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East Lansing, Michigan 48824

USE OF REMOTE SENSING FOR LAND USE POLICY FORMULATION

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Myles Boylan

Myles Boylan, Principal Investigator
Professor, School of Urban Planning
and Landscape Architecture

Raymond D Vlasin

Raymond D. Vlasin, Chairman and
Professor, Department of Resource
Development

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FOREWORD: Scope of Report

This report is a summary description of the activities carried out during the first half of the 1976-77 grant year from June 1, 1976 through November 30, 1976 by the research participants in the Michigan State University Remote Sensing Project. It is a continuation of the Semi-Annual Progress Report, dated July 29, 1976 which covered the period December 1, 1975 to May 31, 1976.

A C K N O W L E D G E M E N T S

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Faculty Investigators:

+ Myles Boylan (Principal Investigator), Professor, School of Urban Planning and Landscape Architecture.
+ Raymond D. Vlasin, Chairman and Professor, Department of Resource Development.
+ Dieter Brunnschweiler, Professor, Department of Geography.
+ Delbert L. Mokma, Assistant Professor, Department of Crop and Soil Sciences.
+ Wayne L. Myers, Associate Professor, Department of Forestry.
+ Gene R. Safir, Assistant Professor, Department of Botany and Plant Pathology.
+ Ronald L. Shelton, Associate Professor, Department of Resource Development and School of Urban Planning & Landscape Architecture.
+ Eugene P. Whiteside, Professor, Department of Crop and Soil Sciences.

Project Research Staff:

+ William R. Enslin, Project Director
+ Stephen E. Tilmann, Specialist
+ Richard Hill-Rowley, Graduate Research Assistant
+ Kenneth Keifenheim, Graduate Research Assistant
+ Benjamin Richason, Graduate Research Assistant
+ Nor Salleh, Graduate Research Assistant
+ Gerry Schultink, Graduate Research Assistant
+ Chris Cialek, Photointerpreter
+ Gary Spariosu, Photointerpreter

I N T R O D U C T I O N

The problems of land and water resource use, misuse, and debilitation continue as one of the primary areas of urgent concern for the people of Michigan and the United States. Action programs are required for remedying accumulated abuses and mismanagements; for preserving and conserving the environmental resource qualities remaining. Effective programs can only be formulated by a broad community of scientific disciplines and by the energies and actions of many public and private institutions. A prerequisite to the formulation and acceptance of any effective action program is the ready availability of accurate and timely information for the formulation of policies which can be quickly translated into combinations of short term and long range remedial and preventative programs. Remote sensing is now becoming recognized and acknowledged as a major technological means for providing this kind of information. This Project has been playing a major role in bringing this change about in Michigan.

The primary objective of the Project is to work with agencies at all levels of government in Michigan, as well as with private organizations, to develope a wide diversity of applications of remote sensing for improving land/resource use decisions and actions. To realize this objective, Project activities are aimed at improving, across the board, the process of analyzing and allocating land and resource use in Michigan and eventually developing a responsible and self-supporting community of users of remote sensing in the state. To accomplish these aims Project staff conduct demonstration applications of remote sensing, provide user services, and participate in educational activities.

The following presentation describes in summary fashion the principal activities engaged during the June 1, 1976 to November 30, 1976 portion of the grant year. For reporting purposes, the activities were grouped under three broad headings: (A) application activities, (B) service activities, and (C) contract activities.

A. APPLICATION ACTIVITIES

This section reports on applications of remote sensing to selected natural resource situations and problems for which base data could be quickly located, identified and evaluated using remote sensing technology. The problems selected were ones for which program implementation and/or improvements in the quality and effectiveness of on-land actions could occur.

Some of these applications initially demanded considerable Project input. When rendered operational, these were gradually transferred to appropriate agencies for continuation or development to more advanced stages which would lead to subsequent actions. Others are expected to return to command Project attention from time to time when new information might be determinable or when additional decisions will need to be made regarding on-land applications.

A1. Inventory of Potential Mosquito Breeding Sites for Vector Control

Vector Control Section
Parks and Recreation Department
City of Lansing
431-A City Hall
Lansing, Michigan 48933

Mosquitoes have always been a nuisance during late spring and summer in Michigan. The outbreak of St. Louis Encephalitis in 1975 transformed the nuisance into a potentially major health hazard as this strain of encephalitis virus, transmitted by mosquitoes, is potentially fatal (92 cases and 2 deaths in Michigan; 600 cases and 39 deaths in Illinois). In response to this threat, the Michigan Department of Public Health developed an encephalitis surveillance program in 1976 to detect evidence of virus activity. A major objective of the surveillance program was to identify and map the location of mosquito breeding sites in the target area. This objective will be given clearer focus if Michigan Senate Bill 1116, the Mosquito Control Act, which is now under consideration by the state legislature, achieves passage. The Act will provide for the establishment of mosquito abatement districts and allocate funding for mapping activities to be undertaken.

The Vector Control Section of the City of Lansing was established in 1959 by the Center for Disease Control, U.S. Department of Health. This unit deploys several field teams each year to treat standing water and wetland areas with appropriate compounds for mosquito larvae extermination. Effective eradication, however, is crucially dependent on a comprehensive inventory of breeding sites. A sample aerial survey, conducted in the spring of 1975 indicated that the field maps used by the Lansing treatment teams only indicated 50 percent of the number of potential breeding sites in a six square-mile area. Non-treatment of this number of potential sites seriously jeopardizes the overall eradication effort.

A comprehensive inventory of all standing water (as small as puddle size) and wetlands in the Lansing/East Lansing area (90 square miles) was undertaken by the Michigan State University Remote Sensing Project (RSP) during 1976. Using a motorized Hasselblad camera, 70 mm color trans-

parencies were acquired for the area at a scale of 1:18,000. Coverage was obtained from a small plane during the spring when water levels were at their highest. The photography was systematically interpreted using a zoom stereoscope (24X magnification). Delineations were made on clear acetate jackets and then transferred to a specially prepared series of square mile (section) mylar base maps. A total of 90 maps were prepared at a scale of 1:6,700 and sequenced to facilitate easy field use. Reduced scale paper copies of the original maps were produced to an 8½ X 11" format and these copies, protected in acetate jackets, were included in a three ring binder to be used as the primary reference document for the field treatment crews. A wall sized inventory map showing the standing water/wetland distribution for the whole Lansing/East Lansing area was also prepared.

The standing water/wetland inventory identified 2,078 potential treatment sites consisting of 476 standing water bodies, 1,222 wetlands and 380 drains or river segments. A sample evaluation of this data in a particularly wet test area (11 square miles) revealed that the field teams were treating only 19 percent of the existing sites: 40 as compared with 211. It is unlikely that this figure can be extrapolated to the whole area but it does show that the inventory provides significantly improved information.

At the beginning of eradication activities in 1977 specific treatment information pertaining to individual sites will be indicated on the field maps including sequence of treatment within square mile sections, permanency of water, access points, obstacles to treatment and type of treatment. These maps will then be used in the systematic treatment of mosquito breeding sites throughout the year.

Vector Control activities in Michigan are extremely limited and the Lansing program is viewed as a prototype for future developments in the state. The standing water/wetland inventory has documented a procedure to generate, in a cost effective manner, information essential for an adequate eradication program and as such is demanding much attention from other government units with mosquito control problems.

A2. Estimation of Biomass for an Old Field Ecosystem Used in Waste Water Recycling

Institute of Water Research
Michigan State University
East Lansing, Michigan 48824

Color-infrared photography was used to evaluate the plant biomass of a group of experimental plots in an old-field ecosystem that were being treated with different levels of waste water from a sewage treatment facility. Vegetation samples were collected at two to four week intervals to give field estimates of biomass and a complete harvest was collected on June 15 and September 2, 1976. The plots were photographed from a light plane on four different occasions, concurrent with sample and harvest dates. Two Cibachrome prints (8"x10"), at a scale of approximately 1:1,600, were produced from a selected 35 mm color-infrared slide of each flight.

The photographs showed distinct tonal differences between treatment and control plots and the tonal appearance ranged from reddish-purple to pinkish-red, depending on the density of the plant community and month of photography. To analyse this density pattern a five-level tonal density scale was established for each photo set and "standard" tonal chips were prepared from one of the prints. Using this scale and a transparent multi-cell grid, registered to ground panels shown on the photographs, a series of tonal density values were recorded for each plot. A mean tonal value of each photo plot was subsequently obtained for each photograph. Correlation analysis between mean tonal density and harvest biomass gave consistently high coefficients ranging from 0.680 to 0.896 at the 0.001 significance level. However, correlations of mean tonal density values and sample biomass data were low and not significant, as was the case between sample biomass data and harvest biomass data. Correlations with wet weight biomass data were better than dry weight biomass data. Multiple regression analysis using the number of each of the five tonal values interpreted in each plot as the independent variables against biomass, yielded higher regression coefficients, but estimates of some values were

quite variable. However, the multiple regression analytical technique is statistically valid as the tonal density levels are ordinal data. The use of the mean of ordinal data in the simple regression analysis is statistically invalid. The multiple regression technique overcomes this limitation. A review of remote sensing literature indicated that this analytical technique has not been much used in such studies before.

The results of this study indicate that low altitude 35 mm photography, taken as early as one month before harvest, can be used to estimate the total biomass of an old field ecosystem. If old field ecosystems become a standard way of utilizing waste water, the method described may be both technically feasible and cost effective in monitoring the vegetative response to waste water utilization. Further work is needed in relating filtration rates and nutrition recovery to photo tonal values but the positive results of the project indicate a real potential of using photographs in the management of waste water irrigation projects.

A3. Agricultural-Use Valuation

Eaton County Equalization Dept.
127 W. Harris Street
Charlotte, Michigan 48813

Agricultural Experiment Station
Michigan State University
East Lansing, Michigan 48824

The Michigan State Tax Commission developed in 1970 a procedure of agricultural land value assessment based on the natural soil productivity and current land use. This procedure has been widely adopted throughout Michigan.

The Crops and Soil Science Department at MSU, in collaboration with the Remote Sensing Project (RSP) and the West Michigan Regional Planning Commission, has been developing an agricultural land value model using computer-based natural resource data. This model is basically the procedure outlined by the State Tax Commission, but adapted to conform with the resource data structure of grid-based information systems. The RSP has taken the prototype model developed in a test site in Kent County, Michigan, and incorporated the model into the Resource Analysis Program (RAP).

The RSP is currently working cooperatively with the Eaton County Equalization Office in developing and refining the land value model. This Agency enjoys a state-wide reputation for innovation and progressiveness. It is anticipated that successful application of the computer-based technique in Eaton County will stimulate other areas to follow suit.

This application involves the use of a Natural Resource Information System (NRIS) for both the soils data and the land use (remote sensing) data. The RSP has recently completed a land cover/use map for Eaton County, which will serve as the remote sensing data base. In addition, a detailed soil map has also been recently completed for the County.

The remote sensing data determines whether a parcel of land is in active crop land or orchards. Only these land uses can be assessed with the technique. The soil data determines a relative productivity index (ranging from 1 to 100), based on crop yield. The model is calibrated by entering known values of land recently sold in the study area (this

approach is known as the Market Value comparison).

The estimated market value for each unit of land (either 10 or 2.5 acres) is displayed on a map for each section of the study area. This graphic display permits an easier access and interpretation of the data. In addition to market value, the maps also show current land use and soil type.

This application is significant from several aspects. First, the application demonstrates the use of resource data (some of which is obtained through remote sensing) for land value assessment. Second, if the application is adopted by the host agency, then the need for accurate, current land cover/use data (from remote sensing) will be instituted for this area. Third, this application provides exposure to a local level agency to the usefulness and benefits of the technology surrounding remote sensing.

A4. Preservation of the Grand Mere Dune Environment

Grand Mere Association
Box 140
Stevensville, Michigan 49127

The Grand Mere area, located along the southeast shore of Lake Michigan in Berrien County, and consisting of streams, bogs, lakes, wooded upland, open beaches and dunes, represents one of Michigan's few remaining unique dune environments. The Grand Mere Association is a group of people who have expressed concerns relative to the impact of man on the Grand Mere area in terms of land use changes of parts of the area or adjacent buffer zones and the impact of intensive recreational activities.

In the Fall of 1975, assistance from the MSU Remote Sensing Project was requested for deriving crucial information from remote sensing data as a sound basis for the development of appropriate planning guidelines and management programs.

Specific problem areas as perceived by the Grand Mere Association were identified:

1. Invasion of Off-Road-Vehicles (ORV) and subsequent erosion and damage to the vegetation cover of shorelines and dunes on state-owned and private properties.

2. Potential impact of rezoning and commercial development of Federal Highway Interchange bordering the Grand Mere area.

3. Recommendations for Nature Trail development on state-owned land.

4. Maintenance of specific ecosystems to protect unique and endangered species (orchids, hop tree, etc.).

5. Existing or potential proliferation of sandmining on adjacent properties to the Grand Mere State Park.

The initial MSU Remote Sensing Project involvement focussed on the off-road-vehicle impact. Up to date, 70 mm color aerial coverage was acquired in October, 1976 by Project staff at a scale of 1:14,000. On the images specific sample areas were selected, according to previously defined criteria, allowing for a time comparative analysis over the time period 1970-1976. For the previous years, B/W shoreline photography from

the Michigan Department of Natural Resources was used with an approximate scale of 1:5,000.

The vegetative cover for these sample areas was delineated and the percent vegetative cover was calculated using a standard dot grid. Based on these figures, a linear regression between the vegetation cover and time variable was completed for the two sample areas. Sample area #1, with the lowest access potential for ORV use, shows an average vegetation loss of 1.901% per year, while the loss for sample area #2 amounts to 5.889% per year.

Extrapolation of this recession rate justifies, therefore, the prediction that if no access limiting measures will be taken, complete vegetation loss will occur in a relatively short period; for example, area #1 (±14.4 hectares) in 33.5 years or sample area #2 (±16.8 hectares) in 8.3 years.

Relative recession ratios for the sample areas in specific years were also calculated. Clearly visible was the influence of the energy crisis on the ORV use during the period 1973-1974, when gasoline prices went up and gasoline became a scarce commodity for some time.

Based on these quantifications, it is now possible for the Grand Mere Association to present figures relative to the ORV impact to all administrative units involved, and to prevent further deterioration of this unique environment.

Further cooperation relative to the previously outlined problem areas will continue in 1977 between the Grand Mere Association and the MSU Remote Sensing Project.

B. SERVICE ACTIVITIES

Project personnel routinely provide consultation on the use of imagery, educational activities not a part of other user applications, and support materials to foster additional remote sensing applications by new prospective users.

The MSU Project team has acted as a service bureau for an increasing number of potential users. To facilitate this function, Project staff have provided general technical assistance, NASA-produced imagery and training in the use of equipment to a broad range of user agencies.

The type and amount of assitance provided varied among agencies, but has basically included the following activities:

(1) Problem identification;

(2) Data source identification;

(3) Data classification procedures;

(4) Identification of decisions that need to be made (policy and action choices);

(5) Determining data efficiencies to get at the policy and action choices;

(6) Assistance in reviewing available imagery;

(7) Assistance in acquiring available imagery and equipment;

(8) Imagery interpretation training;

(9) Merging remotely-sensed data with other natural resource information.

It is expected that the major benefit to be derived from these service bureau activities is the preliminary education of agencies and individuals to the potential of remote sensing for day-to-day or periodic needs. At an appropriate stage in each agency's program, remote sensing may be the most economical tool to accomplish program objectives.

The following activities relative to the 208 Program are a clear example of this situation in that the Program mandates participating regional agencies to produce a land cover/use inventory which realistically has to be accomplished using remotely sensed data. Clarification of the data sources, classification scheme, and mapping options available constructively contributes to agency decision making.

Furthermore, comparative analysis can be accomplished by effectively merging remotely-sensed land cover/use data with other natural resource information using an integrated, computer-based information system. This provides

a powerful tool for regional analysis and the development of appropriate land/resource use decisions and subsequent on-land actions. Such a system is currently under development at MSU and is reported in sections B2 and B3.

B1. Merging Land Cover/Use Data from LANDSAT, Aerial Photograpny, and Map Sources

Current and accurate land cover/use information is a basic component of natural resource analyses and the land planning process. In fact, its acquisition is often mandated by new legislation and governmental programs, e.g. Section 208 of t e Federal Water Pollution Control Act Amendments of 1972. Recently, many regional planning agencies in Michigan (under Section 208 funding) have acquired land cover/use information through either computer-assisted categorization of LANDSAT data or manual interpretation of aerial photography. Concurrently, there is an increasing demand for interfacing the remotely-sensed inventory data with existing geocoded information storage, analysis, and retrieval systems.

Both photographic and satellite data sources have advantages and limitations with repsect to providing all data elements in an accurate cost-effective manner. LANDSAT data processing is a least-cost method of producing general land cover maps and tabular data for large areas. Planning studies, however, often require more detailed land cover/use information at a accuracy level that is difficult to provide consistently over a range of categories through the LANDSAT data extractive process. Agencies in Michigan are also using grid-based conversion for LANDSAT data. Manual interpretation of aerial photography is a more expensive and time-consuming process than digital multispectral processing, but it yields the more detailed categorization of land cover/uses that many planning activities require. Many of these categories appear to l unobtainable by LANDSAT.

There is a need, therefore, to establish an apporpriate combination of procedures that maximize the effective use of both data sources in the provision of an integrated information system for regional analyses. Such a procedure is currently being investigated and developed at Michigan State University (MSU).

The overall objective of the program described is to provide a grid-based land cover/use data file that is responsive to the specific needs of regional planning agencies by utilizing a cost-effective combination of

of data capture procedures. This is accomplished through the blending of interpreted results achieved by computer-assisted categorization of LANDSAT data and manual interpretation of aerial photography and maps.

Specific tasks accomplished in producing the merged land cover/use data file and subsequent output products are identified in Figure 1. The tasks are divided into two parts: those tasks on the right side of the flow diagram are primarily concerned with the interpretation and geocoding of data from photography and maps, and subsequent data analysis and output; those on the left side are associated with the computer processing of LANDSAT data and the production of the final color-coded maps.

Effective implementation of the merging method is crucially dependent upon selecting the "best" data source for each user-specified category in terms of accuracy and time/cost trade-offs. A test of an implementation procedure is currently underway that has the following three objectives:

1. determine which categories can be consistently identified through routine LANDSAT data categorization procedures at an adequate level of accuracy (85 to 90 percent);

2. determine appropriate alternative data capture procedures employing aerial photography and maps for those categories that LANDSAT cannot accurately identify;

3. evaluate the accuracy and time/cost associated with operationally applying the integrated inventory procedure with reference to inventories developed from a single data source.

Land cover/use data has been assembled for a test area consisting of four townships in central Michigan, representing a diversity of land cover/use conditions. The townships were inventoried through both LANDSAT data processing and manual interpretation of 1:60,000 and 1:120,000 NASA color-infrared photography acquired in 1975. Both data sets have been geocoded to the dominant category per grid cell.

At this time the registration between the LANDSAT and photo-interpreted files are being evaluated. The next step is to identify cells

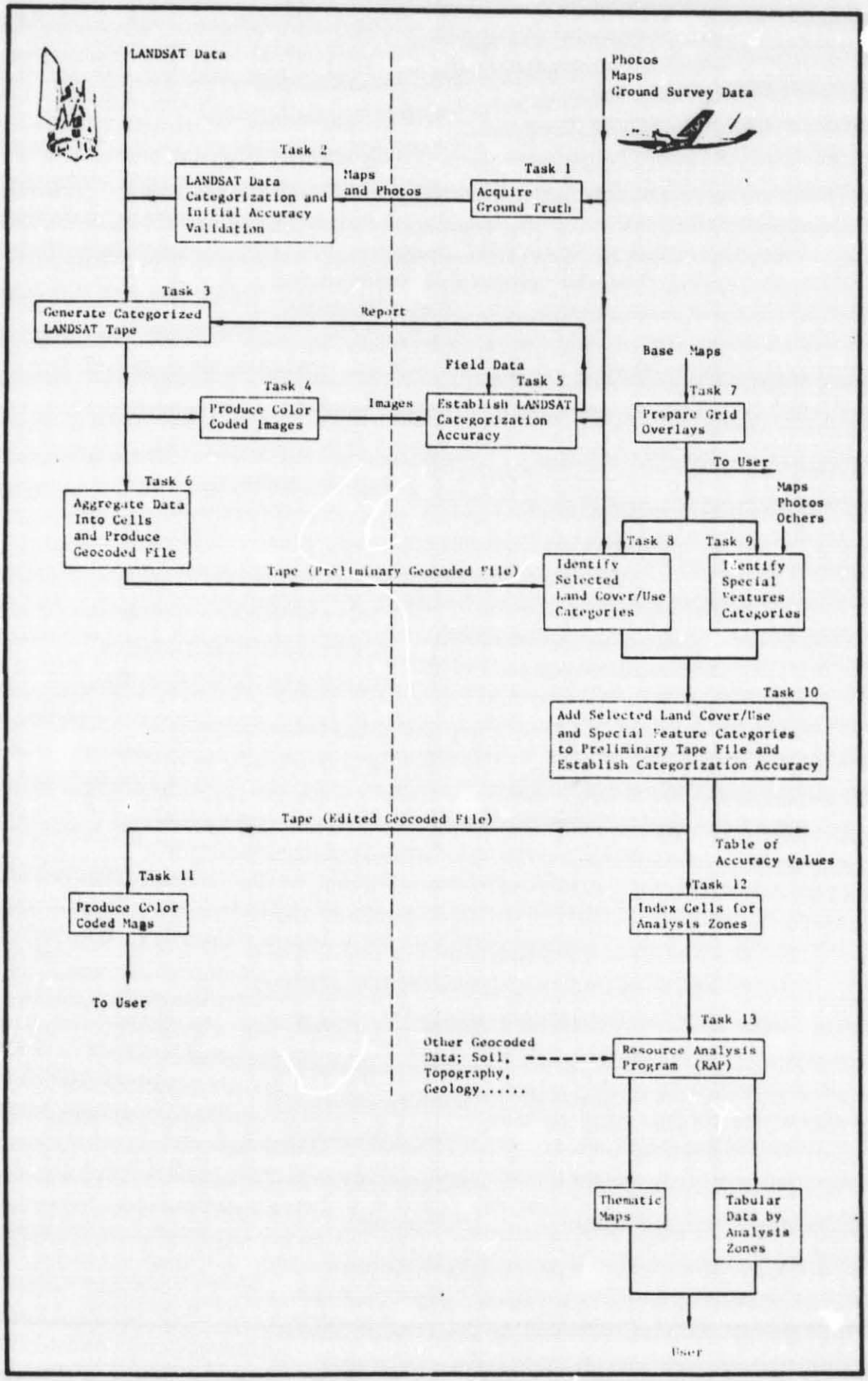

Figure 1. Flow Diagram

mis-categorized by LANDSAT on the basis of the photo inventory. To accomplish this task a cell-level category matrix will be generated from the combined geocoded file. This matrix cross-tabulates the land cover categories identified from LANDSAT data with the categories derived from photo-interpretation.

Analysis of this matrix indicates the initial overall compatibility of the two categorizations. More importantly, the analysis allows the pinpointing of cells that, on the basis of photointerpretive information, have been mis-categorized by LANDSAT processing.

The methodology developed provides a framework by which users can integrate selected data elements from LANDSAT, photographic, and map sources. The procedures and associated computer software to accomplish integration have been developed, however, effective implementation requires indentifying the optimum data source for each land cover/use category. This is a complex issue which has warrented further investigation prior to operationally applying the integrated inventory method. To determine the "best" data capture source and procedure for each category, both LANDSAT and photo categorization of land cover/use in four townships in central Michigan are being analyzed. The objective is to identify a combination of data sources and procedures that provide a more detailed, accurate, and cost-effective land cover/use inventory compared with deriving all the data from a single source.

B2. Resource Analysis Program

Many of the activities in which the RSP has participated have been involved with computer-based information storage, analysis, and display systems. In these activities, data gathered with remote sensing forms the base, against which other spatial data are comparatively analyzed. In addition to providing a more useful picture of the study problem, these information systems also provide an expanded opportunity for the role of remote sensing in resource-related decision making.

In response to the need for an effective analytical/mapping software package, the Project developed the Resource Analysis Program (RAP). RAP is a general utility, user-oriented software system, designed to operate off grid-geocoded data bases, including categorized LANDSAT data.

RAP features a variety of multi-task analytical and mapping phases (Table 1). Each phase operates independently, but through a common data structure. This permits the user to link the various phases into an analysis strategy, suited for many resource study problems.

This software system was initially tested in Windsor Township, Eaton County, Michigan under contract to the Tri-County Regional Planning Commission (see Section C1 of this Report). The test resulted in an eleven map portfolio (example Fig. 2) focussing upon non-point source pollution and waste disposal (Table 2).

RAP is currently being developed to include an agricultural land value model. This model will develop a base land sales value, from which assessments can be made. The procedure is based upon that recommended by the Michigan Tax Commission. The Eaton County Equalization Office is serving as the user agency. This agency has repeatedly expressed the intention of incorporating this approach into their procedures.

TABLE 1

PHASES OF RAP AND THEIR FUNCTION

	Phase	Function
1.	AGVALUE	Determines State equalized assessment values for agricultural land
2.	DELETE	Delete a factor from the Work File
3.	END	Stops execution of RAP
4.	EROSION	Calculate on-site erosion susceptibility according to the Universal Soil Loss Equation
5.	GROUP	The factor values are grouped and each group is assigned an integer number (mapping directive), default or user specified
6.	INVERT	Invert the numerical range of a factor
7.	LIST	Lists the factor names currently on the Work File
8.	MAPIT	Constructs symbol maps with a plotter
9.	NORMALIZE	Normalize the numerical value of a factor between user specified or default range
10.	OVERLAY	Generates comparative site indices by overlay process with weighting values
11.	PRINTERMAP	Constructs symbol maps from a line printer
12.	SCALE	Generates comparative site indices by a multi-dimensional scaling algorithm
13.	SOILTABLE	Retrieves soil and/or slope related properties
14.	SORT	Assigns a value (mapping directive) to pair-wise combination of factors
15.	STATISTICS	Generates frequency table for factor values
16.	UPDATE	Updates the master file by adding or deleting factors
17.	WORKFILE	Retrieves factors from master file and places them on the Work File

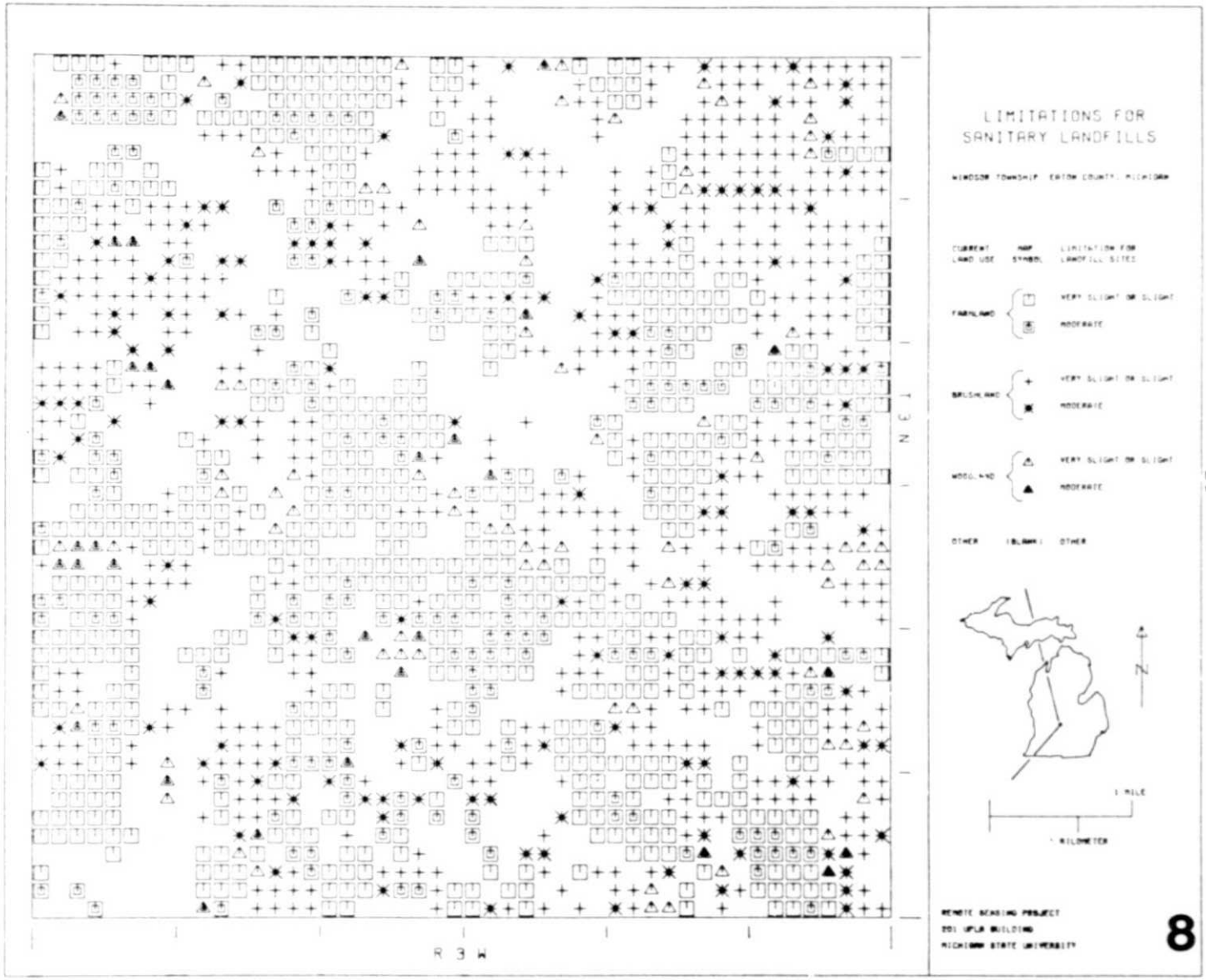

Figure 2: Example of a mapping option that displays land cover/use (nominal scale data) and limitations for sanitary landfills (ordinal scale data).

MAP TITLE	DATA USED IN ANALYSIS								PHASES OF RAP USED									
									Analytical							Map Symbols		
	Land cover/ use	Soils	Slope	Elevation	Depth to Bedrock	Drift Per- meability	Water bodies	Data de- veloped with RAP	EROSION	GROUP	OVERLAY	SCALE	SOILTABLE	SORT	STATISTICS	Alphabetic	Octagons	Geometric
1. Surface Topography and Natural Features				x														
2. Land Cover/Use	x														x	x		
3. Potential Ground Water Recharge Management Areas	x	x	x		x	x	x			x		x		x				x
4. Soil Phosphorus Availability		x											x				x	
5. Potential On-Site Erosion		x	x						x	x							x	
6. Potential Phosphorus Loading Source Areas		x						x1/					x	x				x
7. Limitations for Septic Tanks	x	x	x										x	x				x
8. Limitations for Sanitary Landfills	x	x	x					x2/		x		x		x				x
9. Limitations for Spray Irrigation	x	x	x					x2/		x		x		x				x
10. Soil Stability		x											x				x	
11. Limitations for General Agriculture	x	x	x										x	x				x

1/ Potential On-Site Erosion

2/ Limitations to Ground Water Recharge

TABLE 2. MAP PRODUCTS AND DATA ANALYZED BY RAP FOR THE WINDSOR TOWNSHIP STUDY

B3. Users Guide to Aerial Imagery of Michigan

Preparation of the guide has been a continuing effort for the past two years. It started as a simple revision of an existing guide (Users Guide to High Altitude Imagery of Michigan) but has subsequently developed into an undertaking of considerable magnitude as information on the full range of remotely-sensed imagery available of Michigan has been incorporated into the new guide.

A final draft of the guide has been prepared during this reporting period. The Agricultural Experiment Station at MSU has accepted the guide for publication, and its editorial staff is presently reviewing the draft. A brochure announcing the forthcoming release of the guide will be distributed in the next few months. The Michigan Department of Natural Resources intends to financially support a portion of the publication costs. An initial printing of 1,500 to 2,000 copies will be made.

SUMMARY

The Guide to Aerial Imagery of Michigan provides a single-source reference document which identifies aerial imagery available for areas in the state. It contains comprehensive indexes to: a) NASA LANDSAT satellite and Skylab space craft imagery; b) high altitude imagery acquired by NASA RB57 and U2 aircraft; c) aerial photo coverage of counties secured by various federal and state agencies; and d) photo coverage of local areas obtained by state agencies such as the Michigan Department of Natural Resources and by aerial survey firms.

Each index presents information on photo coverage, date, scale, film type and source agency in a map or computer listing format and is preceded by general background information and appropriate explanatory comments for effective use of the section. To further assist users, a brief overview of the fundamentals of aerial imagery and a section documenting basic procedures for imagery acquisition is included.

The guide is printed on 8½" X 11" paper drilled to fit standard three ring binders and includes examples of black and white and color imagery.

CONTENTS

C. CONTRACT ACTIVITIES

Due to Project demonstration activities, there has been an increasing need by public and private agencies within the state for the utilization of remote sensing technology on a periodic project basis. In most cases, however, agencies lack the appropriate equipment and the photo interpretative skill to meet the need. They usually do not retain staff with photo interpretation expertise because their services are not needed on a continual basis. However, most agencies would like to have a means of acquiring such skills for limited periods to complete specific projects. MSU now has the capability to meet this need through either a contractual or student support basis due to the development of on-campus faculty and student remote sensing expertise by Project personnel.

All of the contract activities have occurred as a direct spin-off from Project demonstration activities and demonstrate the commitment of funds by other agencies to the use of remote sensing. They have been included in this report in order to substantiate the repetitive need for photo-derived information and the operational capability of previously demonstrated remote sensing procedures for specific data acquisition needs.

C1. Windsor Township Natural Resources Information System

Tri-County Regional Planning Commission
2722 East Michigan Avenue
Lansing, Michigan 48912

The Tri-County Regional Planning Commissi contracted with the Remote Sensing Project to demonstrate the ness of a computer-based Natural Resource Information System (N) for regional water quality studies. This study served as a prototype, providing the first opportunity for the Commission to evaluate the effectiveness of a computer system to integrate remote sensing data with other natural resource information. The immediate objective of the contract was to develop an eleven map portfolio, with accompanying technical report, specifically focussed on landscape features affecting non-point source pollution and waste disposal. Longer term objectives include future system demonstrations for other regional, county and local agencies.

The NRIS was developed for Windsor Township, Eaton County, Michigan. This area was chosen because of a very rapidly developing land base, large acreage of prime and unique farmlands, and the rural-to-urban pressures being placed on the Township.

The data base for the Windsor Township NRIS was constructed from commonly available information sources: topographic map, land cover/use map, soil map, and water well records. This data was recorded for each 10-acre (4 hectare) piece of land, resulting in a matrix-type data structure of 48 rows and 48 columns. The Resource Analysis Program (RAP), developed at MSU, was the analytical/mapping software system used for the study.

The Windsor Township study was completed and all contract items delivered in August, 1976. The Commission is currently evaluating the project, including training of Commission staff in the use of RAP. In addition, Project staff are currently developing additional analytical and mapping programs for assisting the Eaton County Equalization Office for farmland equalization using the Windsor Township NRIS and RAP.

C2. Comprehensive Resource Inventory and Evaluation System (CRIES) Project

In the last quarter of 1976, the U.S. Department of Agriculture, Economic Research Service (ERS) contracted with the Remote Sensing Project to provide consulting services for remote sensing and geographic data file construction. The ERS is developing an econometric model of the agricultural sector of the Dominican Republic. This national policy model operates off a land-based information system which includes land use.

The Remote Sensing Project is designing a data file system that is compatible with categorized LANDSAT data. The Intralab at NASA, Goddard, is also cooperating by providing categorized data for two test sites in the Dominican Republic. The intent of this effort is to evaluate the usefulness and cost-effectiveness of LANDSAT in future ERS projects of this nature.

In addition to providing consulting servies for remote sensing, MSU staff are designing and constructing a spatial data file for the Dominican Republic. The file consists of over 100,000 grid cells based on the square kilometer grid of the UTM earth referencing system. Procedures have been developed to geo-code spatial data (crop types, soil/climate maps, political boundaries, and so forth). This data file will provide the necessary resource data for the ERS model. In addition, the data file will be transferred to the Dominican Republic (after suitable training) for in-country use in resource evaluation.

Appendix

PUBLICATIONS and PRESENTATIONS

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1. "Investigation of Land Resource Use in Southeast Michigan." J. G. Ahl, M. G. Boylan, D. L. Mokma, W. L. Myers, S. W. Schar and R. D. Vlasin. Proceedings of the Eighth International Symposium on Remote Sensing of Environment. pp. 23-33. Environmental Research Institute of Michigan. Ann Arbor, Michigan. October 1972.

2. Remote Sensing in Michigan for Land Resource Management: Highway Impact Assessment. Environmental Research Institute of Michigan. Ann Arbor, Michigan. December 1972. 107 p.

3. Users Guide to High Altitude Imagery of Michigan. Mark C. Sullivan and Stephen W. Schar. Michigan State University. East Lansing, Michigan April 1973. 39 p.

4. Proposed Land Use Classification System. Project for the Use of Remote Sensing in Land Use Policy Formulation. Michigan State University. East Lansing, Michigan. July 1973. 26 p.

5. Proceedings of the Conference on Practical Applications of Remote Sensing. (May 15-16). Ken Keifenheim and Stephen W. Schar, Editors. Michigan State University. East Lansing, Michigan. September 1973. 72 p.

6. Image Interpretation for a Multi-Level Land Use Classification System. Mark C. Sullivan and Gary Higgs. Michigan State University. East Lansing, Michigan. September 1973. 35 p.

7. The Use of Color Infrared Photography for Wetlands Mapping: With Special Reference to Shoreline and Waterfowl Habitat Assessment. William R. Enslin. Michigan State University. East Lansing, Michigan. October 1973. 33 p.

8. Upper Kalamazoo Watershed Land Cover Inventory. Benjamin Richason III and William R. Enslin. Michigan State University. East Lansing, Michigan. October 1973. 39 p.

9. "A Comparative Analysis of Remote Sensing Scale/System Attributes for a Multi-Level Land Use Classification System." Mark C. Sullivan and Gary Higgs. Proceedings of the American Society of Photogrammetry Fall Convention. pp. 335-367. American Society of Photogrammetry. Falls Church, Virginia. October 1973.

10. Evaluating Data Collection Costs with Emphasis on Remote Sensing. Marilyn J. Bennett. M.S. Thesis, (unpublished). Michigan State University. East Lansing, Michigan. 1974. 146 p.

11. "Focus on Community Development." Michigan Science in Action. Report No. 26. Michigan State University Agricultural Experiment Station. East Lansing, Michigan. February 1974.

12. "Resource Inventory for Multi-Agency Watershed Planning." W. R. Enslin, B. Richason III and M. J. Bennett. Remote Sensing of Earth Resources. Volume III. pp. 653-670. The University of Tennessee Space Institute. Tullahoma, Tennessee. March 1974.

13. "The Use of Color Infrared Photography for Wetland Assessment." William R. Enslin and Mark C. Sullivan. Remote Sensing of Earth Resources. Volume III. pp. 697-720. The University of Tennessee Space Institute. Tullahoma, Tennessee. March 1974.

14. "Operational Remote Sensing for Land Capability Analysis of Michigan." Myles G. Boylan and Stephen W. Schar. Presented at Michigan Academy of Science, Arts and Letters. Environmental Studies Section. Michigan State University. East Lansing, Michigan. March 1974.

15. "A Quick Procedure for Developing Environmental Planning Inventories in Michigan." Stephen W. Schar. Presented at Michigan Academy of Science, Arts and Letters. Environmental Studies Section. Michigan State University. East Lansing, Michigan, March 1974.

16. "Color-Infrared Airphotos as a Source of Forest Resource Data for Regional Information Systems: Putting Remote Sensing Technology to Work in Northwestern Michigan." William D. Hudson and Wayne Myers. Presented at Michigan Academy of Science, Arts and Letters. Environmental Studies Section. Michigan State University. East Lansing, Michigan. March 1974.

17. "Collection and Manipulation of Land Use Information for Corridor Analysis." Mark C. Sullivan. Presented at Michigan Academy of Science, Arts and Letters. Environmental Studies Section. Michigan State University. East Lansing, Michigan. March 1974.

18. Remote Sensing in Michigan for Land Resource Management: Waterfowl Habitat. A. N. Sellman, I. J. Sattinger, L. B. Istvan, W. R. Enslin, W. L. Myers, M. C. Sullivan. Environmental Research Institute of Michigan. Ann Arbor, Michigan. April, 1974. 43 p.

19. "Resource Analysis Applications in Michigan." S. W. Schar, W. R. Enslin, I. J. Sattinger, J. G. Robinson, R. S. Fellows, K. R. Hosford and J. G. Raad. Summaries of the Ninth International Symposium on Remote Sensing of Environment. pp. 236-237. Environmental Research Institute of Michigan. Ann Arbor, Michigan. April 1974.

20. "Design Concepts for Land Use and Natural Resources Inventories and Information Systems." R. L. Shelton and E. E. Hardy. Summaries of the Ninth International Symposium on Remote Sensing of Environment. pp. 53-54. Environmental Research Institute of Michigan. Ann Arbor, Michigan. April 1974.

21. "Resource Analysis Applications in Michigan." S. W. Schar, W. R. Enslin, I. J. Sattinger, J. G. Robinson, R. S. Fellows, K. R. Hosford, and J. G. Raad. Proceedings of the Ninth International Symposium on Remote Sensing of Environment, Vol. III, pp. 2073-2081. Environmental Research Institute of Michigan. Ann Arbor, Michigan. April 1974.

22. "Design Concepts for Land Use and Natural Resources Inventories and Information Systems." Ronald L. Shelton and Ernest E. Hardy. Proceedings of the Ninth International Symposium on Remote Sensing of Environment. Vol. I. pp. 517-536. Environmental Research Institute of Michigan. Ann Arbor, Michigan. April 1974.

23. Determining Regional Soil Losses Resulting from Construction Activities. S. E. Tilmann, D. L. Mokma and R. L. Stockman. Project for the Use of Remote Sensing in Land Use Policy Formulation. Michigan State University. East Lansing, Michigan. January 1975. 21 p.

24. "Improved Resource Use Decisions and Actions through Remote Sensing." M. Boylan, W. R. Enslin, R. Hill-Rowley and R. D. Vlasin. Abstracts of the NASA Earth Resources Survey Symposium. pp. 231-233. Johnson Space Center. Houston, Texas. June 1975.

25. Michigan Land Cover/Use Classification System. Michigan Land Use Classification and Referencing Committee. Office of Land Use, Department of Natural Resources. Lansing, Michigan. July 1975. 60 p.

26. "Improved Resource Use Decisions and Actions Through Remote Sensing." R. Hill-Rowley, M. Boylan, W. Enslin and R. Vlasin. Proceedings of the NASA Earth Resources Survey Symposium. Vol. IC. pp. 1747-1767. Johnson Space Center. Houston, Texas. September 1975.

27. "Improved Resource Use Decisions and Actions Through Remote Sensing." M. Boylan, W. R. Enslin, R. Hill-Rowley and R. D. Vlasin. Summaries of the Tenth International Symposium on Remote Sensing of Environment. pp. 112-113. Environmental Research Institute of Michigan. Ann Arbor, Michigan. October 1975.

28. "Survey of Recent Resource Applications in Michigan." W. C. Taylor, W. R. Enslin, C. E. Olson, Jr., and I. J. Sattinger. Summaries of the Tenth International Symposium on Remote Sensing of Environment. Ann Arbor, Michigan. October 1975.

29. "Improved Resource Use Decisions and Actions through Application of High Altitude Color-Infrared Imagery." W. R. Enslin, M. Boylan. R. Hill-Rowley and R. D. Vlasin. Proceedings of Applications of Remotely-Sensed Data in North Central United States. p. 35. American Institute of Aeronautics and Astronautics and Bendix Aerospace Systems Division, Ann Arbor, Michigan. November 1975. (Abstract).

30. "Improved Resource Use Decisions and Actions Through Remote Sensing." M. Boylan, W. R. Enslin, R. Hill-Rowley and R. D. Vlasin. Proceedings of the Tenth International Symposium on Remote Sensing of Environment. pp. 793-801. Environmental Research Institute of Michigan. Ann Arbor, Michigan. October 1975.

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

32. "Remote Sensing of Abandoned Vehicles for County Planning," Salleh M. Nor. Remote Sensing of Earth Resources, Vol. V, edited by F. Shahrokhi, The University of Tennessee Space Institute, Tullahoma, Tennessee, 1976. (In Press).

33. "Improved Land Use Decisions and Actions in Michigan Through Remote Sensing." Richard Hill-Rowley and William R. Enslin. Proceedings of the Association of American Geographers, Vol. 8. pp. 132-136. Association of American Geographers, Washington, D. C. April 1976.

34. "Remote Sensing for Identifying Essential Lands." William R. Enslin. Presented at the Fourth Annual Michigan Land Use Policy Conference. Michigan State University, East Lansing, Michigan. April 1976.

35. "Report on the Land Use/Cover Map and Soil Limitations Maps for the 1865 Treaty Lands of the Saginaw-Chippewa Indian Tribe." NASA Remote Sensing Project, Michigan State University, East Lansing, Michigan. May 1976, 19 p. (Mimeographed).

36. "Soil Management Groups: A useful tool for interpretive and glacial maps." S. E. Tilmann and G. Larson. Presented at the North-Central meeting of the Geological Society of America, Kalamazoo, Michigan. April 1976.

37. "Evaluating limitations to ground water recharge by a multi-dimensional scaling model." S. E. Tilmann. Presented at the North-Central meeting of the Geological Society of America, Kalamazoo, Michigan. April 1976.

38. "A Strategy for Land Use/Cover Data File and Map Preparation." Stephen E. Tilmann and Robert H. Rogers. Bendix Aerospace Systems Division. Ann Arbor, Michigan. May 1976. 21 p. (Mimeographed).

*39. "1972 Land Cover/Use Inventory of Clinton, Eaton and Ingham Counties, Michigan." Remote Sensing Project, Michigan State University, East Lansing, Michigan. June 1976. 49 p. (Mimeographed).

*40. "Report on the Natural Resource Information System Developed for the Tri-County Regional Planning Commission." Remote Sensing Project, Michigan State University, East Lansing, Michigan. July 1976. 95 p. (Mimeographed).

*41. "Identifying and Mapping Forest Resources From Small-Scale Color Infrared Airphotos." W. D. Hudson, R. J. Amsterburg Jr., and W. L. Myers. Michigan Agricultural Experiment Station Research Report 304. Michigan State University, East Lansing, Michigan. July 1976. 12 p.

*42. "Documentation: 1970 SEMCOG Land Use Inventory." Johnson, Johnson and Roy, Inc. Ann Arbor, Michigan. July 1976. 22 p. (Mimeographed).

*43. "Engineering properties of soil management groups." S. E. Tilmann and D. L. Mokma. Michigan Agricultural Experiment Station Research Report 313. Michigan State University, East Lansing, Michigan. August 1976. 12 p.

*44. "Soil management groups and soil erosion control." S. E. Tilmann and D. L. Mokma. Michigan Agricultural Experiment Station Research Report 310. Michigan State University, East Lansing, Michigan. August 1976. 16 p.

*45. "Mapping of Remote Sensing Data for Michigan Agencies." Kenneth E. Keifenheim. Presented at the East Lakes Division Meetings, Association of American Geographers, Ann Arbor, Michigan. October 15, 1976.

*Published or presented this reporting period.