Association of American Geographers, Seattle, Washington, 29 April—1 May 1974
- Annual meeting, MSU President's Club, 31 May 1974, devoted to "Energy Related Programs."



Appendix A
AGREEMENT WITH DEPARTMENT OF MANAGEMENT
AND BUDGET



11 January 1974

Mr. D. John Beck
Director of Federal Grants
Office of Intergovernmental Relations
Lewis Cass Bldg.
Lansing, Michigan 48913

Dear Mr. Beck:

As a follow-up of discussions with you, Dr. Dempsey and Dr. Miller, I would like to formalize our interest in working with you on remote sensing matters by submitting the enclosed no-cost proposal. Briefly, we propose, under the auspices of our NASA Grant (NGR23-005-552), to provide you with support to evaluate the role of remote sensing technology in state government activities.

I propose that the activities outlined in the attachment be treated as a memorandum of understanding between the State and ERIM. These activities will be directed by Mr. Donald Lowe, Deputy Director of the Infrared and Optics Division. I suggest that we initiate this program on 14 January 1974. I feel strongly that this is an important venture for ERIM and have asked Don to be our Lansing representative during this formative stage of the program.

We look forward to working with you. If you have any questions, please do not hesitate to write or call me.

Sincerely,

William M. Brown
President

WMB:msj

Enclosure



ASSISTANCE TO STATE OF MICHIGAN
IN REMOTE SENSING TECHNOLOGY

- I. Performance Period
 - A. Initial Period - January 1974 through June 1974.
 - B. Renewal Proviso - July 1974 through December 1974, based on continuation of NASA Grant to ERIM.
- II. Operational Mode
 - A. Assignment of ERIM Resources
 - 1. One principal ERIM staff member to spend 2 days per week in Lansing.
 - 2. Back-up staff at ERIM to be assigned as needed.
 - B. ERIM Activities
 - 1. Act as general consultant on remote sensing technology and applications.
 - 2. Explore practical application of Remote Sensing to programs of various state agencies.
 - 3. Apply ERIM capabilities to solution of specific problems.
 - C. DMB Activities (carried out by OIGR, Division of State-Federal Program coordination)
 - 1. Provide office space for ERIM staff member.
 - 2. Assign specific project or program needs to ERIM for study.
 - 3. Assist in entry to state agencies.
 - 4. Conduct bi-weekly review of ERIM activities and accomplishments.
- III. Areas of Major Emphasis for Remote Sensing Applications
 - A. Physical Resource Inventory Analyses, Evaluation, etc.
 - 1. Natural resources
 - 2. Cultural impact on natural environment

B. Analysis of Land Utilization Trends

1. Use of time lapse analysis to describe impact on the environment.
2. Application of possible predictive methods.

C. General Counsel to State Government on Selected Projects Having Policy Impact

1. Environmental review processes
2. Growth/urbanization/dispersion (related to industry, highways, utilities, etc.)
3. Land development policies
4. Legislative review and analysis

IV. Benefits

- A. Series of working papers dealing with methods for improved management practices, cost-savings, etc.
- B. Summary report for the benefit of key decision-makers in the state government
- C. Paper on latent federal resources that may be harnessed for state/local benefits
- D. Recommendations on future directions to be pursued.
- E. A no-cost pilot program which allows the State to explore and evaluate the supporting role of a high technology organization in assisting the state.

Appendix B

The Ann Arbor News, Sunday, April 28, 1974

The Science Beat

Governor Gets Space Picture

Gov. William G. Milliken was presented with a five-foot, color photograph of the entire state taken from space recently as part of the Ninth International Symposium on Remote Sensing of the Environment.

Presented by Dr. William M. Brown, president of the Environmental Research Institute of Michigan (ERIM) and former U-M professor of electrical engineering, the photo is composed of a number of images taken from NASA's Earth Resources Technology Satellite (ERTS).

The technology which made the mosaic possible was pioneered at the University of Michigan's former Willow Run Laboratories, which are now the ERIM laboratories. The ground facility which received signals from space and processed the pictures is operated for NASA by Ann Arbor's Bendix Aerospace Systems Division.

Scientists from across the nation and around the world presented papers on remote sensing at the conference held on the U-M's Ann Arbor campus.

In accepting the space photograph, Gov. Milliken said the state is exploring potential uses of ERTS and high-altitude aircraft imagery for assessing and monitoring Michigan's resources. This activity is being carried out by ERIM under a NASA grant.

The satellite snaps a continuous series of images of areas 100 by 100 miles from an altitude of 570 miles. Its orbit is such that it passes over the same area every 18 days.

"With its repetitive coverage, ERTS can observe changes in vegetation and land use, shoreline erosion, water quality, lake circulation patterns and the extent of flooding," Brown said.

"Complementing the use of ERTS data, the program investigates the use of similar data taken from aircraft. The prime advantage of ERTS is the rapid coverage of large areas," he said.

"Aircraft coverage, on the other hand, favors smaller area surveys with resulting finer detail in the image."

Brown said that "to determine the relative merits of data obtained from space and aircraft, ERIM is mapping the entire shoreline of Michigan with its remote sensing aircraft.

"These data will be compared with that obtained from ERTS to assess the relative advantages of space and aircraft imagery for collecting information needed in order to effectively manage Michigan's 2,000 miles of shoreline," he added.

Ann Arbor's Daedalus Enterprises, a spin-off firm from the Willow Run Laboratories which was founded by the late Dana Parker, a remote sensing pioneer, "is doing better than at any time in the past," said his brother, Allen Parker, the firm's president.

We caught Parker just as he was ready to leave for Japan where the local firm has sold a multispectral scanner to the Japanese weather agency. It was their second sale of equipment to that country.

"We are working in Yugoslavia on a fairly large program, and we're doing a lot of survey work in various parts of the United States," Parker said.

He said the firm recently delivered a "made-in-Ann Arbor" scanner to France, following a delivery earlier to the French Space Agency. "We have also been doing business with NASA," he added, and a survey for Dow Chemical Company "relative to the energy crisis."

Daedalus builds scanners and other remote sensing equipment at its Jackson Road plant, and makes remote sensing surveys for governments, industries and others around the world, in addition to serving as consultants.

This new science-based technology appears to be providing us with more and more benefits, particularly in the area of environmental monitoring. The skills in interpreting infrared and multispectral imagery are improving all the time.

Appendix C

The Ann Arbor News, Sunday, May 19, 1974

Plan To Save Marsh

Four prominent State Representatives, in a bipartisan effort, have announced joint sponsorship of legislation to save one of the few great marshlands remaining in Michigan.

State Representatives Warren N. Goemaere (D-Roseville), Joseph M. Snyder (D-St. Clair Shores), William L. Jowett (R-Port Huron) and Bill S. Huffman (D-Madison Heights) made known efforts to seek a special \$1.2 million appropriation in state funds, to be matched by federal money, to purchase more than 2,400 acres of the St. John's Marsh along Lake St. Clair in St. Clair County.

Goemaere serves as Chairman of the House Committee on Conservation, Environment and Recreation and Snyder, Jowett and Huffman are all ranking members of the House Appropriations Committee.

The four legislators, in their

joint statement, offered several reasons for their interest in acquiring the vast wetland, which in the summertime, closely resembles the Florida Everglades.

Among reasons were the natural characteristics of the marsh, providing a prime resting and feeding ground for thousands of migratory birds, a critical spawning and rearing habitat for several varieties of fish numbering in the tens of thousands, a home and feeding ground for dozens of other forms of wildlife, and the functional purpose of wetlands with respect to adjoining lake waters as a buffer zone during high water levels and its filtering capability in improving surrounding water quality.

The legislative interest in purchasing the St. John's Marsh, for the purpose of preservation, came amid numerous plans of private interests to develop the area into a substantial housing project, mobile home parks, a shopping center and parking lots. A few months ago, the principal owners of the marsh indicated a willingness to sell to the state and have the property managed by the Department of Natural Resources for the public benefit.

Representatives Goemaere, Snyder, Jowett and Huffman promised every effort in securing the necessary funds through an amendment to a Department of Natural Resources appropriation bill.

The legislators said a matching \$1.2 million in federal monies has been promised through the Land & Water Conservation Fund under the U.S. Department of the Interior, once the Michigan legislature authorizes their special appropriation request.

All four Representatives cautioned that failure of the legislature to act, would have

some very serious implications to the future of Lake St. Clair, particularly if the marshland is developed.

Appendix D

The Ann Arbor News, Friday, July 12, 1974

Shoreline Damage Studied

YPSILANTI — Are measures against air and water pollution actually having an adverse effect on Michigan's thousands of miles of shoreline?

Two Eastern Michigan University geographers, working under a grant from the National Science Foundation, are trying to find out.

Some 7 million cubic yards of sediment are dredged from the waters between Port Huron and Toledo every year and deposited along the shoreline. Other thousands of yards are used to construct dikes.

Purpose of the study by Eugene Jaworski and Nicholas Raphael is to determine the effect of these man-made changes on the American side of the Great Lakes.

"We know we have lost many of the marshlands in this area," said Raphael. "The area is constantly changing with increased population and industry.

"We want to know what all these changes mean to the vegetation, marine and wildlife," Jaworski said. "We hope to find out how much of the marshland has been lost and what might happen in the future."

The geographers explained in an interview that restrictive dumping regulations have compounded the problem.

"The regulations are cleaning the air and water but now the sediments and waste are filling up the lowlands and the marshes are disappearing," Jaworski said.

"There are some estimates that industry now traps several tons of water pollutants daily in this area," Raphael added. "They have to get rid of

the waste products somehow so they are filling the marshes on their property."

Water-front homes and cottages with their dikes are also decreasing the number of marshes, forcing ducks and fish to find less disturbed areas. The geographers want to make sure there will be enough of the natural areas left.

"This is the first time this

type of study has been done," Raphael said. "We are combining an historical survey with a regional study to document the changes in the area."

"We hope to find out what marshlands have been lost, the amount we have left and the need for them in the future. We then might be able to better control our practices."

To accomplish this they are

charting the changes in the shorelines by using maps from the 1800s and comparing them with maps from various decades of the 20th Century.

Photographs, obtained from the Skylab and Apollo missions through the Environmental Research Institute of Michigan (ERIM), detail industrial and commercial developments of the area as a whole.

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

REFERENCES

1. I. J. Sattinger, A. N. Sellman, L. B. Istvan and J. J. Cook, Remote Sensing in Michigan for Land Resource Management, Annual Report, 1 June 1972 to 1 June 1973, Report No. 193400-2-F, Environmental Research Institute of Michigan, Ann Arbor, 1973.
2. T. L. Gotts, Michigan's Statewide Transportation Modeling System: Volume VI-A, Environmental Sensitivity Computer Mapping, Michigan Department of State Highways and Transportation, Bureau of Transportation Planning, Lansing, 1974.
3. A. N. Sellman, I. J. Sattinger, L. B. Istvan, W. Enslin, W. Myers, and M. Sullivan, Remote Sensing in Michigan for Land Resource Management: Waterfowl Habitat Management at Pointe Mouillee, Report No. 193400-1-T, Environmental Research Institute of Michigan, Ann Arbor, 1974.
4. T. W. Wagner, A Preliminary Study of Multispectral Imagery for Soil Survey, Report No. 193400-4-L, Environmental Research Institute of Michigan, Ann Arbor, 1974.
5. I. J. Sattinger, et al., Remote Sensing in Michigan for Land Resource Management: 1972 Annual Report, Report No. 190800-2-F, Environmental Research Institute of Michigan, Ann Arbor, 1972.
6. Office of Land Use, Michigan Land Use Classification System, Michigan Department of Natural Resources, Lansing, 1974.
7. R. E. Esch, The Application of ERTS Data in Michigan's State Wide Transportation Modeling System, Paper presented at ERTS in Michigan Symposium, American Institute of Aeronautics and Astronautics, Michigan Section, Ann Arbor, June 7, 1974.
8. Program Policy Guidelines for the Fiscal Year 1975-1976, State of Michigan, Lansing, 1974.
9. Water Resources Commission, A Plan for Michigan's Shorelands, Michigan Department of Natural Resources, Lansing, 1973.
10. F. J. Thomson, et al., ERIM Progress Report on Use of ERTS-1 Data, 1 July through 31 December 1973, Report No. 193300-37-P, Environmental Research Institute of Michigan, Ann Arbor, pp. V-4 through V-6.
11. S. P. Shaw and C. G. Fredine, Office of River Basin Studies, Wetlands of the United States, Circular 39, USDI Fish and Wildlife Service, Washington, D.C., 1971.
12. Remote Sensing in Michigan for Land Resource Management: Highway Impact Assessment, Report No. 190800-1-T, Environmental Research Institute of Michigan, Ann Arbor, and Michigan State University, East Lansing, 1972.
13. J. Ahl, M. Boylan, D. Mokma, W. Myers, S. Schar, R. Vlasin and I. J. Sattinger, Investigation of Land Resource Use in Southeast Michigan, Proceedings of Eighth International Symposium on Remote Sensing of Environment, Vol. I, Environmental Research Institute of Michigan, Ann Arbor, 1972, pp. 23-33.

14. T. W. Wagner, R. D. Dillman, and F. J. Thomson, Remote Identification of Soil Conditions with Ratioed Multispectral Data, Remote Sensing of Earth Resources, Vol. II, The University of Tennessee Space Institute, Tullahoma, 1973, pp. 721-38.

DISTRIBUTION LIST

NASA Scientific and Technical Information Facility
P.O. Box 33
College Park, Maryland 20740

(5 + Repro)

Office of University Affairs
NASA Headquarters
Washington, D.C. 20546

ATTN: Mr. J. A. Vitale, Code PY

(10)