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REMOTE SENSING IN MICHIGAN FOR LAND RESOURCE MANAGEMENT

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Infrared and Optics Division

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16. Abstract

An extensive program was conducted to establish practical uses of NASA earth resource survey technology in meeting resource management problems throughout Michigan. As a result of contacts with a large number of people in Michigan-based agencies and organizations, a broad interest in and understanding of the usefulness of remote sensing methods was developed and a wide variety of applications was undertaken to provide information needed for informed decision-making and effective action.

Specific tasks undertaken provided information leading to protection of wetlands through improved management or public acquisition, implementation of plans for statewide wetlands inventory and management programs, establishment of zoning restrictions by counties to protect new structures along the Great Lakes shoreline from damage by continued beach erosion, a wide variety of applications of remote sensing by regional agencies, highway planning modifications, selection of industrial or government sites, and definition of remote sensing applications for law enforcement and public health purposes.

Remote sensing methods have now been adopted by many interested agencies as a continuing operational method of problem solving and a large current data base of remote sensing coverage of Michigan is available for these and other potential users.

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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.

The program described in this report was conducted from the period 1 September 1971 through 31 December 1972 under NASA Contract NSR23-005-527 and was continued through 31 May 1977 under NASA Grant NGR23-005-552.

The goal of this program was to demonstrate the successful use of earth resource survey technology in the solution of problems in land and water resource management of current concern to public agencies and private organizations. 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 NASA Grant NGL 23-004-083. At MSU, direction was provided by Myles G. Boylan, Director of the School of Urban Planning and Landscape Architecture, and Raymond D. Vlasin, Chairman of the Department of Resource Development.

Staff members at the Environmental Research Institute of Michigan who participated in this program are listed below.

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STATE OF MICHIGAN

OFFICE OF THE GOVERNOR

LANSING

WILLIAM G. MILLIKEN
GOVERNOR

April 8, 1977

Dr. William M. Brown
President
Environmental Research Institute of Michigan
Post Office Box 618
Ann Arbor, Michigan 48107

Dear Dr. Brown:

Members of my staff have recently briefed me on the program conducted by the Environmental Research Institute of Michigan in using remote sensing information to address many of the substantial problems we face in Michigan. I have been gratified to see that new developments in technology resulting from federal research efforts can be put into practice at a level that helps state and local government. State government is constantly confronted with difficult environmental and economic problems for which factual and unbiased information is essential to making responsible decisions.

As you know, Michigan's government is highly responsive to the people's interest in maintaining the outstanding quality of its land and water resources. In recent years, important new legislation has been proposed and adopted which enables the State to protect its wetland and shoreline areas, encourages the preservation of farmland and open space, and controls the earth change processes resulting from construction, mining, and other human activities. We particularly appreciate the results of the NASA sponsored effort in several of these key areas of State concern. I want to acknowledge specifically the contributions to our plans to inventory our wetlands throughout the State, to purchase ecologically sensitive segments of the St. John's Marsh, to control new construction along the shorelines of the Great Lakes, and to establish better methods of classifying and identifying our land use throughout the State.

As a result of your extensive cooperation with our State government, the special kinds of information made available has had a direct bearing on many important public issues. Your approach to collecting

and evaluating basic information will continue to find expanding use in the future. Through your organization, I would also like to thank the National Aeronautics and Space Administration for supporting your work in practical problem solving.

Kind personal regards.

Sincerely,

William D. Milliken

Governor

1

INTRODUCTION

This report summarizes the achievements of a program running from 1971 through 1977 supported by the NASA Office of University Affairs. The objective of this program was to establish practical uses of NASA earth resource survey technology in meeting resource management problems throughout Michigan. The program was conducted in close cooperation with many agencies of Michigan-based local, state, and federal government, and with private industry and citizen groups. The program emphasized applications of remote sensing technology already developed under many other NASA-supported projects.

A large-scale effort in research and development of remote sensing technology, much of it funded by NASA, has resulted in the demonstration of technical feasibility of a great variety of applications of remote sensing to agriculture, forestry, wildlife management, water resources, urban and regional problems, geological exploration, and other disciplinary areas of environmental, economic, and social importance. As individual techniques reach a fully developed stage, their widespread introduction requires the demonstration of effective applications to existing problems requiring practical solutions. This program concentrated on identifying such problems and applying remote sensing under operational conditions.

Therefore, in selecting remote sensing applications for active participation by project personnel, the major criterion was that the information resulting from the data collection and analysis effort have a high probability of leading to decision making and direct action by the user agency to deal with a significant problem facing it. In order to achieve this objective, a large number of contacts were made with Michigan-based government agencies, private industries, and citizen groups. Discussions were held to identify problems needing solution, and the applicability of remote sensing methods to these problems was carefully considered. Candidate applications oriented toward decision

making or direct action were identified, and preference was given to these projects in directing effort under the grant. In most of the applications summarized in this report, decisions were made or actions taken, although in some cases extraneous factors delayed or prevented such anticipated results.

1.1 SUMMARY OF MAJOR ACCOMPLISHMENTS

Accomplishments of the program, as discussed in this report, fall into four major categories:

-Contacts with a large number of people in Michigan-based agencies and organizations have developed a broad interest in and understanding of the usefulness of remote sensing methods.

-A wide variety of applications were undertaken and information derived from remote sensing data entered into the decision-making process of public agencies or private organizations and resulted in appropriate courses of action.

-The remote sensing method used for many of these applications has been adopted by the interested agencies as a continuing operational method of problem solving.

-A large current data base of remote sensing coverage of Michigan has been made available for these and other potential users.

1.1.1 DISSEMINATION OF INFORMATION ON REMOTE SENSING TECHNOLOGY

The program resulted in widespread dissemination throughout Michigan of the potential of NASA earth resource survey technology for problem solving. During the six years of program activity, literally hundreds of individuals throughout government and industry were contacted and informed of remote sensing opportunities and techniques (see Section 2). Many of the individuals introduced to remote sensing technology now have access to a large remote sensing data base and either use remote sensing methods for routine problems, or readily adopt these methods when they can be applied to special problems.

1.1.2 DECISIONS AND ACTIONS INFLUENCED BY THE PROJECT

Tasks undertaken during the program have provided remote sensing information and analyses which significantly influenced courses of action taken by government, industry, and private citizens throughout Michigan. Among the specific decisions or actions affected by project results are the following:

-Selection and acquisition of land adjacent to the Pointe Mouillee State Game Area at the mouth of the Huron River to compensate for wetlands lost to high lake levels and storm action.

-Improvements in the management of vegetation at the State Game Area to increase its value as waterfowl habitat.

-Construction of a barrier dike offshore of the State Game Area for the dual purpose of protecting the game area from further deterioration and providing a site for spoils from dredging the Detroit River to maintain its navigability.

-Projected acquisition of 1260 hectares of St. Johns Marsh on the shore of Lake St. Clair to protect it from continuing development.

-Denial of a permit by the Michigan Department of Natural Resources (DNR) for development of 500 apartments on 62 acres of wetlands in the St. Clair Flats.

-Statewide inventory of wetlands mandated by legislative action as the basis for developing an overall program of wetlands protection and management.

-Decisions occasioned by Lake Erie shoreline flooding during the spring of 1973 relating to improved planning and zoning of shoreland use, relocation and redesign of sewer and water systems, and improved procedures for flood disaster response and relief.

-Establishment of zoning restrictions by counties to protect new structures along the Great Lakes shoreline from damage by continued beach erosion.

-Establishment of a statewide land use classification system for general use by state and local agencies.

-Use of remote sensing data by the Southeast Michigan Council of Governments for its land use planning functions.

-Modifications to the drainage plan along the Ann Arbor-Plymouth right-of-way of the new M-14 freeway to alleviate ground and surface water problems, and save $10,000 in earth-moving costs.

-Selection of sites for a school, branch banks, recreational facilities, and sand and gravel mining operations.

-Support for a variety of decisions by regional planners and industry in Southeastern Michigan and the Saginaw Bay area of the Lower Peninsula, and in the Upper Peninsula.

In addition to the decisions and actions listed above, a number of others arising out of the program activities are discussed in following sections of this report. Remote sensing information already provided by the program will continue to affect decision-making in the future.

1.1.3 ADOPTION OF REMOTE SENSING METHODS

Problem-oriented tasks undertaken as a part of the program resulted not only in direct action as described in Section 1.1.2, but in demonstrating the utility of remote sensing as an operational tool. In many cases, the agencies with which we worked have continued the use of specific applications of remote sensing.

The following list covers those applications which are now being routinely used as well as others considered for possible adoption:

-Wetland inventory and management

-Wildlife habitat evaluation

-Great Lakes shoreline protection

-Beach recession rate measurements

-Inland lake water quality monitoring

-Mosquito control

-Land use planning

-Site selection

-Highway planning and route selection

-Monitoring of earth change activites

-Shallow grave detection

1.1.4 REMOTE SENSING DATA BASE

The extensive remote sensing data base assembled during the program period for Michigan areas makes such continuing applications practical, effective, and convenient. The Michigan data base brought into existence by NASA during recent years includes the following major items:

-High-altitude color and color IR photography of more than 70 percent of the Lower Peninsula and selected coastal areas of the Upper Peninsula. In a number of areas, notably Southeastern Michigan, repeated coverage has been obtained, allowing the application of change detection techniques for noting trends in land use.

-Large-scale color aerial photography and multispectral scanner coverage of 3000 km of Michigan shoreline, collected by the ERIM C-47 aircraft in the spring of 1974. This coverage will continue to be useful for a variety of purposes for many years and will also provide a historical record for change analysis whenever updated coverage is obtained in the future.

-Repeated LANDSAT coverage for all of Michigan, available in black-and-white and color photography and as computer-based multispectral data.

-SKYLAB coverage of a considerable portion of Michigan, including high-resolution black-and-white, color, and color-IR photography, and multispectral tapes.

1.2 GENERAL EXPERIENCE IN APPLICATIONS OF REMOTE SENSING

In achieving the results summarized in Section 1.1, the ERIM staff gained valuable experience in discovering the basic requirements and the most effective methods for advancing the use of remote sensing

as a practical means of problem solving.

We found that NASA high-altitude aircraft photography has the broadest application to Michigan-based problems. This is a result of both its high resolution and the use of color and color-IR film, which enhances its interpretability. The substantial coverage of Michigan areas, much of it provided under this program, was also a major factor in its widespread use.

Several applications were also undertaken using LANDSAT data. Space imagery has its most effective applications in studies of large areas often for general planning rather than for short range investigations leading to explicit decisions.

Aircraft MSS data were found to be applicable to specialized studies of areas of moderate extent, perhaps a few square miles. The relatively limited availability prevented us from making wider use of such data in applications where it would have distinct advantages.

Most of the people with whom we made contact during this project were receptive to the use of remote sensing, but needed instruction in its characteristics and in practical methods of interpreting and applying such data. As a result of the detailed discussions we have had, many of these people now make a practice of turning to remote sensing data where its value is indicated. A substantial data base of Michigan coverage is readily available for their purposes.

Written material oriented toward specialized problem areas can be valuable for educating technical people and furthering the extended use of remote sensing. For example, we have prepared and issued under the program a report entitled "Remote Sensing of Wetlands" (Reference 12), which deals directly with data collection and analysis for many wetland management functions and provides the user with specific recommendations on how to adapt remote sensing technology to meet particular wetland management objectives.

The most effective performance under the program required that ERIM clearly define its proper role in undertaking individual applications. On the one hand, ERIM staff members must take the leadership in analyzing a new problem, devising a strategy for acquisition and use of remote sensing information, and carrying out the task plan. On the other hand, it was desirable to share the responsibility as much as possible with the agency staff, so that the staff members maintained the necessary interest and involvement in the task and were prepared to carry on the work at the completion of ERIM's activity.

To achieve this necessary agency interest and activity, it was helpful to develop an understanding of the program at management level and on the part of the technical staff, as well. The most successful results are obtained when an individual at the technical level becomes sufficiently convinced of the usefulness of remote sensing techniques that he voluntarily takes over the initiative for task accomplishment and for finding new applications.

The proper selection of projects is also important to program success. Remote sensing is normally one of several sources of information needed in problem solving and must be combined with information from other sources to provide a complete data base for decision making. Project selection should accurately assess the cost-effectiveness of remote sensing as compared to other information sources, so that its use is clearly appropriate for the specific case.

Over and above this is the need to assess whether decision-making and subsequent action can be accomplished, even if adequate information for decision making is available. Action on the basis of available information may be inhibited by a number of factors. In many cases, appropriate action must be taken by a legislative body or by executive action, and this action may be precluded for reasons unrelated to the technical analysis of the problem. For example, lack of funds to accomplish the desired result is often a decisive inhibitor of needed action.

In still other cases, remote sensing provides data which are not consistent with established methods of decision making and substantial modifications of agency procedures would be needed to make effective use of the data. It is therefore important not only to collect and analyze remote sensing information, but to integrate its use into the established procedures of operating agencies.

In the program conducted under the NASA grant, the highest priority was placed on selecting applications that would result in decision-making and subsequent action. Cost-effectiveness was also considered, but did not override the first requirement. In most cases, the information provided did lead to an identifiable action, although in some cases the expected result was prevented for one of the reasons mentioned above.

ERIM will continue to work actively with the organizations and individuals we have cooperated with in the past. Many of the applications growing out of the program involve continuing problems that will require collection and analysis of remote sensing data for future action.

In addition, many of the projects initiated in past years will, without further technical input from the program, continue to pay off in years to come in the form of decisions and actions influenced by remote sensing information.

In the following sections of this report, the major activities and accomplishments of the program are summarized. Further detailed discussions of these program results can be found in technical reports and annual reports published during the project, as listed in Section 12.

2

CONTACTS WITH THE USER COMMUNITY

The implementation of operational uses of remote sensing in the State of Michigan was accomplished through an extensive program of contacts, information exchanges, and problem analyses that involved a comprehensive cross-section of government agencies at various levels, many private industries, and individual groups of citizens. Table 1 is a listing of the organizations with whom significant contacts were made. Although the purpose, nature, and extent of these contacts covered a wide range, the total effect was the broad dissemination of information to a great many potential users of the technology.

Our information dissemination activities covered a variety of methods, depending on the specific purpose of the contacts. In the early phases of the project, a number of meetings were set up for the specific purpose of describing remote sensing activities and exploring agency problems that might be amenable to remote sensing solutions. Other methods of general information dissemination included symposia, workshops, technical papers, lectures, displays, and brochures. As interest was developed on the part of a potential user, emphasis shifted to individual discussions that analyzed specific problems and defined remote sensing approaches to the solution of these problems. Once the necessary rapport was built up betweeen the remote sensing staff and the agency staff, technical discussions were carried on covering task planning, execution, and evaluation.

TABLE 1

MICHIGAN ORGANIZATIONS CONTACTED BY THE PROJECT

Michigan-Based Federal Agencies

Department of Agriculture
- Soil Conservation Service
- Forest Service
- Agricultural and Stabilization and Conservation Service
- Economic Research Service

Army Corps of Engineers
- Detroit District
- Chicago Division

National Park Service

Department of Interior
- Lake Central Regional Office, Bureau of Outdoor Recreation
- Great Lakes Fish Eries Laboratory, Fish and Wildlife Service

Great Lakes Basin Commission

State Agencies

Department of Agriculture

Department of Commerce
- Office of Economic Expansion
- Public Service Commission

Department of Labor

Department of Management and Budget

Department of Military Affairs

Department of Natural Resources
- Environmental Review Board
- Bureau of Land & Water Management
  - Land Resource Programs Division
    - Office of Land Use
    - Water Development Service

TABLE 1 (cont'd)

Geology Division
Water Management Division
Bureau of Recreation
Parks Division
Bureau of Renewable Resource Management
Forestry Division
Fisheries Division
Wildlife Division
Rose Lake Wildlife Research Center
Pointe Mouillee State Game Area
Field Bureau
Region III, Southern Michigan
Natural Areas Advisory Council
Department of Public Health
Department of Social Services
Department of State Highways and Transportation
Bureau of Transportation Planning
Department of State Police

State Legislature

House of Representatives Committee on Conservation, Environment, and Recreation

Regional Agencies and Planning Commissions

Huron-Clinton Metropolitan Authority
Central Upper Peninsula Planning and Development Region
Eastern Upper Peninsula Regional Planning and Development Commission
East Central Michigan Planning and Development Region
Northwest Michigan Regional Planning Commission
Southeast Michigan Council of Governments
Toledo Metropolitan Area Council of Governments
Tri-County Planning and Development Region (Eaton, Ingham, and Clinton Counties)

TABLE 1 (cont'd)

Western Upper Peninsula Planning and Development Region
West Michigan Shoreline Regional Development Commission

County Planning Commissions

Livingston County Planning Commission
Macomb County Planning Commission
Monroe County Planning Commission
Oakland County Planning Commission
Washtenaw County Metropolitan Planning Commission
Washtenaw County Parks and Recreation Commission
Wayne County Planning Commission
Wexford County Planning Commission

County Agencies

Monroe County Drain Commission
Monroe County Civil Defense
Tri-County Mosquito Control Commission
Washtenaw County Department of Public Health

Municipal Agencies

Detroit Port Authority
Monroe Port Authority
City of Ypsilanti, Michigan
Ann Arbor Police Department
Ann Arbor Planning Commission
Saline Area Regional Planners

Business and Industry

AMOCO Production Company
Commonwealth Associates Inc.
Consumers Power Co.
Detroit Metropolitan Airport
General Motors Proving Grounds
Homestake Mining Company

TABLE 1 (cont'd)

Manufacturers National Bank of Detroit
Martin-Marietta Corporation
Trenton State Bank
White Pine Mining Company
Universal Oil Products

Technical Societies and Trade Associations

Michigan Society of Planning Officials
West Michigan Sand and Gravel Association

Citizens Groups

Ann Arbor Ecology Center
Colony Park Home Owners Association
Huron River Watershed Council
Lake St. Clair Advisory Committee
Michigan Duck Hunters Association
Michigan Environmental Network
Natural Areas Council
St. Clair Flats Land-Use Policy Committee
Sierra Club
Washtenaw Land Conservancy, Inc.
West Michigan Environmental Action Council
University of Michigan Environmental Law Society

Educational Institutions

Michigan State University
- College of Agriculture and Natural Resources
  - Crop and Soil Sciences Department
  - Forestry Department
  - Resource Development Department
- Agricultural Experiment Stations

College of Social Sciences
School of Urban Planning and Landscape Architecture
Geography Department
University of Michigan
School of Architecture and Urban Planning
School of Natural Resources
Institute of Science and Technology
Wayne State University
Eastern Michigan University
Michigan Technological University
Forestry Department
Geology Department
Mercy College, Detroit
Oakland County Community College
Jackson Community College
Michigan Space Center
Ann Arbor Public Schools
Huron Valley Lutheran High School
Ypsilanti High School

3
WETLANDS PROTECTION AND MANAGEMENT

Under the auspices of the NASA grant, ERIM conducted a broad program aimed at increasing the use of remote sensing by state and local governments in Michigan for wetlands preservation and management. Wetlands are an important resource in Michigan, occupying over 6 percent of the state's total land area and supporting a diverse variety of ecologically important plant and animal communities. In addition, wetlands furnish products of significant economic value. Undesirable changes resulting from both human activities and the natural processes associated with succession, are, however, leading to the rapid destruction of Michigan's wetlands. Even though accurate estimates of the total loss are not available, the extent of these losses is substantial.

In an effort to provide decision-makers with the information they need to reduce these losses, ERIM's efforts have been directed toward both short-range and long-range goals. Short-range goals centered around the preservation and management of wetlands (1) at the Pointe Mouillee State Game Area on the Lake Erie Shoreline, and (2) on the St. Clair Flats, including St. John's Marsh. Long-range goals have been pursued by assisting state agency personnel in learning to use remote sensing data and in developing an inventory methodology needed for meeting the wetland preservation and management objectives mandated in the Michigan Wetlands Bill (House Bill 4329). This proposed legislation provides for a state wetlands inventory to be followed by development of a statewide plan for wetlands protection and management.

3.1 WATERFOWL HABITAT MANAGEMENT AT POINT MOUILLEE

The Point Mouillee State Game Area is located at the mouth of the Huron River on the Lake Erie shoreline just south of Detroit. For generations this low-lying area, situated on two important migration corridors for ducks and geese, has been prime waterfowl habitat. In

recent years, however, the quality of the habitat has been impaired through gradual deterioration of marshland in the river estuary and because of severe flooding as a result of storms occurring during the fall of 1972 and spring of 1973. To add to these problems, dredge-spoil sites were proposed for the immediate area. Thus, the viability of the Point Mouillee State Game Area was seriously threatened by both natural influences and man's activities. Unless action was taken, the habitat would cease to function as a high quality recreation area for hunters and would continue to decline in value as a waterfowl refuge.

To help solve the problems affecting Pointe Mouillee, the Environmental Research Institute of Michigan (ERIM) and Michigan State University (MSU) jointly undertook an investigation which emphasized the use of wetlands inventory data acquired by remote sensing methods. A major objective of the investigation was to determine the magnitude of marshland losses and look into the possibilities of replacing this lost habitat [3].

The extent of storm damage during the winter and spring of 1972-73 was determined from interpretation of aerial photography acquired by flights of the ERIM C-47 aircraft made in March and April 1973. It was noted in the photography that many of the islands surrounding Pointe Mouillee which previously had been used as duck cover or duck blinds had been destroyed by the recent storms and high water, increasing the urgency of replacing the lost habitat. Interpretation of this aerial photography allowed us to map and measure the areas destroyed by flooding, as well as adjacent areas subject to future flooding. Permanent changes in land/water boundaries could not be determined from the aerial photography of near-high-water conditions, but at least a preliminary estimate of these changes was possible. We supplied such an estimate to James Foote, Game Biologist at Pointe Mouillee, to aid him in the management and decision-making needed for maintaining the continued viability of the area.

Our continuing effort on this project also led to the evaluation of adjacent land for conversion to marsh habitat. This evaluation was based on vegetation, soils, topography, and land use data provided by remote sensing and other data sources, and included the extent of flooding shortly after the peak of the April storm. Under further analysis, this information suggested appropriate dike construction and vegetation management measures necessary to effect the conversion to marshland.

Another objective of the investigation was to provide detailed information needed for improved management of waterfowl food and cover vegetation in the State Game Area. For the actively managed diked area of 148 hectares within the State Game Area, both a detailed vegetation inventory prepared by photointerpretation and a generalized vegetation inventory obtained by processing multispectral scanner imagery were prepared. These products provided information needed for modifying management practices in the area, served as a data base for checking future changes, and afforded a means of recording and communicating information to other game management personnel, supervisory personnel, and the general public. The data were applied to the problem of *improving the types and conditions of vegetation necessary for wildlife food and cover.* The study of the vegetation inventory led to recommendations for modification of seasonal flooding practices to prevent the accumulation of dead vegetation, and changes in earth grading to allow emergent vegetation to replace upland vegetation of little value to waterfowl.

These two analyses indicated that large additions to waterfowl habitat could be provided by (1) changes in vegetation management in existing sections of the Pointe Mouillee State Game Area, (2) Department of Natural Resources (DNR) acquisition and conversion of adjacent land, and (3) the proposed construction of a barrier dike offshore of Pointe Mouillee. Altogether, the total area that could be affected by these measures amounts to nearly 13 sq. km. On the basis of these analyses, ERIM

recommended how further study could be used to determine which measures, applied singly or in combination, would prove most economical and effective in replacing lost habitat (see Figure 1).

To meet the problems existing at Pointe Mouillee, the Corps of Engineers and DNR, acting jointly, 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 preparation of the Environmental Impact Statement. DNR has proceeded to purchase the lands bordering the game area to the west, as recommended by the ERIM study, 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 was assigned a high priority and funds for its accomplishment allocated.

This investigation was conducted in close cooperation with Mr. James Foote, Game Biologist for the Department of Natural Resources stationed at the Pointe Mouillee State Game Area. Mr. Foote was extremely helpful in providing information concerning the operating practices and information requirements needed for successful management of the area, assisting with the collection of ground truth, and evaluating the data obtained through remote sensing.

3.2 WETLANDS PROTECTION AT ST. CLAIR RIVER DELTA

Remote sensing was used to obtain quantitative data describing wetland condition as a function of changing land use and environmental conditions at the mouth of the St. Clair River, one of the most environmentally sensitive areas in the state. The data generated were used to support the following management applications: (1) wetlands acquisition; (2) contested wetlands development; (3) decision on extension of leasing rights; and (4) fisheries biology research.

The St. Clair Flats are among the best known of Michigan's wetlands.

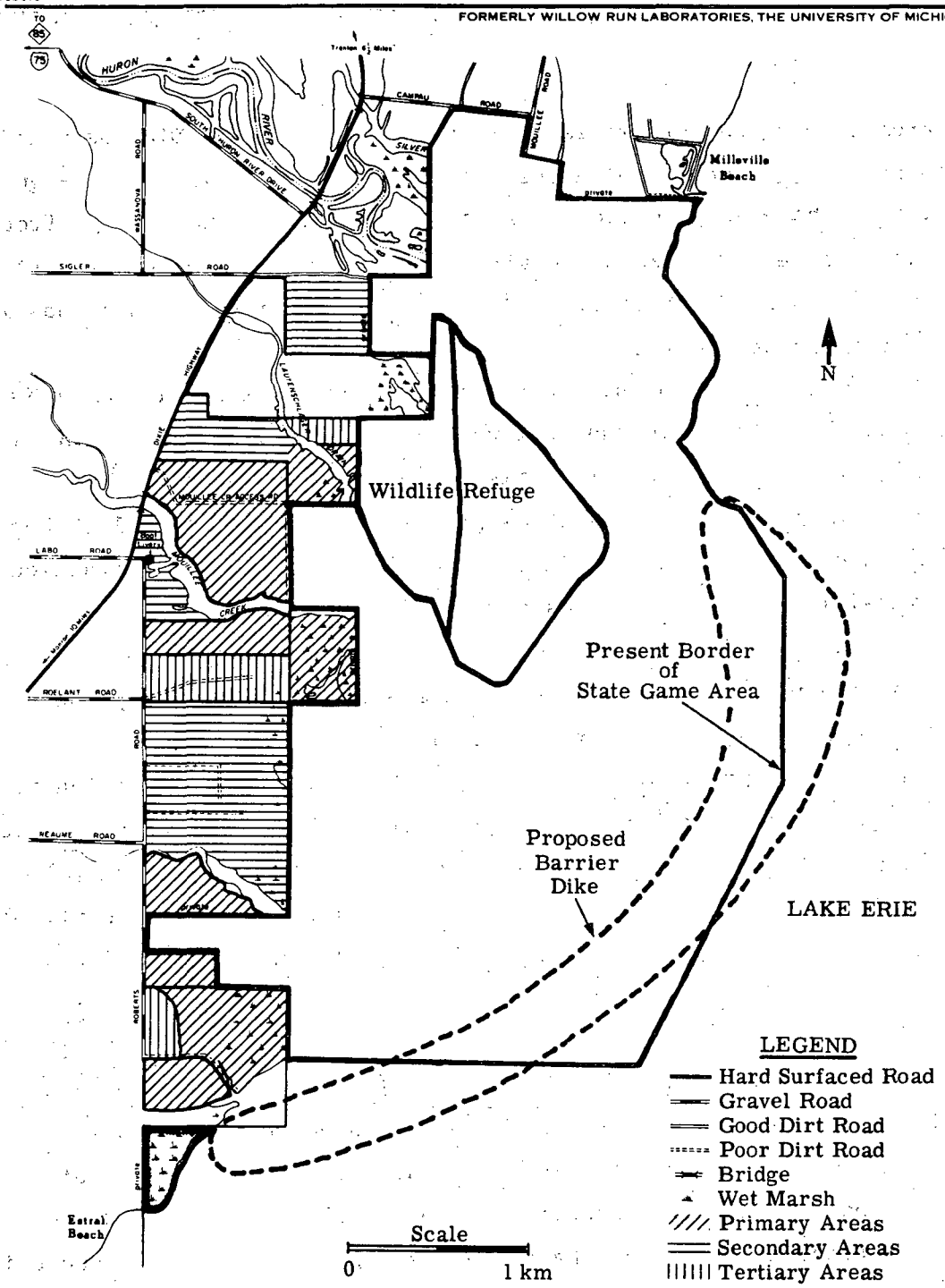


FIGURE 1. PROTECTIVE MEASURES FOR THE POINTE MOULLEE STATE GAME AREA. Protection and improvement of an important waterfowl habitat area in Southeastern Michigan is being accomplished through construction of a barrier dike offshore from the game area, purchase of lands bordering the game area to the west, and modification of management practices in the diked wildlife refuge. Remote sensing data provided needed information for undertaking these activities.

The area is composed of two large islands (Harsen's and Dickinson Islands) and many smaller ones forming the delta of the St. Clair River (Figure 2). These areas have been subject to flooding and wave action damage from high water levels in Lake St. Clair in recent years. There has also been a pattern of dredge, fill, and construction activity which has led to the rapid urbanization of valuable natural areas.

Although the northeast shore of Anchor Bay in Lake St. Clair is St. John's Marsh, an important spring and fall feeding and resting area on a major continental waterfowl migration route and a major fish nursery. The State of Michigan has proposed the purchase of 1260 hectares of this land as a means of saving a valuable wetland from destruction and maintaining its viability as a wildlife refuge area. The DNR plans to request a special appropriation from the state legislature to provide a part of the purchase cost of St. John's Marsh and to make up the remaining shore with federal matching funds.

An essential part of the program is the preparation of an environmental impact assessment (EIA) to comply with the NEPA requirements for obtaining the federal funds. This assessment is intended to show that without the protection afforded through acquisition and management, the last large block of remaining wetlands along Michigan's shoreline will be lost through development and pollution.

For use in the EIA, *ERIM furnished the Wildlife Division of DNR with remote sensing data and maps demonstrating the ongoing degradation of the area.* Space and high-altitude photographs were used to show the area in its regional context. In addition, ERIM prepared a set of three maps to show land use and vegetation cover in 1938 and 1974 and the "zone of transient wetlands" that occurs along the Great Lakes shoreline due to cyclical changes in water level (Figure 3). From these maps, ERIM prepared statistics summarizing changes in land cover and use between 1938 and 1974. Losses and gains in wetlands were evaluated and the forces most responsible for wetlands destruction identified [9].

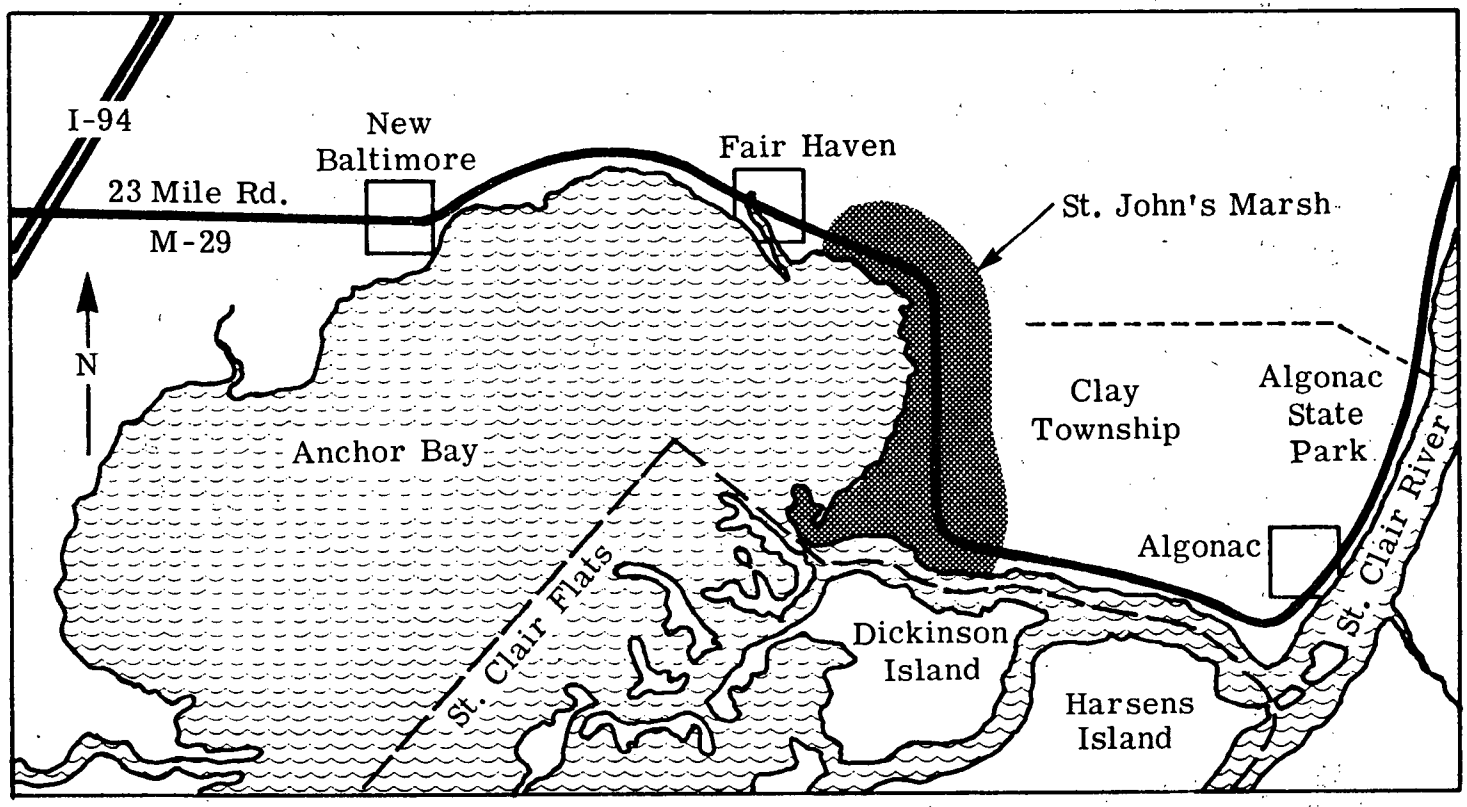


FIGURE 2. WETLAND AREAS ON LAKE ST. CLAIR

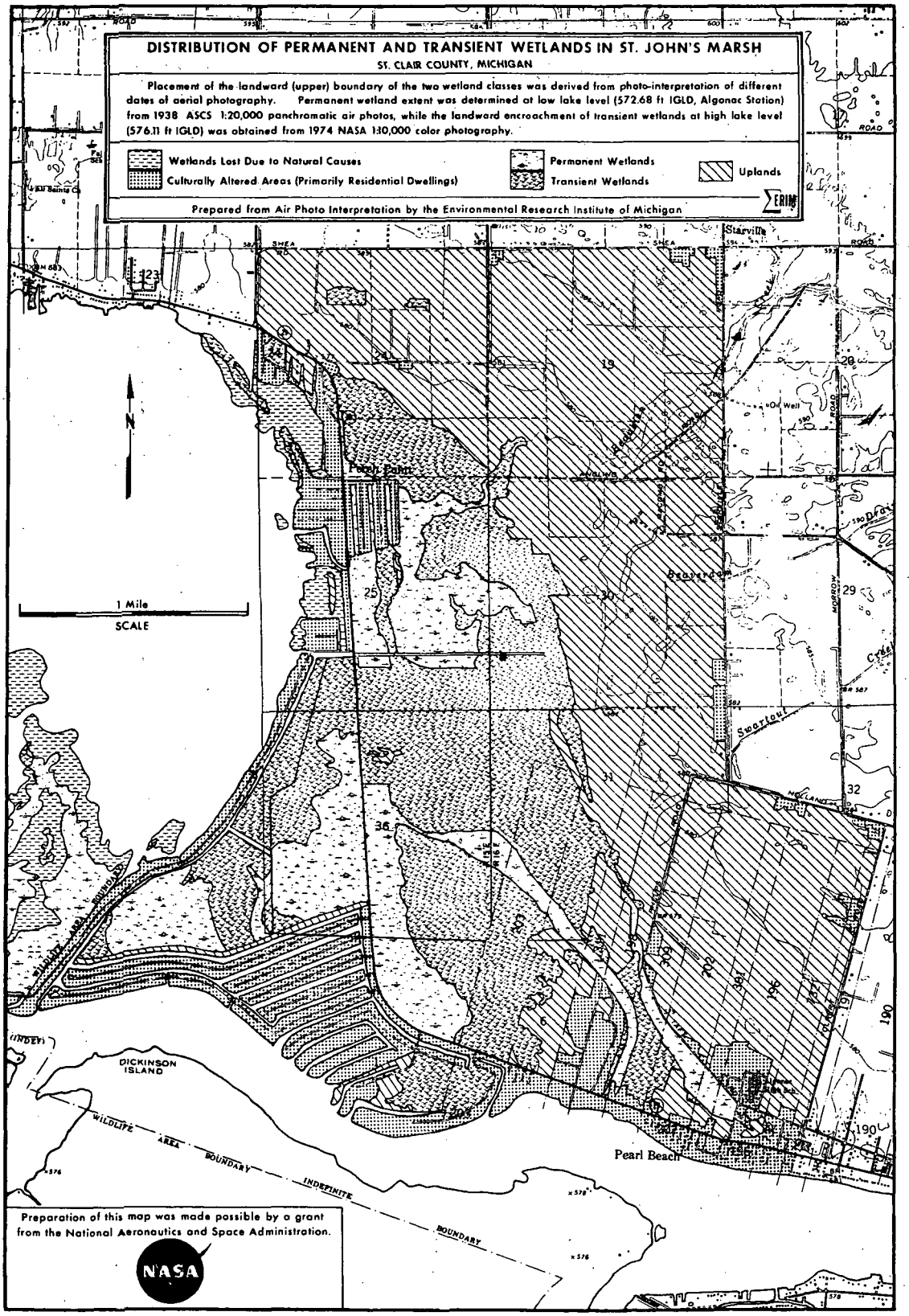

DISTRIBUTION OF PERMANENT AND TRANSIENT WETLANDS IN ST. JOHN'S MARSH
ST. CLAIR COUNTY, MICHIGAN
Placement of the landward (upper) boundary of the two wetland classes was derived from photo-interpretation of different dates of aerial photography. Permanent wetland extent was determined at low lake level (572.68 ft IGLD, Algonac Station) from 1938 ASCS 1:20,000 panchromatic air photos, while the landward encroachment of transient wetlands at high lake level (576.11 ft IGLD) was obtained from 1974 NASA 1:30,000 color photography.
Wetlands Lost Due to Natural Causes
Culturally Altered Areas (Primarily Residential Dwellings)
Permanent Wetlands
Transient Wetlands
Uplands
Prepared from Air Photo Interpretation by the Environmental Research Institute of Michigan
ERIM
N
1 Mile
SCALE
Pearl Point
Starville
DICKINSON ISLAND
WILDLIFE AREA BOUNDARY INDEFINITE BOUNDARY
Pearl Beach
Preparation of this map was made possible by a grant from the National Aeronautics and Space Administration.
NASA

FIGURE 3.

Internal DNR review of the entire proposal of which the EIA is a part will be conducted in the spring of 1977. This review will be followed by hearings before the Michigan Environmental Review Board and public hearings, and any necessary revisions will be made. *Once these steps are completed, the legislation will act on approving the expenditure of state funds. If approval is forthcoming, then Federal matching dollars will be obtained through the Land and Water Conservation Fund.*

We expect that the remote sensing data and imagery used in the St. John's Marsh EIA *will be used by the Lake St. Clair Advisory Comittee and other citizen conservation groups to promote the preservation of the marsh and rally public support for the move.*

Two significant pieces of legislation that passed in 1976 will make it possible to get moving on acquiring parts of the marsh regardless of the outcome of the legislative appropriation, however. The first is the Duck Stamp Act, which it is estimated will produce $200,000 annually for the purchase of wetlands. The second is the Heritage Fund Act which stipulates that the royalties on mineral and oil leases will be applied toward state purchase of high value natural and recreational areas. Between these two acts, it is estimated that $500,000 will be available in 1977 as state generated funds for purchase of land in St. John's Marsh. At the same time, it should be possible to obtain an additional $500,000 through a matching arrangement with the Bureau of Outdoor Recreation from their Land and Water Funds. This means nearly $1,000,000 will be available in 1977.

Two parcels of land have been singled out for acquisition this first year. The first priority is the St. John's Family property consisting of 337 hectares inside M-29. Second priority is the Blue Water Isles property on the west side of M-29, adjacent to Lake St. Clair (see Figure 4). It is anticipated that purchase of the St. John's parcel will require most of the $1,000,000 available in 1977.

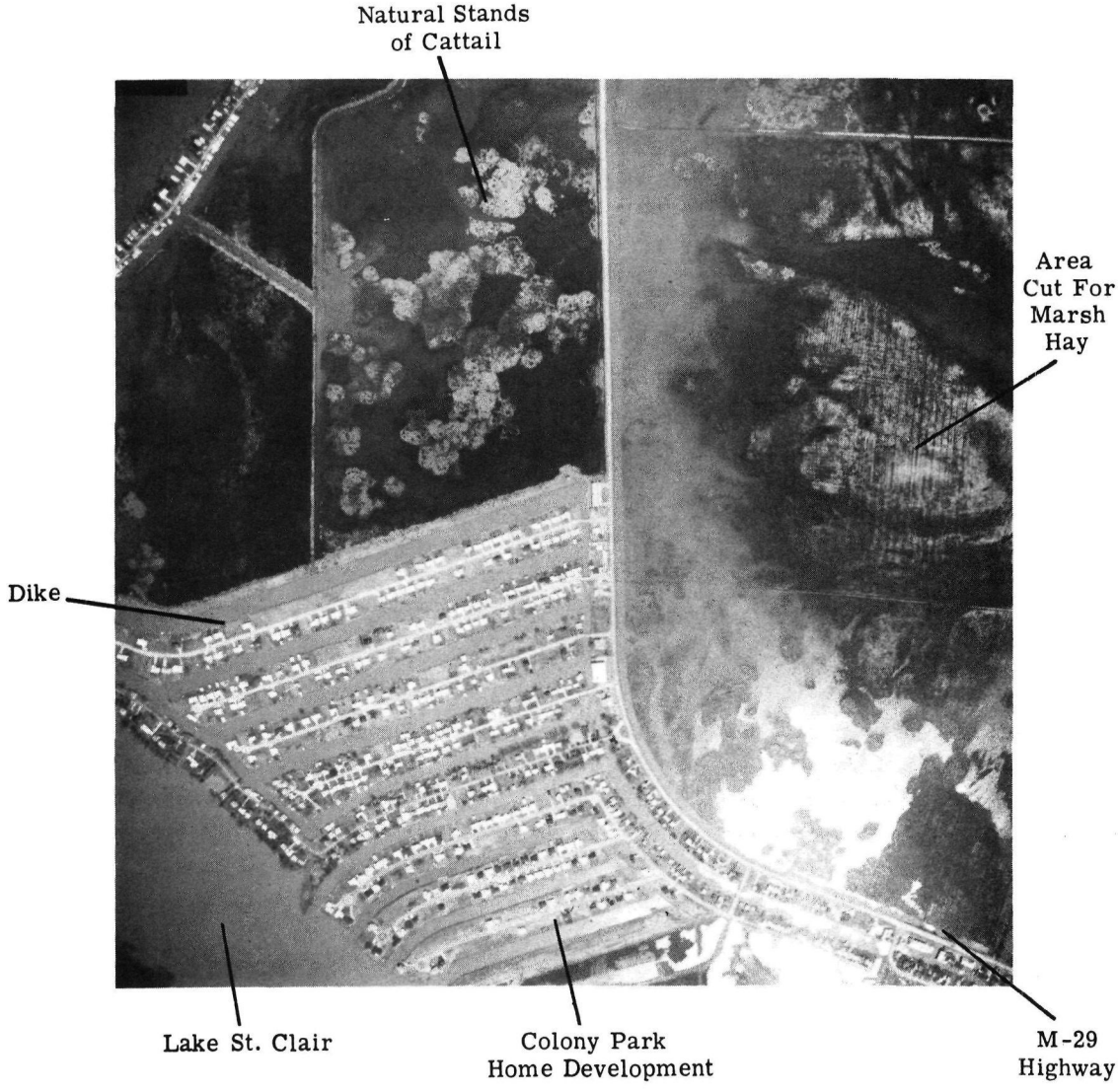


FIGURE 4. PORTION OF ST. JOHN'S MARSH, APRIL 1974. Expansion of residential areas poses a serious threat to the environmental value of St. John's Marsh as a waterfowl and fish habitat. The Michigan Department of Natural Resources is planning to acquire 1260 hectares of this valuable land and maintain it as a wildlife refuge. First priority for land acquisition is the area just north of the Colony Park Home Development, both east and west of the M-29 highway.

In addition to its use in the public acquisition process, remote sensing has been applied for other purposes. Part of the St. John's Marsh is the site for a proposed luxury condominium with more than 400 boatwells. The Blue Water Isles Realty Company wants to put in multi-unit structures complete with boatwells, canals, and parking for 1000 cars on 25 hectares just north of Old Colony Subdivision. Although the Clay Township Planning Board has given preliminary approval, area residents have strongly opposed the development at public hearings. Before the project could proceed, DNR permits were needed to dredge, fill, and install sewers. *Based on the analysis of the EIA prepared for the area, DNR has denied the permits.* This judgment will be appealed in the courts. *DNR intends to use the evidence generated by ERIM's analysis of NASA-furnished remote sensing data to justify its action on the permit request.*

The St. Clair Flats Land-Use Policy Committee is made up of members of many agencies within DNR. The Committee is presently concerned with decisions on the continuation of leasing rights to cottage owners. Using Michigan shoreline photography for 1938 and 1974 and recent U-2 photography collected under the NASA program, ERIM prepared an inventory for 93 sq. km of the Lake St. Clair shoreline and delta islands. The cover type mapping system used was the Michigan Land Cover/Use Classification System developed by the Land Use Programs Division. Based on the inventory data, change detection statistics were derived by ERIM. *Each committee member reviewed the material supplied by ERIM to help formulate his personal recommendation on the issue of continued leasing rights.*

Lake St. Clair is currently the site of an ongoing Fish and Wildlife Service (FWS) study being conducted by the Great Lakes Fish Laboratory to determine the role of fresh water marshes as spawning grounds and nurseries for larval fish. FWS has conducted a two year study in certain locations in Lake St. Clair to study the relationships between

different types of shallow water shoreline habitat and larval fish survival. *To select sampling stations, FWS has studied NASA photography of St. John's Marsh. In the process, the ability to identify several other factors possibly related to fish survival was discovered,* such as the spatial relationships among various types of vegetation, and the effects of varying water levels on vegetation. A larger area inventory using remote sensing will be carried out by FWS beginning in 1977. LANDSAT data will be used to study lake current and turbidity patterns, and higher resolution photography will be used for vegetation mapping to identify areas critical to fish survival. The resulting survey could lead to a more intelligent setting of catch limits and an improved program of habitat and commercial fishing management.

3.3 NEW MEASURES FOR STATEWIDE WETLANDS PROTECTION

In response to increasing public recognition of the recreational and ecological value of the State's extensive wetland areas, HB 4329 will establish a formal state program to identify, protect, and where possible, acquire these critical environmental areas. As much as 400,000 hectares of wetlands may be involved. House Bill 4329 requires the Michigan Department of Natural Resources to conduct a special inventory of the State's wetlands resources and prepare a plan for their subsequent use, management, and protection. At the same time, it prohibits dredging and construction in wetlands, and requires a permit for any other uses or developments. The passage of this bill requires a whole new program area of environmental inventory and monitoring, and land-use planning and regulation within the State.

As one of the activities of the NASA grant, ERIM actively worked to promote the objectives of the bill, principally by demonstrating that remote sensing can provide the needed information for management. We have worked with governmental resource management agencies, legislative groups, and citizens concerned about environmental quality. At

the state level, our work has been done in cooperation with DNR, specifically, the Wildlife Division, and Land Resource Programs Division. Our effort included the recommendation of features of the wetlands bill that will facilitate the use of effective remote sensing methods of data collection and analysis. We have also provided to citizen conservation organizations remote sensing imagery illustrating examples of wetland destruction.

As a result of new legislation, it is very likely that by 1979 both state and federal wetlands inventories will be carried out for the State of Michigan. Michigan will get the mandate to do its own wetlands inventory from the passage of the pending wetlands bill. At the federal level, Michigan is currently scheduled to be one of the first states completed as part of the National Wetlands Inventory sponsored by the Fish and Wildlife Service. In support of both these programs, a central objective of ERIM's effort has been to aid various groups in the Michigan DNR in selecting the most effective remote sensing techniques for use in a statewide wetlands inventory and providing guidelines for the use of remote sensing in the everyday management of wetlands.

ERIM provided material assistance to the Michigan Land Use Classification and Referencing Committee in *selecting an optimum system of wetland classification* that would ensure the compatibility of remote sensing input with the operational use of the classification system [10]. Our assistance to the Wildlife Division of DNR eventually resulted in adoption by the Land Resource Programs Division of Golet-Larson System as a basis for wetland classification. The advantage of this system is that it categorizes wetlands mainly on the basis of the dominant lifeforms of vegetation, a characteristic easily and reliably identified by remote sensing methods and well adapted to provide appropriately detailed information for analysis and decision-making purposes.

Another accomplishment is based on the development of new methods for evaluating wetland management strategies and measuring the current status of resource condition on a local basis. We have *demonstrated to DNR methods of land use analysis* using comparisons of historical and current photography *to quantitatively assess changes in wetlands. This method has already been applied by DNR* in helping to settle a dispute concerning the construction of the new 320-hectare Secondary Governmental Complex southwest of Lansing.

To provide needed management data on the current condition of wetland resources, we have taken advantage of other work done at ERIM to show that processing and analysis of LANDSAT data provides an effective and economical method for large-area mapping and analysis of waterfowl habitat. This approach to large-area inventories *has been discussed with the Wildlife Division as a better means of analyzing wildlife habitat* and as a means of producing the statewide inventory that will be required by the wetlands bill.

Information on remote sensing methods of wetlands inventory and evaluation *has been made available to potential users through participation in workshops and by presentations at user conferences. Also, a technical report "Remote Sensing of Wetlands"* [12] *has been prepared* to explain how to apply remote sensing techniques to wetlands inventory and analysis both effectively and economically.

Once the state wetlands bill (HB 4329) has passed, DNR will be required to conduct a statewide survey of Michigan's wetland resources. ERIM worked closely with DNR to *evaluate a strategy based on remote sensing for producing a useful inventory within a reasonable cost and time*. A source of data for the state wetlands inventory required by the bill is currently under development. The Land Resource Programs Division is coordinating the aerial photography requirements of several groups in an attempt to provide a single set of data that satisfies many users' needs at substantially reduced costs to any individual

organization. Among the organizations actively contributing funds are the U.S. Forest Service, a group of private forest industries in the Upper Peninsula, and the DNR Forestry Division. Other state agencies such as the Highway Department and DNR Wildlife Division are also expected to support the program. At the Federal level, the National Wetlands Inventory is also interested. Presently, the major uses of the photography are envisioned in the areas of forestry, land use and wetlands mapping. Both the Forest Service and Forest Division will use measurements of trees and forest land area to update their inventories and management plans. The Land Resource Program Division intends to develop a computerized state land use data bank using the photography.

A major part of ERIM's participation in this work has been to help plan the collection of 1:24,000 color infrared photography of the entire State. *ERIM helped to develop an inventory plan* for which financial support could be provided jointly by these agencies and which would benefit all of the groups. *ERIM provided technical advice on such considerations as film scale and film type, and data acquisition and interpretation costs.* The resulting multi-purpose remote sensing program will be initiated with data acquisition flights in the Upper Peninsula during the summer of 1977. ERIM staff members will remain in contact with the developing program and provide consultation and advice on remote sensing procedures as needed.

4
GREAT LAKES SHORELANDS PROTECTION

Michigan's Great Lakes shorelands constitute one of the State's most important natural resources, providing a great variety of economic, recreational, ecological, and aesthetic benefits. To perpetuate these benefits, the State must effectively manage its shorelands to protect property from erosion and flooding caused by high lake levels and storms, the shorelands from encroachment of residential and industrial development, and the nearshore waters from pollution. The Michigan Department of Natural Resources (DNR) has been designated as the lead agency to provide this management. However, local government is also heavily involved in monitoring shorelands processes and protecting the shorelands through zoning ordinances and other government regulations and procedures. During the project, ERIM worked with state and local governments, and with private citizen groups to apply remote sensing to a variety of problems affecting shorelands management and protection. This program had two objectives: 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 adopt remote sensing imagery as the basis for major management decisions governing the state's entire 3700 km of shoreline.

4.1 LAKE ERIE SHORELINE FLOODING

One of the first efforts involving shorelands management under the NASA grant was to assess the effects of storms occurring during March and April, 1973. A combination of high lake water-levels and strong east winds resulted in extensive flooding along the western shorelines of Lake Erie, Lake St. Clair, and Lake Huron. Extensive flood damage occurred, and disaster relief was made available to residents of the area.

ERIM's C-47 aircraft was flown over the flooded areas along the Lake Erie shoreline within 36 hours after the peak of the flooding to collect photography and scanner imagery for a variety of purposes. Photomosaics were made for studying the extent of flooding, and scanner processed data were used to identify the land-water boundaries under high water conditions. Several meetings were arranged to present the results to a number of federal, state, and local agencies. Our purpose was both to assist the agencies in meeting their immediate responsibilities and to introduce them to the types of information which could be provided in the event of future flooding occurrences.

At the local level the information provided was directly used for the following purposes: improved planning and zoning of shoreland use; relocation and redesign of waste disposal sites, water pumping stations, and county drain systems; and adoption of improved procedures for flood disaster response and relief. At the state and federal levels the data are most useful for longer-term activities concerned with land use planning and zoning.

4.2 SHORELAND DATA COLLECTION

This task was initiated 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.

After approval early in 1974 of C-47 flight missions, the ERIM staff was active in planning 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. Color aerial photography and multispectral scanner data of excellent quality were obtained for 3000 km of shoreline, and the major part of the data met the requirements for planned applications (Figure 5).

A comprehensive plan for the utilization of the data was developed, with ERIM acting to coordinate the needs and proposed tasks to be undertaken by DNR, MSU, and ERIM.

4.3 CRITICAL SHORELANDS REGULATIONS

Operating under the Michigan Shorelands Protection and Management Act of 1970, DNR is legally required to delineate, evaluate, and institute management plans for all high-risk erosion areas along 1100 km of shoreline, and environmental areas along 800 km (Figures 6,7, and 8).

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. To prevent damage to buildings for a 30-year period after construction, building location must be limited to an area beyond a designated setback distance from the bluff line. This setback distance can be established by knowing the average recession rate of the beach.

Beginning in 1971, ERIM worked with the Water Development Services Division of DNR to demonstrate the usefulness of remote sensing methods for measuring beach recession rates. Practical procedures for making recession rate measurements with sufficient accuracy for setting zoning regulations were worked out by ERIM using historical and current photography.

When the 1974 shoreline flights were completed, ERIM supplied black-and-white prints of the photography to the Water Development Services Division, and assisted them in making urgently needed beach erosion measurements. This included both development and demonstration of quick and efficient techniques for making the measurements. These

measurements were immediately made available to local zoning officials and developers. This initial response to urgent data needs has now been followed by a continuing program in which zoning and building decisions are made routinely.

The technique developed by ERIM is used by DNR to calculate erosion rates for the entire Michigan shoreline. Such information is used to establish zoning restrictions in the coastal area, either by zoning ordinances formulated by township or county planning officials, or by DNR if these officials do not act.

Zoning restrictions are now in force for the entire shoreline, built around the erosion rate guidelines developed by the ERIM technique. For about 30 percent of the shoreline, zoning restrictions were formulated by local officials. Of the 30 percent, one-third were plans submitted by local officials and approved by DNR. The remaining two-thirds are plans submitted by local officials and currently undergoing DNR approval. For the remaining 70 percent of the shoreline, DNR is controlling development in high erosion rate areas through a construction permit system. Thus, the NASA grant program was instrumental in developing an erosion rate measurement technique which gave state and local officials the information to formulate realistic planning restrictions in high erosion rate areas of Michigan's coastal zone [20].

4.4 OTHER USES OF SHORELINE PHOTOGRAPHY

The shoreline photography collected by ERIM in April and May 1974 is finding many other uses in addition to its major use in enforcing critical shorelands regulation.

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

FIGURE 5. MICHIGAN SHORELINE COVERED BY FLIGHT MISSION X252M, APRIL-MAY 1974

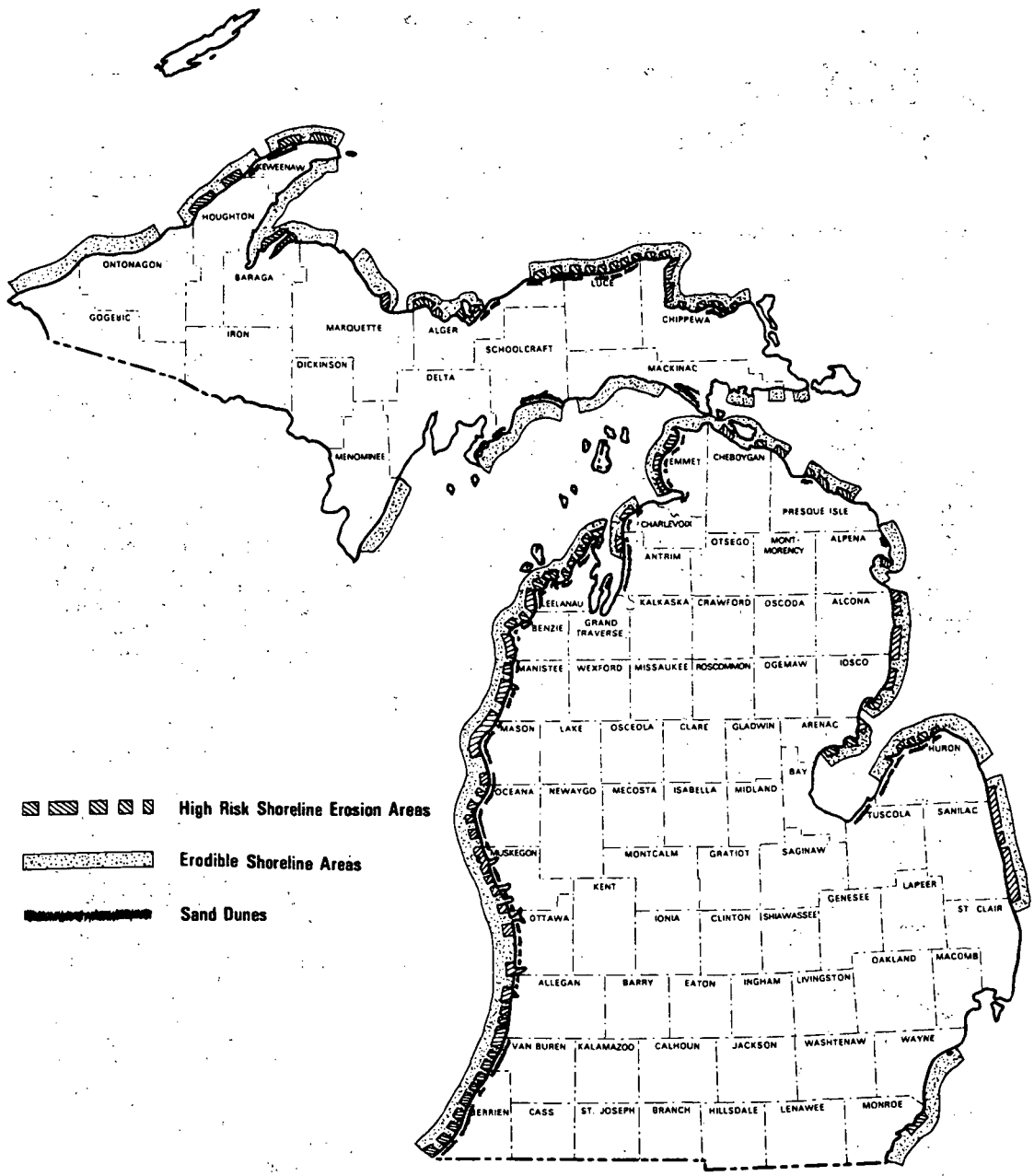


FIGURE 6. SIGNIFICANT AREAS ALONG GREAT LAKES SHORELANDS.

THE NEW YORK TIMES, SUNDAY, SEPTEMBER 30, 1973

MICHIGAN URGED TO PROTECT SHORE

A Report Terms 1,000 Miles Ecologically 'Significant'

Special to The New York Times

LANSING, Mich., Sept. 29—Nearly 1,000 miles of Michigan's Great Lakes shorelands are "environmentally significant" and should be protected from development, the first comprehensive study of the state's shorelands recommends.

The Michigan Legislature, alarmed at rapidly spreading and largely uncontrolled shorelands development, especially second-home construction, ordered the study with passage of the Shorelands Protection and Management Act of 1970. The report, titled "A Plan For Michigan's Shorelands," was prepared by the State Department of Natural Resources.

The study recommends public acquisition of 400 miles of the 1,965 miles of "environmentally significant" shorelands to guarantee that these vital fish and wildlife habitats will be preserved.

However, the report makes no recommendation on how funds for such a major land acquisition program would be raised.

50% Are Publicly Owned

About half of the "envioronmentally significant" shorelands are already in public ownership, mostly as state and Federal beaches and parks.

More than 500 miles of "high-risk" erosion areas, where the shorelands act requires that new development be restricted to lessen future property losses, are also identified. Since last Nov. 3, storms and high water have caused more than $40-million property damage along the state's 3,282 miles of mainland and island Great Lakes shorelands.

Shorelands are defined in the report as a strip 1,000 yards inland from ordinary high water and out over the water to where it is 120 feet deep.

Although the report says "it can be forcefully argued" that a total ban on shorelands development would "yield the greatest long-term benefits," it does not recommend this. It does urge banning such non-water-oriented uses as parking lots and coal yards on shorelands.

The development of a detailed plan for managing shorelands is left to local governments, many of which have no zoning ordinances. The shorelands act, however, provides for state regulation starting next April where local governments fail to adopt controls on certain shorelands development.

The study marks the state's first major involvement in shorelands protection and management outside of its role in developing public beaches, parks and harbors. The reliance on local government for implementation reflects the strong sentiments of many Michigan residents about local control of land use decisions.

"If we had as many people crowding our beaches as they do in California (where voters last year adopted a combined state and regional commission system to develop a coastal development plan) there would probably be much more public support for state action," observed Jim Dooley, a state water resources planner and key author of the report.

The state's $1.65-billion-a-year tourist industry is one reason strong shorelands protection may gain support here. Tourism ranks second only to manufacturing in the state's economy. Of the more than 18 million visitors to the state last year, most spent at least part of a day at the Great Lakes shoreland area, according to the Michigan Tourist Council.

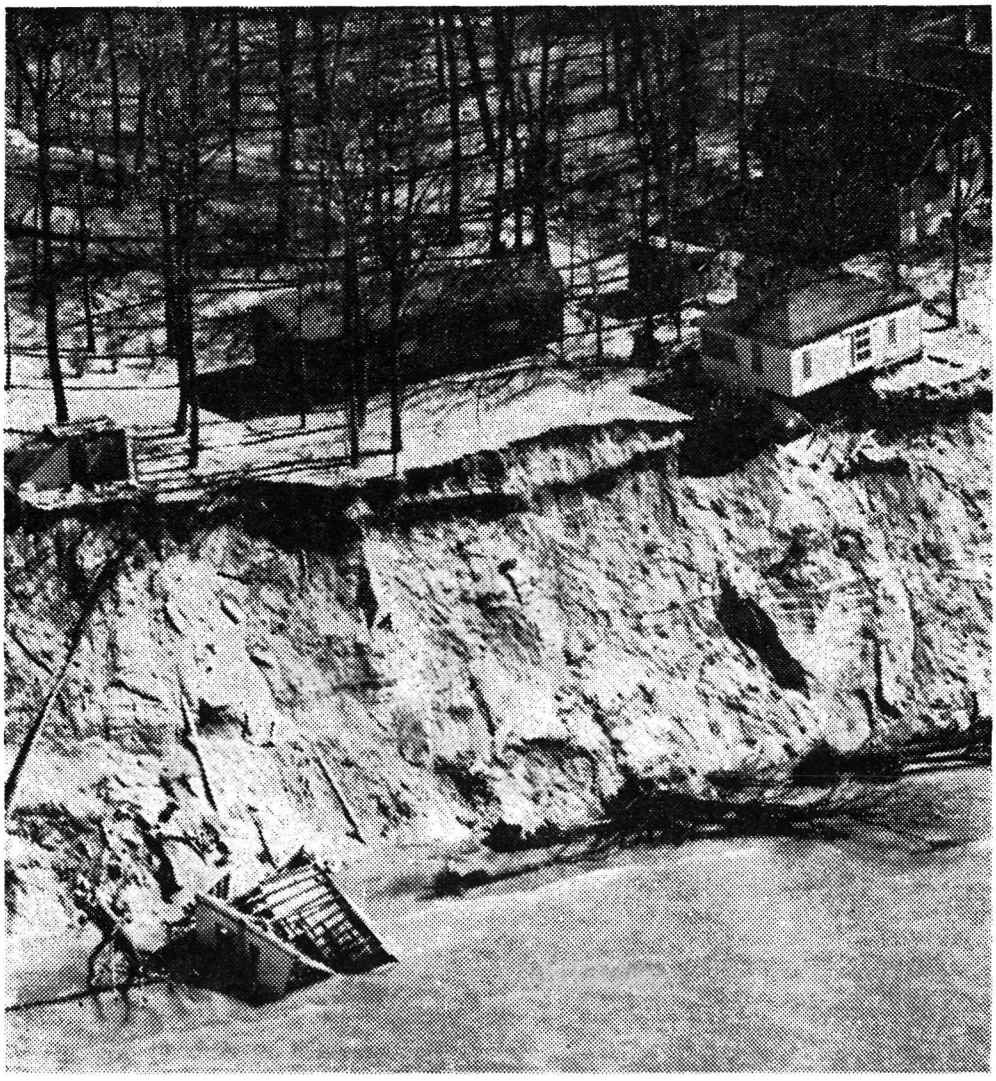
The state promotes itself on its license plates and elsewhere as "The Great Lakes State."

The report recommends creation of a shorelands advisory committee that would include representatives from such special interests as fishermen, farmers and the recreation industry.

It also recommends legislation extending protection against development to "areas of outstanding natural, historic, scenic, cultural or esthetic significance."

FIGURE 7. NEWS ARTICLE ON MICHIGAN SHORELANDS.

The Ann Arbor News, Friday, March 30, 1973 7



Lake Michigan Cottage Near Palisades Park Has Fallen In Water

FIGURE 8. EROSION DAMAGE. Zoning restrictions developed from remote sensing information are now being enforced by Michigan counties to prevent future destruction along the Great Lakes shoreline.

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

Color photography obtained in the 1974 flights was used in the evaluation of the St. John's Marsh discussed in Section 3.

Thermal imagery collected during the Michigan shoreline flight program was used to *identify possible point sources of thermal effluents into the Soo Harbor* at Saulte Ste. Marie, Michigan. These point sources are believed to be responsible for melting and detaching ice from the shoreline, thereby causing ice jams in the Little Rapids Cut downstream of the harbor.

4.5 SHORELINE ATLAS

Many additional uses of data from the NASA shoreline flights of April and May of 1974 are possible. To facilitate these additional uses, *a shoreline atlas concept was developed under the grant.* The atlas represents an important opportunity to develop aerial photography and photointerpretation techniques into a routinely used information resource for all coastal zone decision-making in the State. It fulfills the need for documenting land use and development patterns along the shoreline for each county, and includes topographic maps and other data. The atlas thus provides a readily accessible information source for DNR staff and local agencies concerned with managing coastal areas.

A prototype of the atlas was prepared by ERIM and delivered to DNR. On the basis of this presentation, DNR adopted the concept and provided funding to ERIM to create the first example of this in the Michigan Thumb (a six-county region in the eastern part of the state) [22]. This effort was extended to other parts of the State in 1975 [23]. ERIM has worked directly with local units of government during assembly of the atlas and will therefore have the opportunity to encourage and participate in the use of the atlas for decision-making at local government levels.

5
STATE LAND-USE MANAGEMENT

The State of Michigan faces critical policy decisions on how it can effectively protect its land and water resources. In 1972, the State Planning Division of the Bureau of Programs and Budget began, at the direction of the Governor, the task of defining the land management policy to be adopted by the State. Because of our staff's early discussions with the State Planning Division, ERIM was able to participate in this task and make important contributions to the planning and implementation process.

5.1 LAND-USE INVENTORY AND MANAGEMENT

One phase of the work initiated by the State Planning Division was intended to provide a uniform land-classification system for use throughout the entire State. This system includes general classification levels for statewide inventory as well as more detailed classification levels for uniform inventory of individual counties, municipalities, and other local governmental units. To provide the means for this inventory, a set of base maps was prepared, sources of remote sensing and other data were surveyed, and methods of using these sources for environmental analysis were developed.

ERIM's initial cooperation led to additional task assignments performed under State funding. The work performed by ERIM *contributed substantially to the survey of remote sensing sources and the development of feature identification and mapping procedures.* ERIM's final report for the state-funded program was submitted in June 1973 [14]. Included in this report were:

- Color and black-and-white Landsat photomosaics of the entire State of Michigan.
- A seven-category land use map derived from conventional information sources and Landsat-1 photointerpretation.
- A survey of the status and availability of land use planning data on a county-by-county basis.

ERIM continued to work closely with the DNR Office of Land Use, created to handle the State's continuing land use monitoring and management function. OLU continued with activities leading to initiating and using 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 was the ERIM representative on the Michigan Land Use Classification and Referencing Committee set up by OLU to develop and disseminate a four-level classification system for uniform use by State and local agencies [19]. ERIM and Michigan State University participated in the effort, and *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 submitted to the Governor.
- Adoption and dissemination of four-level land classification system.

5.2 LANDSAT APPLICATIONS

Studies at both ERIM and MSU under the NASA Landsat-1 Program resulted in the development of Landsat technology for a wide variety of applications in resource management and environmental monitoring. Taking advantage of this experience, the project assisted several government units in the investigation of Landsat potential for Michigan applications. For this purpose, Landsat imagery of an area in the Hiawatha National Forest near Munising in the Upper Peninsula was processed to produce a land use and land cover map [15]. This map and other Landsat products for Michigan areas were shown to the staffs of a number of federal, state, and local government agencies (including units of the Michigan Department of State Highways and Transportation, the Department of Natural Resources, the U.S. Department of Agriculture, and the Bureau of Outdoor Recreation). Review of these mapping results indicated that Landsat data can be of assistance in the work of these agencies.

Based on this favorable response, Landsat data utilization for land use and land cover mapping was expanded to consider its use for transportation system planning. The Statewide Transportation Analysis Unit of the Transportation Planning Division of DSH&T has developed a preliminary highway-corridor location model which can be used for the selection of routes based on regional environmental chracteristics. A statewide land-use model was developed and calibrated. Both the computerized corridor-location model and land use models require up-to-date land use information in a quickly accessible form. In the past, up-to-date information of this type has been difficult to obtain and include in the data base needed for transportation analysis. Under the NASA grant, we demonstrated the use of Landsat data processed by multispectral pattern recognition to delineate land use categories. We processed a Landsat-1 data tape of the area previously discussed and supplied it for use in the Highway Department's existing computerized model. Programmers and other researchers in the Statewide Transportation Analysis Unit then worked with this land-use recognition tape to test the requirements for formatting it and other such tapes into their computerized information systems. The objective was to enable DSH&T to *use Landsat data combined with other data in an improved highway-corridor selection process* [17,18].

In order to establish land cover mapping capabilities for the state system in a different geographic area, ERIM processed Landsat-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 needed for *planning future growth and development* within the county.

Landsat data can also be useful for other applications. Under this and other projects, Landsat data are being applied or developed for such purposes as wildlife habitat evaluation and hydrologic and water quality studies in Michigan.

5.3 ENVIRONMENTAL MONITORING

In 1975, ERIM laid the groundwork for using remote sensing to promote and enforce environmental legislation. This effort centered on the Sand Dune Mining Act, which was enacted into law in 1976, and the Soil Erosion and Sedimentation Act of 1972, for which enforcement agencies and procedures are in existence. ERIM's activities have resulted in making public interest groups and state and local agencies aware of the potential of remote sensing for these purposes. Assistance has been given in specific cases, and ERIM is continuing to work toward extending the application of remote sensing to additional cases as they arise.

ERIM cooperated with the West Michigan Shoreline Regional Development Commission (WMSRDC) and the West Michigan Environmental Action Council (WMEAC) in attempting to induce local zoning actions and state legislation to protect recreational and environmental areas against damage from sand and gravel mining operations. *High altitude color IR aerial photos supplied by ERIM were used as part of a public information program undertaken by WMEAC.* The Sand Dune Mining Act, which WMSRDC and WMEAC were active in promoting, is now law.

ERIM is also cooperating with citizen groups and public agencies in *encouraging the use of remote sensing to monitor earth change activities* which may violate the Soil Erosion and Sedimentation Act of 1972, and to document such violations for enforcement action.

6

HIGHWAY IMPACT ASSESSMENT

During the first year of this program, ERIM and MSU jointly undertook the task of applying remote sensing to assessment of the environmental impact likely in highway construction and to the preparation of environmental impact statements. Reference [1] describes application of these techniques in connection with the planned extension of the M-14 freeway between Ann Arbor and Plymouth, Michigan.

The environmental data on the M-14 site provided to the Department of State Highways and Transportation (DSH&T) were used to advantage as a basis for changing the drainage pattern at a point where the new highway would traverse wetlands feeding the headwaters of Fleming Creek. In the original design complete drainage of the area had been planned. This would have affected the viability of the wetlands area and the flow of water to Fleming Creek. Maps of the area provided by the M-14 study were used to redesign drainage factors so that only partial drainage is accomplished. *The resulting change not only lessened the environmental damage but saved DSH&T $10,000 in earth-moving costs.*

The M-14 impact assessment was also used in helping the Environmental Liaison Unit of DSH&T develop effective methods of impact assessment for other highway projects throughout the state.

The major factors which must be considered in assessing the ecological impact of highway construction are described in [1]. Since the time of that report, the Environmental Liaison Unit has been rapidly developing and adopting criteria and procedures for impact assessment. Development of the remote sensing methods covered by the report paralleled to a considerable extent the Unit's continuing development of improved procedures of impact assessment. It is likely that the adoption of those procedures was influenced to a considerable extent by the interaction of the two separate efforts.

Reference [1] reported preliminary information on the extent of adoption of the proposed remote sensing methods by the Unit. Since issuance of that report, the Unit has further implemented some of the recommended methods. Color infrared photography is now being acquired and used by DSH&T for ease and speed of photointerpretation. There is also increasing use of the concept of assessing environmental impact through the study of a coordinated set of maps or overlays useful for noting direct relation among various features. The trend is toward increasing the variety of information and the amount of detail presented and analyzed. In vegetation mapping, for example, both the use of major vegetation categories and the mapping of individual species or communities of sensitive vegetation appear to be required for full impact assessment.

As a result of favorable experience with color infrared photography of the M-14 cooridor provided by the RB-57 flights, DSH&T has obtained color infrared photography of other state areas in which future highway construction is being considered. Specifically, the Department contracted with a private company to supply this type of coverage for sizable areas in Northern Michigan. Existing RB-57 photography and additional photography provided under our program can also be used for highway corridor selection and impact assessment in covered areas.

Land use and land cover maps prepared efficiently and economically by computer processing of Landsat data can also provide data needed in the impact assessment process associated with initial corridor selection. The application of Landsat technology for highway planning is referred to in Section 5.2.

7
SOIL SURVEY IN JACKSON COUNTY

Operational soil surveys conducted throughout Michigan provide a comprehensive and accurate source of data widely disseminated to many private and public users -- farmers, forest managers, urban planners, and civil engineers.

Past experience at ERIM in soils mapping has indicated that the use of multispectral scanner data can increase the speed, economy, and accuracy of the operational procedures for conducting these surveys [1,7,16]. To demonstrate these capabilities, the project participated in the National Cooperative Soil Survey begun in Jackson County in the fall of 1973. This work was done in cooperation with the staff of the Soil Conservation Service and Michigan Agricultural Experiment Station to enable them to evaluate the role of remote sensing in future operational surveys.

Multispectral scanner data and aerial photography collected over a 4 x 42 km portion of Jackson County in April 1974 were used operationally to assist the survey personnel. The excellent 23-cm photography obtained during the flight was used by the field mapping party. An evaluation of the multispectral data indicates that the thermal bands contain the most useful information for soil survey purposes. *The operational survey work demonstrated the ability of temperature differences to delineate the distribution of organic and mineral soils.* It is probably feasible to provide additional information on soil texture by ratio-processing of thermal imagery in two adjacent bands.

8
SITE SELECTION

Remote sensing can play an important part throughout the process of selecting sites for commercial, industrial, institutional, or recreational development. ERIM undertook a number of specific applications to assist in the process of site selection and evaluation for various purposes.

8.1 COMMERCIAL SITE SELECTION

High-altitude aerial photography acquired in 1969 and in 1972 was furnished to the Trenton State Bank to assist it in *identifying potential sites for new branch banks* within 40 km of its main office. The photography was used as a basis for analyzing the following: major concentrations of industrial, commercial, and residential areas; growth trends in these areas; and the location of these areas with respect to major transportation arteries. On the basis of this analysis, several possible sites for new branches were recommended to the bank's Board of Directors.

8.2 RECREATION SITE SELECTION

The Lake Central Region of the Bureau of Outdoor Recreation has increased its use of NASA photography for many purposes throughout its area of responsibility. A study of future needs for park and recreation space in a 10-county area in Southeast Michigan was completed by the Bureau in 1973 and made available to local units of government as a planning aid. The study made extensive use of RB-57 photographs taken over the area in September, 1969 (Mission 103) and purchased from ERIM. This study projected future requirements totalling 600,000 acres for park and recreation space within the 10-county area. The 10 counties presently have some 200,000 acres in their parks system. *The RB-57 photography was specifically used to identify 596 sites (426,185 acres) possibly available as future parks.* The sites, all in rural settings,

either have frontage on lakes, streams, or reservoirs (and future reservoirs), or are sufficiently wooded and large enough to be considered for use as parks.

8.3 SCHOOL SITE SELECTION

ERIM supplied Dr. Karl S. Peterson, Principal of the Huron Valley Lutheran High School with information that was used in the selection and evaluation of a 10 hectare site for a future school. The aerial photography supplied to Dr. Peterson and other data on soils, vegetation, and topography was obtained from ERIM's 1972 study of the M-14 freeway extension conducted under the NASA grant [1]. *This information was instrumental in the decision to purchase the site for $108,000.*

8.4 INDUSTRIAL SITE LOCATION

The Martin-Marietta Corporation is interested in finding *sand and gravel deposits* in the Southeast Michigan area and contacted the Office of Economic Expansion of the Michigan Department of Commerce to assist them. At the request of OEE, ERIM provided Martin-Marietta with RB-57 photography of the area to assist them in preliminary location of potential sites. Using this remote sensing data in conjunction with ground checks, *Martin-Marietta was able to locate a 340 hectare site in the Oakland-Macomb County area,* and has since conducted soil tests on this site to determine its suitability for their purposes.

9

REGIONAL RESOURCE MANAGEMENT

Regional planning and development commissions are in the vital position of acting as resource centers for economic, social, and environmental planning and development. Recognizing the opportunity these agencies offer for the extension of remote sensing technology to many potential users at the regional level, ERIM initiated programs in several regions of Michigan to develop interest in remote sensing and to encourage useful applications of the technology.

One of the earliest efforts in this direction was performed in cooperation with the Southeast Michigan Council of Governments (SEMCOG), which is an association of local governments of seven counties in Southeast Michigan. As a result, SEMCOG is now actively using remote sensing data to meet its information needs. With assistance from ERIM, *SEMCOG obtained and used HUD funds to investigate practical uses of remote sensing.* One application of importance was the preparation and use 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 later funded a project *to prepare an inventory and make area measurements for the entire region.*

The NASA grant later supported a program to provide technical assistance through the three agencies in Michigan's Upper Peninsula: the Western Upper Peninsula Planning and Development Region (WUPPDR), the Central Upper Peninsula Planning and Development Region (CUPPAD),

and the Eastern Upper Peninsula Regional Planning and Development Commission (EUPRPDC).

The basic data source available for these applications was provided by a U-2 photography mission over the Upper Peninsula shoreline flown by NASA in July 1974. ERIM conducted a training workshop, a public seminar, and several meetings at various points in the Upper Peninsula to acquaint the regional staffs and other users with the data base and to instruct them in its use.

A wide variety of accomplishments have resulted from this effort. Some examples of these accomplishments are listed here.

- Use of the NASA U-2 photography allowed the Upper Peninsula regions to achieve project goals for *mapping and inventory of general land use, wetlands, shorelands, and forests* under their respective Coastal Zone Management Programs far in advance of Michigan's eleven other regions.
- WUPPDR staff used their mapped information to *recommend changes to a proposed shoreline recreation development* during their routine A-95 review process. Their proposed change, which was designed to protect a waterfowl breeding area, was accepted as a permanent modification to the project.
- CUPPAD staff prepared an environmental assessment of a proposed industrial park site for the City of Manistique, using the U-2 photography as the primary information source for this analysis.
- CUPPAD completed a land/water resources study for Menominee Township in preparation for a long-range development plan. The U-2 photography and resultant mapped material were *used in public meetings for this project.*
- The Hannahville Indian Community sought the assistance of CUPPAD staff to *prepare a federal grant proposal to start a hog farming operation.* The photography proved a *valuable data source for part of the field analysis required.*

- EUPRPDC staff used the U-2 photography to help prepare a *master plan for the Kinross Township fairgrounds and a timber inventory in Whitefish and Clark Townships.*
- Staff from Ottawa National Forest used the photography for *forest compartment planning.*

Other applications included monitoring of environmental areas, snowmobile trail selection, airport zoning, and sea lamprey control.

A program for developing applications of remote sensing in regional resource management was subsequently carried out in cooperation with the East Central Michigan Planning and Development Regional Commission, located in Essexville, Bay County. ERIM planned a high-altitude aircraft photographic mission which was flown by NASA on 29 July 1975. A training workshop was then conducted for regional staff members. Since January 1976, the regional commission staff and representatives of local government agencies have made extensive use of the imagery for many purposes.

Specific results of using the imagery provided by NASA include the following:

- In support of the region's Coastal Zone Management (CZM) Program, wetlands, shore erosion, and land use have been mapped as a *prerequisite for implementation of the management plan to be created under the state CZM program.* The remote sensing data have also been used in debates over specific rulings on areas to be put under restrictive use and in at least one case *provided the evidence needed for reversing a decision on land use.*
- High-altitude photography has been used for *preliminary identification of potential sites of sewage treatment plants.*
- Ground truth information was provided for Landsat mapping of the entire 20,000 sq km region carried out to provide *basic data for the region's Section 208 Areawide Wastewater Management Program,*

aimed at maintaining or improving the surface water quality of the region.

In addition to accomplishments achieved under fully developed regional resource management programs, our individual contacts throughout Michigan opened up a number of opportunities for specific uses of remote sensing at the regional level. Two examples of these directly-oriented opportunities are summarized here.

- Remote sensing was used to assist the Sierra Club's outing program. The 1977 summer season program included two National Trips scheduled by the Midwest Subcommittee for the Upper Peninsula of Michigan. One of these was the "Superior Shoreline Knapsack Trek", running from Whitefish Point to Grand Marais, a distance of 50 miles along the Lake Superior Shoreline. The NASA shoreline photography, taken in May 1974, was provided to the trip leader to replace outdated maps and was used to select overnight camping sites and food drop sites, and to identify needed changes in routes to avoid areas eroded by high water and river channel changes.

- ERIM has worked with Charles E. Gass, Director of the new Michigan Space Center being constructed on the Jackson Community College campus, just outside Jackson, Michigan, to recommend suitable remote sensing exhibits for the Center. With support from the State, this Space Center will display significant accomplishments of the NASA space program to both Michigan and out-of-state visitors and will act as a research and educational center. ERIM has provided the Director with examples of space photography and technical reports, with special emphasis on work done on Michigan test sites.

NASA-supplied remote sensing products are now playing a major role in the activities of the Southeastern Michigan, Upper Peninsula, and East and Central Michigan Regions. A responsive audience at both the regional and local levels has been reached, and identifiable products and results of this introduction of a new technology have been achieved. Use of existing remote sensing imagery for many varied purposes and expanded acceptance of the technology are expected to continue.

10

FRESH GRAVE DETECTION

In the field of crime detection, the problem of locating fresh shallow graves or buried objects is an urgent matter, even though the need arises only occasionally. ERIM has received inquiries from law enforcement agencies on this subject from time to time. Our previous research on the use of thermal detection indicates that fresh shallow burials are usually thermally detectable, but the question arises as to whether these changes are sufficiently significant and predictable to permit reasonable detection probability within acceptable false alarm rates.

It would be of distinct value to law enforcement agencies to be able to detect fresh graves by thermal methods, and to understand the circumstances under which these methods can be successfully applied, as well as the equipment and procedures for applying them. A capability for undertaking a search on short notice would represent an important addition to the ability of local law enforcement agencies to conduct criminal investigations. ERIM therefore conducted under the NASA grant a small field study to demonstrate the detection of buried bodies. The results of this field investigation and conclusions as to operational feasibility were summarized and presented to local law enforcement agencies so that they are in a position to select this method where circumstances justify its use.

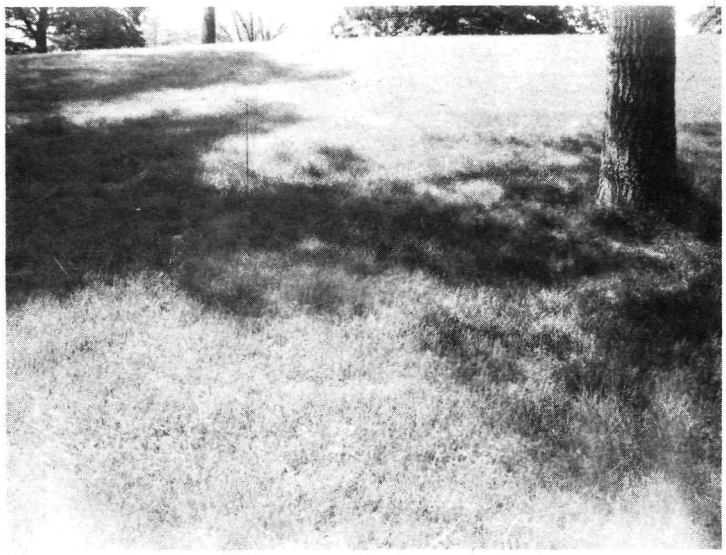
To demonstrate the capability of this technique, ERIM conducted a preliminary investigation utilizing a portable ground-based infrared imaging system (AGA Model 750 Thermovision). A local cemetery containing only surface gravestones was selected for the demonstration in order to reduce thermal anomalies due to shadows.

Parameters which must be considered in determining the optimum time to look for signature differences include amount of and time

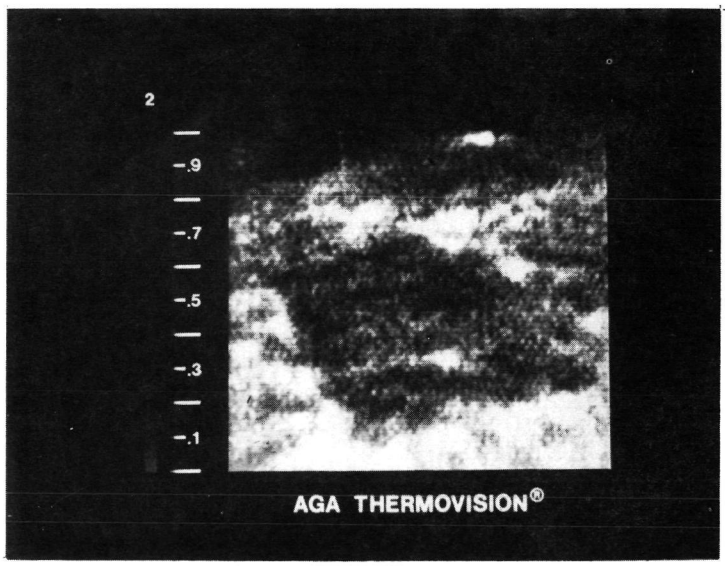
duration since last rainfall, season, time of day, cloud cover, and terrain features. By selecting the proper conditions, three grave sites, ranging in age from four months to two years, were successfully detected. Figure 9 shows an example of this testing.

The results were sufficiently encouraging to justify continued refinement of the application. Further consideration has been given to the applicability of an airborne platform for obtaining thermal images for grave detection. In general, the areas to be searched are large (hundreds of hectares), making the use of airborne remote sensing desirable.

As a result of this demonstration, the Ann Arbor Police Department requested ERIM's assistance in locating a buried body. Two bodies related to the same crime had been found previously, and the police were interested in investigating a suspected location in Lenawee County, near Adrian, Michigan. The Thermovision system was used to check the specific area both during the day and at night and detected an asphalt-paved area which appeared to be abnormally warm. As a result of this detection, the spot was dug up. However, the digging uncovered only plastic bags and tree stumps. Although the primary objective of the digging was not achieved, the thermal sensing system did in fact perform correctly, since its sole function is to identify areas in which the earth has been disturbed. The police may ask for further assistance from ERIM, if other suspicious areas need to be investigated in the future.



FOUR MONTH OLD GRAVE AREA



THERMOVISION IMAGE OF FOUR MONTH OLD GRAVE AREA

FIGURE 9. DETECTION OF GRAVE SITE BY INFRARED IMAGING SYSTEM.

11

PUBLIC HEALTH

Remote sensing applications were undertaken in 1976-77 which had a bearing on two public health problems: (1) mosquito control to reduce St. Louis encephalitis, and (2) identification of improper waste disposal system operation.

11.1 MOSQUITO CONTROL

The objective of this task was to plan for remote sensing procedures to aid in mosquito control programs in Michigan. The primary reason for undertaking a program of mosquito control is to reduce the incidence of St. Louis Encephalitis (SLE), a potentially fatal viral disease carried by mosquitos. The summer of 1975 marked the first occurrence of this disease in Michigan. Additionally, remote sensing could provide benefits in terms of dollar savings in current control programs devoted solely to the control of nuisance mosquitos. Remote sensing would also enable the use of control measures that do minimal damage to the environment by making such measures as the use of larvacides more specific.

The Tri-County Mosquito Control Commission was the principal agency involved with ERIM in this task. This agency is composed of six people, two from each County Board of Commissioners of Saginaw, Bay, and Midland Counties.

In 1975 Dr. Donald Newson, Associate Professor of Entomology at the Pesticide Research Center at Michigan State University, conducted a survey of mosquitos in Saginaw, Bay, and Midland Counties. This survey confirmed the fact that mosquitos which serve as vectors of SLE are present in the Tri-County area and defined their habitats. The principal breeding sites are areas which were dry and subsequently become flooded, such as after heavy rains.

Detection of standing water is a well-documented capability of remote sensing. Determination of newly flooded areas using photo-

interpretation of low-altitude black-and-white IR film would provide control personnel with locations of areas to sample and/or apply specific control measures. Control may be done by draining or by using larvacides. Because breeding sites may be small in size, aircraft data are necessary. It is possible to detect old tires, a breeding ground for Culex restuans, on aerial photography. We might also detect water in ditches and in catch basins.

The mosquito breeding season in the Tri-County area extends from about late May until frost (September). The size of the Tri-County areas and the fact that the mosquito breeding occurs in a matter of 7-10 days, makes control utilizing ground information alone a very difficult task. An initial photographic survey done in May (after the spring melt) would serve as a baseline against which subsequent surveys can be measured. After the initial baseline survey, flights would be made only after any significant rainfall.

Based upon information on the amount and location of new standing water areas gained from a comparison between the baseline survey and after-rainfall photographs, control personnel can pinpoint those locations which require sampling (of mosquito larvae to determine the presence of the encephalitis vectors) and possible application of control measures.

It seems likely that remote sensing could be of value in an emergency situation, if the mosquito habitat and feeding information for Southeastern Michigan does not change drastically from that determined by existing studies. Based on remote sensing information for an area the size of a mosquito abatement district (50 to 60 sq km), ground crews could eliminate water standing in tires and treat other areas of standing water with larvacides.

The State of Michigan established a surveillance program for St. Louis Encephalitis for 1976. This tied in with a nationwide SLE program run by the Center for Disease Control. Fortunately, the outbreak of SLE which occurred in 1975 was not repeated in 1976, so

that no remote sensing program was needed. However, the analysis of the remote sensing application indicates that *a fast response could be provided if a future outbreak threatens.* In that event, a remote sensing program could be initiated based on the procedures defined in this task.

11.2 WASTE DISPOSAL SYSTEM OPERATION

The objective of this task is to identify overloaded or saturated tile fields, seeps, surface discharges, ponding, or other deficiencies associated with individual waste disposal systems.

Individual septic tank waste disposal systems are an important means of environmental sanitation. With appropriate consideration for soil conditions, land area, and setback, they provide a satisfactory method for wastewater disposal. On the other hand, poorly drained soils, high water table, deficiencies in size, and lack of maintenance can lead to intolerable conditions with respect to public health codes.

Our effort under this task was directed toward assisting the Washtenaw County Department of Public Health. Working with public health officials, three problem areas were identified for which photography and other remote sensing techniques could be useful.

Many of the lakes located within the district exhibit water quality problems which are suspected to arise from faulty septic systems or possibly from direct discharges. High fecal coliform counts observed in the lake waters support this conclusion. However, these measurements made by the public health department are highly variable in time and location. While high counts indicate a problem, they do not generally identify the specific source which needs correction. Low altitude color and color infrared photography is considered useful to identify suspected problems sites as manifested by signs of abnormal drainage from the tile field, high water table, and the abundance of aquatic plant growths in the nearshore areas. Once identified, suspect sites can be further tested by dye tracer techniques.

Several of the small rural communities located within the county are suspected of having inadequate residential waste disposal systems. Surface discharges of sewage or highly contaminated water have been observed from local drains to ditches and streams. While these drains may have originally been emplaced to handle stormwater, some local residences have since been connected directly to the line. To correct the problem, evidence is needed as to which residences are at fault. Aircraft infrared photography and thermal scanner imagery are considered to be useful to identify the residences at fault. During dry late summer periods, active tile fields are frequently easily identified on color infrared photography. Lack of an observable drain field and/or localized high moisture conditions near the road would indicate the need for more complete on-site investigations. Thermal imagery collected at night during cold weather without snow cover could identify warmer discharge pipes as contrasted with surrounding surface soil temperature.

Current and planned rural subdivision development has put pressure on available ground water supplies. Alluvial aquifers used for well supplies are believed to be connected with shallow surface groundwater in areas of aquifer recharge. Contamination of well water supplied from septic tank flows could occur if housing development is allowed in recharge areas. Possible contamination can be averted if knowledge of these recharge zones becomes available. Presently little knowledge is available on groundwater recharge because of complexities in local soil conditions. High altitude infrared photography is considered useful to identify area drainage patterns and surface moisture supply conditions which may be indicative of recharge zones.

In response to the needs of the Public Health Department, low altitude color and color infrared aerial photography was collected for five area lakes and two rural communities in Washtenaw County. *Several suspect cottage sites were identified* to be followed up by the

local sanitarian with on-site investigation to see if the septic system is functioning satisfactorily and meets minimum codes. In addition, *high altitude RB-57 infrared imagery was examined for features which could help identify recharge zones.*

12

DOCUMENTATION OF PROJECT RESULTS

In this section, technical documents that resulted from the work done under the NASA grant are listed. These include all technical and annual progress reports of the project. In addition, journal articles derived from the project work and technical reports on related projects are listed.

12.1 PROJECT REPORTS

1. 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.

2. I.J. Sattinger, et al., Remote Sensing in Michigan for Land Resource Management: 1972 Annual Report, ERIM Report No. 190800-2-F, Ann Arbor, 1972.

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, ERIM Report No. 193400-1-T, Ann Arbor, 1974.

4. 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, ERIM Report No. 193400-2-F, Ann Arbor, 1973.

5. T.W. Wagner, A Preliminary Study of Multispectral Imagery for Soil Survey, ERIM Report No. 193400-4-L, Ann Arbor, 1974.

6. D.S. Lowe, et al., Remote Sensing in Michigan for Land Resource Management: Annual Report, 1 June 1973 to 31 May 1974, ERIM Report No. 193400-5-P, Ann Arbor, 1974.

7. T.W. Wagner, A Continuing Study of the Application of Multispectral Imagery to Soil Surveys, ERIM Report No. 193400-8-S, Ann Arbor, 1975.

8. D.S. Lowe, et al., Remote Sensing in Michigan for Land Resource Management: Annual Report, 1 June 1974 through 31 May 1975, ERIM Report No. 193400-9-P, Ann Arbor, 1975.

9. N.E.G. Roller, Changes in the Wetlands and Land Use Patterns of St. John's Marsh, St. Clair County, Michigan, ERIM Report No. 193400-11-T, Ann Arbor, 1975.

10. N.E.G. Roller, Tentative Classification of Lifeforms and Subforms of Common Michigan Wetland Vegetation, ERIM Report No. 193400-12-T, Ann Arbor, 1975.

11. D.S. Lowe, et al., Remote Sensing in Michigan for Land Resource Management: Annual Report, 1 June 1975 to 31 May 1976, ERIM Report No. 193400-13-P, Ann Arbor, 1976.

12. N.E.G. Roller, Remote Sensing of Wetlands, ERIM Report No. 193400-14-T, Ann Arbor, 1977.

12.2 JOURNAL ARTICLES AND REPORTS ON RELATED PROJECTS

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. A.N. Sellman, T.W.D. Gregg, L.B. Istvan, Land Use Mapping for the State of Michigan, ERIM Report No. 200100-1-F, Ann Arbor, 1973.

15. A.N. Sellman, Land Resource Survey for the State of Michigan, Proceedings of Symposium on Significant Results Obtained from ERTS-1, Goddard Space Flight Center, Greenbelt, Maryland, 5-9 March 1973.

16. 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.

17. T.L. Gotts, Michigan's Statewide Transportation Modeling System: Vol. VI-A, Environmental Sensitivity Computer Mapping, Michigan Department of State Highways and Transportation, Bureau of Transportation Planning, Lansing, 1974.

18. R.E. Esch, The Application of ERTS Data in Michigan's Statewide Transportation Modeling System, Paper presented at ERTS in Michigan Symposium, American Institute of Aeronautics and Astronautics, Michigan Section, Ann Arbor, June 7, 1974.

19. Office of Land Use, Michigan Land Use Classification System, Michigan Department of Natural Resources, Lansing, 1974.

20. J.P. Dooley, F.A. Clinton, and M.R. Jannereth, Michigan Department of Natural Resources, Shorelands Management Using Remote Sensing Techniques, Proceedings of the Tenth International Symposium on Remote Sensing of Environment, Ann Arbor, 1975.

21. W.C. Taylor, W.R. Enslin, C.E. Olson, Jr., I.J. Sattinger, Survey of Recent Resource Applications in Michigan, Proceedings of Tenth International Symposium on Remote Sensing of Environment, Environmental Research Institute of Michigan, Ann Arbor, 1975, pp. 857-865.

22. L.B. Istvan, Michigan Shoreline Photographic Atlas, Phase I Final Report, ERIM Report No. 200200-1-F, Ann Arbor, 1975.

23. L.B. Istvan, Michigan Shoreline Photographic Atlas, Phase II Final Report, ERIM Report No. 200600-1-F, Ann Arbor, 1976.

APPENDIX A

USER REPORTS

This appendix includes a number of letters received from individuals with whom ERIM has worked under the NASA grant program.

These letters present a cross-section of the results achieved by a variety of Michigan-based agencies under the program.

United States Department of the Interior

BUREAU OF OUTDOOR RECREATION

LAKE CENTRAL REGION
3853 RESEARCH PARK DRIVE
ANN ARBOR, MICHIGAN 48104

IN REPLY REFER TO:

N2223 RS

November 28, 1972

Mr. Irvin Sattinger
Willow Run Laboratory
University of Michigan
P.O. Box 618
Ann Arbor, Michigan 48107

Dear Mr. Sattinger:

In accordance with your telephone conversation with Larry Peterson concerning use of RB-57 imagery supplied to us by the Willow Run Laboratory and NASA, we report the photographs have been used primarily in three major efforts (1) Detroit-Toledo, Lake Erie Shoreline Study, (2) Southeastern Michigan Water Resources Study and, (3) the Wild and Scenic River Study of the Maumee River.

(1) Use during Detroit-Toledo Shoreline Study was limited because of the initial unavailability of the coverage. The photographs were used for visual inspection to determine marsh and wetland areas, vegetative types, land uses, and changes in cultural elements since publication of the U.S.G.S. maps. Also of special interest were docks, piers, etc., not mapped along the shoreline.

As a result of our study and interest in this area and the discovery of many other activities which will affect those shoreline areas, low level flights were made of the Pointe Mouillee State Game Area. A great deal of baseline data has been collected. This provides information for present managers of the area and will provide information for the decision making process on proposed projects. This data will also help compare the effects certain projects might have on marsh areas such as Pointe Mouillee. It would have been very helpful to have similar coverage of this shoreline area during or immediately after the recent flooding along the western shore of Lake Erie.

(2) Southeastern Water Resources Study. During the spring of 1972, we utilized the RB-57 photos to select and help evaluate potential recreation resources in seven southeastern Michigan counties. Resource characteristics commonly identified on the photos include land and water acreage, miles of stream and lake frontage, density of vegetative cover, and threat of adverse land-use changes.

The values of the RB-57 photos was not truly appreciated until we were forced to use black-and-white aerial photos for three other southeastern Michigan counties. In every respect, the RB-57 photos were superior. The color contrasts and clarity of the RB-57 photos made site selection, delineation, and evaluation a relatively easy task compared with the difficulties and uncertainities we experienced when using the black-and-white photos.

With the aid of the RB-57 photos, 401 sites encompassing almost 300,000 acres of land were inventoried in the seven counties.

(3) Maumee Wild and Scenic River Study. Only three frames were available as the aircraft was turning around at the south end of the flight strips designed to cover southeastern Michigan. These photos were supplied by BOR to the U.S. Forest Service. The Forest Service is a member of the inter-agency study team assigned to complete portions of the report on land use. We have received a letter from them indicating that the RB-57 photography had been very useful in their land use mapping and inquired if we could obtain additional coverage over the Maumee that they could use.

In addition to the three major projects, the imagery has been used for office inspection of various project sites, including dredge disposal sites, potential park areas, highways, surface mine restoration sites, and scenic river studies. All uses except those at Pointe Mouillee have been based on visual interpretations of the imagery by the regional office staff of the Lake Central Region.

We have enjoyed our association with the staff of the Willow Run Laboratory and their individual willingness to assist us upon our request.

Sincerely yours,

John D. Cherry
Regional Director

STATE OF MICHIGAN

WILLIAM G. MILLIKEN, Governor

DEPARTMENT OF NATURAL RESOURCES

A. GENE GAZLAY, Director

Pte. Mouillee State Game Area
Rt. #2, Rockwood, Michigan 48173

February 21, 1973

Erv Sattinger
Environmental Research Institute of Michigan
P. O. Box 618
Ann Arbor, Michigan 48107

Dear Mr. Sattinger:

In response to a telephone conversation with Mr. Sellman, I will endeavor to evaluate and summarize the use that the Michigan Department of Natural Resources has found for the preliminary information and visual aids provided by the Environmental Research Institute.

The choice of the Pte. Mouillee State Game Area by the Institute was a fortunate one for us in the Department of Natural Resources. This critical piece of wetlands is the subject of a current controversy. It is undergoing many changes and the documentation of said changes by photo interpretation is providing us with needed information and data.

The controversy between environmentalists and the Corps of Engineers is a bitter one and is far from being settled. Many of the facts and comparisons which have been provided by the Institute have been very helpful and have given us a better insight into the rapidly changing marsh habitat. The present record high water levels have caused most of the changes noted.

The series of photos have made us aware of the value of remote sensing to keep abreast of changes. The detailed inventory aspect of the project is just about to bring in results usable to provide a tool for management of the water control areas.

The specific request for information to aid in land acquisition so we can get the most for our money is expected to be an important help.

Use has been made of the photos and information to plan and evaluate repairs suffered during recent storms.

The above represents only a partial summary of the benefits we have received from the project. It would be hard to exaggerate the importance of the expanded knowledge and understanding that we have gained on the area involved. It has been observed that as new situations and problems arise we have a reservoir of information and some hard data to rely on.

We are now planning a meeting of the State's waterfowl area managers and biologists to present the project as it could relate to their areas and to get their input for future decisions and goals. This meeting will take place within the next month.

In essence, the project has shown great prospects for gathering of hard data broadening the basis for intelligent resource management.

Very truly yours,

James E. Foote

James E. Foote
Wildlife Biologist in Chg.
Pte. Mouillee State Game Area

JEF/jmf
cc: R. Anderson, District 13
L. Dayton, Regional Office
B. Sellman, Willow Run

Monroe County Planning Commission

COUNTY COURT HOUSE · MONROE, MICHIGAN · 48161

AREA CODE 313 PHONE 241-6066

June 19, 1973

Mr. Albert N. Sellman
Environmental Research Institute
of Michigan
P.O. Box 618
Ann Arbor, Michigan 48107

Dear Mr. Sellman

This opportunity is taken to confirm that you visited our offices on May 16, 1973 and presented staff with black and white infrared photography of Monroe County's portion of Lake Erie Shoreline. You noted that this photography was flown on April 11,1973 on the day following severe flooding of the Lake Erie Shoreline in Monroe County.

Your representation on behalf of the Office of University Affairs headquartered in Washington D.C. was greatly appreciated by myself and members of my staff. Our exposure to infra red photography and its potential use as a planning tool is limited and your visit served to improve that understanding and to whet our appetite to seek increased opportunities to use infra red photography in our work.

As a result of the availability of the photography you left with us we recently were able to bring to bear unmistakable evidence that a proposed public housing site for the elderly and families in the City of Luna Pier was inundated on April 11, 1973 and indeed the entire community was inundated on that date. With this evidence my planning commission responded negatively to the Department of Housing and Urban Development relative to approval of this housing application pursuant to the Office of Management and Budget Circular No. A-95. Furthermore my Commission has taken positive steps to urge the Department of the Interior, Bureau of Outdoor Recreation to initiate a comprehensive cost/benefit study relative to the merits of acquisition of all Lake Erie Shoreline in Monroe County now in residential or vacant use for public or private recreation oriented uses. Your mapping was also used recently to assess the potential hazards in terms of fly ash stock piles eroding into Lake Erie and have discussed this problem with officials of the Detroit Edison Company who have agreed to dispose of their fly ash residue farther removed from the shores of Lake Erie and adequately diked to eliminate erosion to Lake Erie. While we have not had an opportunity to use infra red photography for zoning decisions we certainly see great potential in its application to zoning decision making.

We hope that your efforts will be continued to be supported as we can see real potential benefits to the interpretation of urban development phenomena.

Sincerely

Ronald F. Nino, Director

RFN:mm

MONROE COUNTY OFFICE OF CIVIL DEFENSE
MONROE COUNTY COURTHOUSE
106 E. FIRST STREET TELEPHONE CH 1-6400
MONROE, MICHIGAN 48161

HAROLD D. STRAUB, DIRECTOR

June 20, 1973

Mr. Buzz Selman
Environmental Research Institute of Michigan
Willow Run, Michigan

Dear Mr. Selman,

We appreciate the two explaination periods that you had on the pictures taken of the Monroe area.

We also appreciate the ariel photos that we are now in the process of assembling. The photos were able to give us a clear picture of the water level attained on 9 April, 1973, at the height of the flooding. We feel that these will be very useful in future planning for this type of disaster. If this same condition exists again with possible rainfall at the same period, would give us valuable information for planning evacuations etc.

The Drain Commission finds the pictures extremely valuable due to the locations of pumping stations along the flooded area.

This source of information has also been extracted for use by the County Planning Commission. As we derive other information from these photos, or see a need for your department, we will forward the information to you.

Thanking you for the photos and all services rendered, I remain,

Sincerely,

Harold D. Straub,
Director, OCP

HDS/aa

DEPARTMENT OF THE ARMY
DETROIT DISTRICT, CORPS OF ENGINEERS
P. O. BOX 1027
DETROIT, MICHIGAN 48231

IN REPLY REFER TO

February 28, 1974

Dr. I. J. Sattinger
Research Engineer
Environmental Research
Institute of Michigan
P.O. Box 618
Ann Arbor, Michigan 48107

Dear Dr. Sattinger:

Thank you for your kindness in supplying the slides of Pte. Mouille for our January public meeting presentation. The slide showing the loss of vegetation over only an eight month period showed very graphically what we may not have been able to say orally.

I would like to thank you for attending the meeting and offering to give explanations if necessary.

Sincerely yours,

David R. Chenoweth

David R. Chenoweth
Public Affairs Office

Western Upper Peninsula Planning & Development Region

P.O. BOX 365 HOUGHTON, MICHIGAN 49931

PHONE 906 – 482-7205

May 12, 1975

Mr. Buzz Sellman
Associate Research Geographer
Environmental Research Institute
of Michigan
P.O. Box 618
Ann Arbor, MI 48107

Dear Buzz:

The high altitude infrared and conventional photography that ERIM was able to make available to us from NASA has been becoming more useful to our agency and other interested parties as time passes. The remote sensing workshops that have been held on both an informal and formal basis have been beneficial to us in learning how to interpret and utilize this resource tool.

During the past year our agency has made use of the photography in the following ways:

1. In our Coastal Zone Management Program, we have used the photography to determine (a) generalized forest cover types, (b) categories of wetlands, (c) shoretypes, and (d) land use.

   In determining forest cover types we have separated the forests in seven major associations; northern hardwoods, aspen-birch, upland conifers, lowland conifers, lowland hardwoods, hemlock and mixed.

   For wetlands, we are attempting to use the State of Michigan's Standard Land Use Classification System at Level III.

   In identifying shoretypes, the photography is quite useful in separating areas of beach terraces and sand dunes from areas of shallow bedrock or lacustrine clay influence. Also separated from each other are beach types. Sand beaches come out as white while beaches of mine tailings have a blue hue. In inventorying land use, we have been using combinations of Level II and III.

2. For our A-95 Review Process we are using the photography to evaluate proposed projects in terms of environmental impact. Application of the photography, in the review of a proposed marina project, resulted in the redesigning of the project, thus preserving a wetland and waterfowl feeding area.

3. In our on-going planning such as sewer/water and land use the photography is constantly being referred to.

Use of the photography by other organizations has included:

A. The White Pine Mining Company is planning to use the photography for geological exploration of copper.

B. The Homestake Mining Company, which is operating an exploratory mining operation in the Keweenaw Peninsula, has expressed interest in viewing the photography for determining the site for a new tailing pond as well as geologic investigation.

C. The Ottawa National Forest is using the photography by their compartment planning (a forest management area).

D. Universal Oil Products (UOP), a corporation which owns a quarter of a million acres in the Keweenaw Peninsula is using the photography in the design of water-related development along Lake Superior. Universal Oil Products forester has also expressed some interest in using the photography.

E. The Forestry Department and Geology Department at Michigan Technological University are also using the photography for academic as well as research activities.

F. Although nothing has yet been done in the area, it is expected that agricultural organizations may have some use for the photography as it shows a number of different types of cropland.

Our office has assisted many of the above mentioned groups in either ordering the photography or in using it at our offices. From where we stand, the photography has been invaluable in performing our role in the Coastal Zone Management Program.

Future needs that we would have for photography would be in selected areas of wetlands, other environmental areas, and agricultural areas that weren't covered in last summer's flight.

We would like to take this opportunity to thank NASA and ERIM for arranging for the flying of our Region last summer. The information filled a very large gap.

Thankfully,

DK Stewart

David K. Stewart,
Associate Planner

DKS/ski

Enclosure

DISTRIBUTION LIST

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Washington, D.C. 20546

ATTN: Mr. J. A. Vitale, Code PY (10)