IMPROVED RESOURCE USE DECISIONS AND ACTIONS THROUGH REMOTE SENSING

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By R. Hill-Rowley, M. Boylan, W. Enslin, and R. Vlasin
Michigan State University, East Lansing, Michigan

ABSTRACT

Michigan State University continues to be engaged in applications of remote sensing to a considerable variety of needs of governmental agencies and private organizations in order to facilitate the operational uses of remote sensing for improving management decisions and actions concerning resource uses. Cumulative experience reveals that operational applications are not all the same and that it is important to distinguish between at least two categories, namely (1) first generation, or direct-action; and (2) second generation or indirect, delayed-action applications. Making this distinction is crucial for many reasons, such as justifying proposed undertakings, guidance for research design, methodolgy requirements, budget allocations, and many others.

From among applications completed during 1974-75, seven case studies are offered in illustration of the many contrasts which can be drawn between first and second generation application studies. These include: (1) multi-agency river basin planning; (2) corridor assessment and route location for highway location together with improvement of county-level planning decisions; (3) improving timber management practices; (4) enforcement of new state statutes; (5) county-wide open space preservation; (6) land value reappraisal relative to property tax equalization; and (7) optimizing agri-business processing plant locations.

INTRODUCTION

Governmental agencies in Michigan at the state, regional and local levels are presently investigating and selectively implementing findings derived from applications of remote sensing techniques. Similarly, a number of private organizations are experimenting with this technology as a means of performing their missions more effectively. Michigan State University, with support from the Office of University Affairs of the National Aeronautics and Space Administration, has been actively involved in demonstration projects and a variety of technical assistance efforts to facilitate the operational uses of remote sensing for improving the decisions and actions for many of these management needs.

After several years of working with a variety of public and private user-agencies in experimenting with many different kinds of applications, the MSU investigators have developed certain perceptions about operational applications which they believe can be helpful to others. By this presentation, the MSU team wishes to offer for examination a summary review of a series of applications as illustrations of how some operational applications of remote sensing technology improved users' performance and improved decisions subsequently made and the effectiveness of actions ultimately taken .... all of which steps are important phases in the process of "management". Management is viewed as a continuum within which there are many interwoven, interrelated strands, and two most essential functions of management for the purposes of this essay, are the making of decisions and the subsequent taking of actions.

Experience demonstrates that these phases or functions of management are interrelated to varying degrees; but relative to decisions and actions being influenced by remote sensing techniques, the factor of TIME-DISTANCE between the making of a decision and the taking of an action, together with the relative generality or specificity of information derived from the remote sensing input reveal a number of important distinctions which should be made between certain kinds of applications. Applications are clearly not one general, uncatalogued collection of remote sensing uses. The MSU experiences revealed that it is important to make distinctions at least between what applications will (a) have direct impacts on a given situtation with a strong likelihood of generating, in a short interval of time, both decisions and implementing actions; and (b) those applications which will produce results over the long term with probably an appreciable time lag in the intervals before results begin to be displayed. These judgments then led to separating operational applications into two categories:

(1) First generation, or direct-action applications.
(2) Second generation, or indirect, delayed-action, multiple-faceted applications.

These two categories of applications are not sharply separable; they do overlap and sometimes conflict. This presentation is intended to show, among other features, for example, how the first generation, direct-action type does not only improve the effectiveness of the action(s) taken in support of decisions made; but provides reliable bases for making the decisions in the first place and shortens the time span between when the decisions are made and actions are taken.

Of the many possible differences between these two generation types, the following are worth noting:

1. For one type (first generation), the application is made for a very specific situation which can be located, identified, and evaluated in a span of weeks or days.. .....while in the other (second generation), the application is made in response to a considerable breadth of general, not immediately specific, needs; usually requires a long period of time (months, years) to identify and inventory characteristics; and evaluations don't usually lead into immediate decisions, let alone actions. Multiple decisions and actions can flow out of this latter type of application; and sometimes other uses for the derived information develop which had not been anticipated.

2. For one type the situation typically is small in scale, such as a functional site or a localized problem.......while in the other type the situation is usually large in territorial magnitute and/or ramifications, such as a river basin or metropolitan region.

3. For one type, the time intervals between initiation of investigation, completion of all research evaluation and reporting, making of decisions, and taking actions are characteristically brief. For the other, these intervals are much longer possibly stretching into multiple months or years.

4. For one, the remote sensing application makes possible the improvement of the quality and effectiveness of actions taken which lead from decisions previously made; but quite different.......such as the passing of an ordinance which establishes certain standards and/or prohibits certain kinds of practices. Remote sensing information may reveal violations of the ordinance thereby providing clear evidence for enforcing its provisions. Under the other type of application (second generation) remote sensing can provide a means for the mere purpose of making decisions more wisely and effectively, and may never lead to actions directly traceable to the original information base.

   Most importantly, the data derived from this type can be useful for other research operations, not necessarily related directly, by being combinable with other kinds of environmental and/or social information.

5. For one, all steps taken are unprecedented or innovative, calling for experimental routines to develop prototypes and indicators. For the other, after research design is tested and readjusted, much of the work becomes repetitive.

These several distinctions are crucial because they permit differentiation between two different needs that user-groups have, each requiring different information inputs which call for different methodologies and procedures for the research design, budget determinations and commitments, personnel logistics, tabulation and presentation formats and analysis routines, data storage and retrieval. The time dimensions can also be a governing factor as to feasibility and what routines need to be utilized.

As noted previously, these perceptions have emerged after many operational application experiences which were varied.......in type of situation, problem, etc.; in scope and magnitude of study; as to user-agency type; as to use of derived information; as to length of time intervals and overall time required to complete the mission.

From among those completed during the 1974-75 year, seven case studies are offered in illustration of the many contrasts which can be drawn between first and second generation studies. These selections include: (1) multi-agency river basin planning; (2) corridor assessment for highway routing and improvement of county-level planning decisions; (3) developing effective timber management practices in areas of scattered forest holdings; (4) enforcement of a recently enacted State of Michigan Soil Erosion and Sedimentation Control Act (P.A. 347-1972); (5) measures and procedures for local implementation of the new State of Michigan Farmland and Open Space Preservation Act (P.A. 116-1974); (6) appraisal standards and applications for land value reassessment relating to property taxes; and (7) optimizing agri-business processing plant locations.

METHODOLOGY

To make such operational applications possible, a basic methodology has to be structured as a prefatory step. Common to any applications research dealing with land features is the matter of following some system for classifying the characteristics of whatever features are to be considered. In Michigan, the Office of Land Use of the State Department of Natural Resources (OLU-DNR) formed a Classification and Referencing Advisory Committee which, in the spring of 1974, completed a working draft of a land cover/use classification system designed to be applicable to any part or all of the State's terrain. The system was especially structured to use both high altitude and spacecraft-generated imagery.

At the completion of the first edition of its classification system, the Committee recommended that it be field tested at the regional and local level and then be appropriately revised as needed corrections became evident. Such field testing was judged to be indispensable before distribution was made of the classification system for any general or particular use.

The Michigan State University Program had five of its investigators serving on the Classification and Referencing Advisory Committee, and because of the demonstrated interest and capabilities of the MSU staff in operational uses of remote sensing, the Program was requested to participate in the testing of operations, working jointly with the West Michigan Regional Planning Commission staff (WMRPC - a nine county official region headquartered in Grand Rapids) and with the State DNR Office of Land Use. In this joint effort the MSU team tested the classification system in a multi-level inventory of two counties and four townships in the WMRPC region.

The interpretation was accomplished using high altitude color infrared photography (1:120,000 and 1:60,000) and medium altitude black and white photography (1:40,000). Information obtained after interpretation was recorded for four hectare gird cells on computer coding forms which are compatible with the WMRPC computer-managed information system.

As a result of the findings of the combined field test and review activities, several changes were made to the system, such as sharpening or broadening definitions, dropping some categories and adding others, etc. The intent of the overall effort was to develop a classification system which could serve the land cover/use inventory purposes throughout Michigan with as much versatility as possible. The MSU Program utilization experiences are repeatedly confirming the effectiveness of this system in a number of different features of operational applications. For example, many of the case studies about to be presented demonstrated that reliable comparability could be made between disparate applications by use of this classification system.

CASE STUDIES

The following presentation expands upon each of these seven case studies by providing summary descriptions of the principal features. (See Figure 1 for locations)

Case Study (1) Second Generation Type Application

Kalamazoo River Basin Study.- Land development in Michigan watersheds over the past two to three decades has generated an aggregate demand for uses of land and water for different purposes which has increased substantially the pressures on water and related land resources. This situation has intensified the need for workable and forceful policies which can monitor and manage resources so that further environmental degradation can be averted.

To achieve any progress in this effort reliable, useful, up-to-date information is needed. With so many different kinds of agencies playing a crucial role in conservation and monitoring processes, coordination is indispensable. In order to facilitate coordinated conservation measures, watershed planning agencies require the very best, latest, and in-depth information, especially information on current characteristics, land cover, and land use. In the past, resource information has been obtained principally via the "Conservation Needs Inventory" and from similar and related programs. All of these utilize an on-the-ground sampling methodology which are not only questionable as to accuracy; but do not meet the need for information on the spatial distribution of categories within a survey area. This situation has led resource planners and policy makers to search for more accurate, more complete, and less extrapolative data acquisition procedures.

The Kalamazoo River Basin, located in Southwest Michigan, is currently the subject of a three year resource planning effort designed to culminate in a series of action programs for the sensible use of land and water resources in the multi-county area. The principal units behind this effort are the River Basin Planning Group (RBPG) of the Soil Conservation Service, U.S. Department of Agriculture (SCS + USDA), the Economic Research Service, the U.S. Forest Service, and the Michigan Water Resources Commission.

Working in collaboration, these several agencies formed a Technical Committee which has been the action arm for the group. The Technical Committee prepared an extensive outline of information needs and research strategies which strongly emphasized the fundamental need for a detailed land cover inventory. The land cover inventory was considered as the major component of basic information which made possible such studies as analysis of flood plain problems, sediment control, identification of wildlife habitats, recreational planning, agricultural crop production and forestry.

At the request of the River Basin Collaborative, the Michigan State University Remote Sensing Research Program was requested to conduct a land cover inventory for the entire 8,600 square kilometer Kalamazoo Basin. The inventory was completed in two stages. The first involved a demonstration of the scope and efficiency of available RB-57 color infrared imagery (CIR) in providing land characteristics data required by the RBPG for the component 2,800 square kilometer Upper Kalamazoo Watershed. A comparative cost analysis framework used to evaluate different methods of interpretation and image types possible in completing the task was also part of the overall mission.

Upon the successful completion of these tasks, the second stage of inventory was undertaken on a contractual basis. This consisted of inventorying land cover characteristics for the substantial remainder of the Kalamazoo watershed.......the 5,800 square kilometers of the Lower Basin. These data were derived from commercially flown and processed color infrared imagery at 1:31,680, with all costs shared by the participating agencies. At the same time the counties within the watershed participated with supplemental funding to have additional territory photographed for those remaining segments of each county that were outside the boundaries of the watershed configuration.

The data collection for this Lower Basin utilized some notable differences in methods, in contrast to those employed for the first stage, i.e., the Upper Basin, namely: (1) commercially flown and processed CIR imagery was used; (2) the user-agencies paid for the imagery; (3) the classification system was revised; (4) inventory data were recorded on U.S. Geological Survey topographic quadrangle base maps; and (5) land use area distribution was calculated in terms of soil associations.

A summary of the inventory characteristics for the combined Upper and Lower Kalamazoo Basins project is displayed on Table I. An illustration of the method of data portrayal on maps is displayed by one example in Figure 2.

Uses of the Kalamazoo Basin Information.- As previously noted, this category of application, the "second generation", or "indirect, delayed-action" type implies long term and, very likely, indirect uses for the derived information to serve as intelligence for the planning and management of the lands and waters of the river basin system.

Already information developed for the Upper Basin (completed in 1974) is being utilized. As reported in an earlier paper of the MSU program in March 1974:

> Several user agencies have found applications for the information obtained in the Upper Kalamazoo Watershed pilot study. The U.S. Soil Conservation Service is applying the study data to analyze flood plains, sediment problem areas, land use, and agricultural water use and pollution. The SCS is also making use of the data in conjunction with the Michigan Department of Natural Resources (DNR) in an examination of fish and wildlife habitats, and area recreational developments. The SCS also plans to use the data in coordinated studies with the Natural River Section of the DNR to analyze natural and scenic river and unique land areas, and in environmental and esthetic quality planning. This agency is also utilizing the study data for defining various activities on land that have been designated as prime agricultural land, and also for determining erosion rates for particular soil groups on specific land uses. Finally, the SCS is cooperating with the Economic Research Service of the USDA in updating and validating the Conservation Needs Inventory.
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> The U.S. Forest Service is using the inventory data in several analyses. The forest type and acreage data contained in the inventory are being correlated with soils information to determine productivity estimates of forest resources in the Upper Kalamazoo Watershed. The Forest Service is also using the study data to compile coefficient indices which represent qualitative evaluations of multiple uses of a mixture of resources in a given area. The coefficient indices will assist in determining management strategies for the optimum multiple use of resources in the watershed. This agency is also using the data in specific studies designed to analyze forested areas near urban concentrations to determine if they should be preserved.
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> In addition to use by federal and state agencies, county planning commissions

will also use the data to update and validate land cover and use information in their counties. ("Resource Inventory for Multi-Agency Watershed Planning". W.R. Enslin, B. Richason III and M.J. Bennett. In Remote Sensing of Earth Resources Conference. Volume III. pp. 653-670. The University of Tennessee Space Institute. Tullahoma, Tennessee. March, 1974.)

For a second generation operational application, these are quite an extensive and varied catalog of early uses. Such prompt application of derived information suggests a long term unfulfilled need for solid, timely, relevant comparative intelligence on land and water characteristics developed on a unified, regional scale.

By completing this dual-basin study, an accurate, cost-efficient, general inventory of land use has been generated which will provide the basis for many possible series of decisions in several spheres. In time some of the decisions will be translated into actions; but it is conceivable that other information needs may be required for some actions to be effectively implemented.

Case Study (2) Second Generation Type Application

Grand Traverse County Special Environments Inventory.- This study was a combination of a general land cover inventory and a special environments analysis conducted in collaboration with a group of public agencies. Grand Traverse County, located in the northwest corner of Michigan's Lower Peninsula, urgently needed a network of land and other resource information for multiple purposes. At the request of the Grand Traverse Bay Regional Planning Commission (GTBRPC), the Michigan State University Remote Sensing Program joined in the collaborative endeavors of the County Planning Commission, the Michigan Department of State Highways and Transportation, and the Office of Land Use within the Michigan Department of Natural Resources (DNR) in developing a general 24 category land cover inventory together with the identification and "flagging" of a series of special environments. This dual final product provided a wider scope and capability than was required in the Kalamazoo Basin project.

The special environments classification consisted of 34 special features which provide information relative to prime agricultural lands, wetlands, steep slopes, forested areas, critical soil conditions, and areas of prominent social values, including: (1) developed, commercial, residential and industrial areas, (2) scenic areas, (3) historic areas, (4) unique wildlife areas, and (5) precious wildnerness situations. A summary of the inventory characteristics for the Grand Traverse Project is given in Table II.

The inventory data were derived from 1:36,000 color infrared imagery using a four hectare grid and were recorded on specially-designed computer coding forms. These forms were constructed so that up to six land cover and seven special environment codes could be recorded for each four hectare cell.

With the raw data in this form, a specific locational indicator for each cell was assigned which then offered the possibility of analysis, evaluation and presentation of the generated information by computer methods. Real world constraints and priority weightings can thereby be established as operating rules for information retrieval by which means information can be made accessible and useful for a variety of disparate uses.

One display technique which has been used is a plotter routine which depicts the inventory data through a combination of different designs and color combinations (see Figure 3). In addition, a sorting process can be used to plot only areas with selected combinations of land uses and special features and, possibly later, soils and topographic conditions. In addition to evaluation of socio-cultural parameters of intensive land use conditions, this procedure facilitates land suitability analyses from a physical characteristics standpoint.

Uses of the Grand Traverse County Information.- Immediately upon completion of the inventories, the data were put to use as a resource base for County planning decisions and continue to serve as a framework for local government participation in highway corridor evaluation and selection. The GTBRPC is using the data to locate the best future growth areas for residential, commercial, and industrial land uses without causing an adverse impact on sensitive environmental areas. For example, the optimum site location for a potential industrial park site was derived by identifying those cells which met the required site criteria of isolation from residential areas, adequate transportation facilities, sufficient contiguous areas for expansion, etc. In addition to these kinds of uses, the inventory information is being applied to locate optimal low environmental impact highway corridors, using weighted values for each land use according to specific geographical areas, primarily the unincorporated territories of townships.

The land cover inventory and particularly the special environments identifications allow a tremendous variety of corridor options to be derived and made available for comprehensive and coherent local discussion and evaluation.......indispensable processes for facilitating improved decisions for identification and selection of an optimum highway corridor. At the State level, the Department of State Highways and Transportation is closely monitoring the utility of special environments intelligence. If experimental applications can demonstrate that this additional method fulfills an adequate function in assisting with highway corridor selection, the procedure can become a required element for future corridor studies.

Although the time-distance interval between decision and action is much less than in the Kalamazoo Basin study, this Grand Traverse endeavor is still a good example of the second generation operational application. To illustrate, data were made available to the Grand Traverse Bay Regional Planning Commission in January 1975 whereby that body was provided with land cover information on which to base planning decisions. A number of decisions were rather promptly made possible. An alternate site for a new industrial plant was derived on the basis of the information provided by the dual inventory. The location and construction of a major new highway, including the selection of an optimum corridor and the location of the specific right-of-way within the expanse of the corridor were made with the fullest possible bases of reliable and up-to-date information, and decisions were able to be made within a comprehensive framework. The Regional Planning Commission is busy making decisions daily as to development configurations with local units of governments which are rapidly developing local/comprehensive development plans. Now that a regional land cover and special environments information system are operational, it will be only a matter of routine functions to keep such a system updated and expanded upon as time advances. This Grand Traverse situation is one which offers encouraging confirmation of the thesis that more competent, effective, and broadly-based decisions and actions will emerge if the informational base is adequate.

Case Study (3) First and Second Generation Type Application

Mason County Forest Inventory.- Timber management, harvesting, and marketing comprise the second largest component of the economic base of Mason County, Michigan. Profits, salaries, tax revenues, and other income are derived substantially from wood-based industries in the County. The viability of this economy is seriously handicapped by the largely fragmented holdings of privately-owned forested lands. Over 80 percent of the forest land in Mason County is privately owned, ownership patterns ranging from very small to moderate-sized holdings; but the small tracts are the most common. The interweaving of national and state forest tracts amidst the private lands only further complicates the management, survey and evaluation of timber stands. Another complicating factor is the great variation in the marketable condition and quality of existing individual stands.

One serious aggregate resultant of the operation of these many deterrents and obstacles is the creation of a pseudo-shortage of marketable timber; whereas, in actuality, Mason

County is rich in mature timber resources.

The logistics of wood processing industries require a mi⁻ imum tributary supply of timber within economic haul limits to sustain a profitable mill facility. Production industries are forced to curtail operations of existing mills when the supply of raw materials is below pre-determined economic production-handling volumes. Consideration of expanding existing mill facilities or building new ones is out of the question in the face of any category of shortage.

Mason County is in the potential position of losing its wood-processing industries and thereby its at-hand market facility. Unless ways can be found to identify, manage, and bring to market the forest resources of the area, the County community can foresee the possibility of having the mill abandoned. At present the forest raw material supplies are indeterminate, widely fragmented, dispersed, and in a condition of pseudo-shortage. In the face of such a contradiction, officials in public agencies and private timber industries turned to remote sensing as a possible means to solving a serious problem.

Through the intervention of the West Michigan Regional Planning Commission, the Michigan State Program was asked to work with the local Soil Conservation District officials in furthering the implementation of an existing program for developing effective timber management and wood harvesting programs under the rubric, "Operation Woodchuck".

Uses of the Mason County Forest Inventory.- To satisfy a need for information on the location and condition of forest resources, color infrared photography at scales ranging from 1:36,000 to 1:120,000 were used to classify the forests into six species groups, three stocking levels, and three maturity classes within a minimum type size of four hectares. Figure 4 represents one of the forest cover type maps prepared for the Mason County project.

The forest resource maps are being used by the Mason-Lake Soil Conservation District, by the West Michigan Regional Planning Commission, and by the timber processing industries in that area. Uses have already begun which include the development of effective timber management and programming of timber havesting for the coming years. The representatives from industry are reporting gratifying results in identifying and locating various grades of timber all within reasonable marketing parameters.

Initially this forest inventory application was conceived as a second generation operational application. Forest resource data were required for an information system being developed by the West Michigan Regional Planning Commission. The system was intended to form a basis for a range of local resource development and management programs. Out of this larger systems program emerged the potential for helping resolve the timber marketing problem, and so this potential is being quickly realized. Forest type maps are now allowing the identification of merchantable stands within the County, and so, in its continuing development, the Mason County study has become for the commerical timber interests, a direct-action, quick-turn-around, first generation operational application leading to direct on-land actions by individual land owners and timber marketing firms. The original intent will still be realizeable over the future months and years as other resource management processes become structured and operational.

Comment.- The remaining four case studies illustrate first generation operational applications. As will be noted, these will highlight direct decision-action applications. While each application is entirely different from the other three .....varying elements in different contexts.......they share a common characteristic in serving a specific clear-cut statement of a situation requiring attention, which, when measured and evaluated, leads to making decision with confidence, and finally, to the taking of definitive actions within a short time-distance interval.

Case Study (4)

Farmland and Open Space Preservation - Wayne County, Michigan.- Under a new statute enacted by the Michigan Legislature in 1974, counties have been designated as the agencies responsible for executing the necessary actions in establishing policies and long-range plans for categorizing appropriate lands as desirable permanent open space, and then taking the necessary actions to implement the reservation of such lands. (State Of Michigan: Farmland and Open Space Preservation Act P.A. 116, 1974.)

Wayne County, Michigan, the home county for the City of Detroit, was the first in the State to initiate implementation of this Act. There were no precedents or guidelines for this kind of development strategy; so considerable consultation and experimentation was essential. When invited by the Wayne County Planning Commission (WCPC) to contribute the potential capabilities of remote sensing to this study, the MSU Program first loaned RB-57 color infrared imagery to the Planning Commission staff, then developed, in collaboration, a land classification system, provided extensive training sessions for Planning Commission personnel, and continued to contribute technical inputs, such as interpretation of imagery. With such assistance, the staff of the WCPC developed an updated inventory of land use for the undeveloped portions of the County. This survey showed, suprisingly, that this very urban County of Wayne has 20 percent (33,381 hectares) of its land still in agricultural uses and other unimproved open space. About one half of this area (16,600 hectares) is currently inactive and unimproved - producing no economic return.

In a policy format, the County Planning Commission declared intent to seek the establishment of a pattern of lands to be reserved as permanent open space. The distribution and location of the ultimate land reservations were to be derived from the future growth configurations emanating from the previously drafted County "development strategies". When these determinations were eventually drawn up, series of public hearings were conducted all around the County to inform residents and officials of the intent of the program, what benefits could accrue, and how implementation would occur. In concluding this analysis phase, the Planning Commission committed the County to reserving a definite number of hectares in accordance with a determined, designed physical configuration.

The new Farmland and Open Space Act provides for implementation by authorizing the execution of contracts with owners of designated open space lands whereby the owner yields development rights and/or easements to the County. In return, the owner receives property tax relief and freedom from special assessments for improvements of no benefit to his land uses. This process insures that a given property will remain in an agricultural or open space use for a period of 10 years or more.

To be fully implemented, however, the zoning ordinance of any local government unit agreeing to participate in this program must be amended to incorporate provisions which will accommodate the special features of land reservation provided for in this State Act. In addition, the local zoning ordinance must also incorporate revised land use district configurations to mesh with the County development strategies plan. The local unit must also formally express concurrence with the policies of the County.

In this case of Wayne County, the optimum location and extent of these open space areas were determined through the use of remote sensing imagery and related techniques. Interpreting soil characteristics, land cover and slope, alternative patterns of open space were constructed. These kinds of information were derived from NASA high altitude (RB-57) color infrared photography. By use of appropriate interpretation, it was feasible to interpret land characteristics of substantial areas in a very short time. The whole County was interpreted and plotted in a matter of weeks. The processes of review and evaluation, via public meetings and deliberations by governmental officials required, however, considerably more time.

To date, five townships in Wayne County have progressively decided to join in this open space preservation program. At the time of preparing this paper, several other local units have various versions of land reservations under consideration. This effort actually has produced other benefits in addition to retaining agricultural productivity of farmlands and the aesthetic values of holding substantial lands in open space condition. The Wayne County study has provided a prototype procedure that has been tested, refined, and restructured in the Wayne County application. The MSU Program is arranging to work with other Michigan Counties to assist in further implementations of Act 116.

Effectuation of policies and programs like the Michigan Farmland and Open Space Act will have substantial impact on the character and nature of human settlement over the next decades; for it will be by means of such concepts that the continuing accretions of undifferentiated urban sprawl that has characterized urban growth over the past 50 years will be arrested and hopefully diverted into more livable and effective patterns.

While long range implications of this kind of legislation are very important, successful implementation will depend to a large degree on an information base which can be derived in a short interval of time. The one major - and most promising and reliable - means for securing the needed information is that of remote sensing technology. As the versatile capabilities of remote sensing become better known, more and faster progress toward essential societal and environmental reform can emerge as technical capabilities make innovative concepts appear achievable.

Case Study (5)

Soil and Sedimentation Control - Antrim County, Michigan.- The Antrim County Planning Department (ACPD) has used remote sensing in an even more direct manner to implement the State of Michigan Soil and Sedimentation Control Act (P.A. 347, 1972). Color infrared photography provided an expeditious, legally acceptable means for both evaluating site construction plans required for earth-change operations and for detecting potential violations of codes and ordinances. Two examples of situations on Torch Lake in Antrim County illustrate this capability of remote sensing for helping evaluate possible violations and earth change requests.

The Act requires that a site plan be approved and an "Earth Change" permit be obtained for any operation which will change the configuration of the ground form.......i.e., an "earth change".......if that activity is located within 500 feet of a lake or stream. A citizen complaint received by the ACPD in August 1974 suggested a possible violation (see Figure 5). The alleged violator was of the opinion that the road construction underway was 600 feet from the nearest point on Torch Lake (the distance A-C on Figure 5). Using the photography, the ACPD determined that in fact the site was 365 feet from the Lake (the distance A-B on Figure 5). A stop-work order was issued to the violator based on the data derived by photo interpretative techniques. The order was initially challenged and a ground survey requested; but both the violator's attorney and the County Prosecuting Attorney agreed that the photographic evidence was legally acceptable, and the order stood.

In another case, also in Antrim County, a site plan and request for an Earth Change permit was submitted for the construction of a groin wall on Torch Lake. The proposed wall (approximately 24 feet long) would be at the north of the owner's property line on the northwest end of Torch Lake (Point A, Figure 6). There is an existing groin wall (Point B, Figure 6) that would be removed when the new wall was constructed. In evaluating the site plan, the ACPD assessed the potential effects of the 24-foot groin wall on the present lake erosion and sedimentation patterns through an analysis of these patterns depicted on 1973 color infrared imagery. A northeasterly and southern lake current (see points D and C, Figure 6) converge at this general area. The resultant heavy turbulence zone creates a sucking and cutting action which promotes shoreline erosion immediately to the north of the present groin wall. The Department decided that a 24-foot long wall at the proposed location would intensify this erosive action, thus an Earth Change permit was denied. Extending tangents from the lake shoreline on both sides determined the location and maximum length (12 feet) of a groin wall that the Planning Department was prepared to allow (Figure 7).

Both examples show that remote sensing technology can provide a timely, accurate, and in some cases, the only comprehensive means to evaluate legitimate Earth Change permit requests and also offer an effective and legally sound method of enforcing the Soil Erosion and Sedimentation Control Act.

Case Study 6

Land Value Appraisal - Charlevoix County, Michigan.- The Charlevoix County Equalization Department is using color infrared photography to reassess more accurately land values, particularly for remote and isolated properties. Beaver Island, located 12 miles off the coast into Lake Michigan provided the County with an especially difficult assessment problem. Large scale black-and-white photography was available for the island; but this imagery did not permit adequate identification of swamp and higher ground which are the two basic criteria for property evaluation in such terrain. Moreover, due to the inaccessibility of the terrain, usual ground inspection methods were deemed unfeasible. Land value appraisal and consequent property taxes levied for the Island, using such limited information as these black-and-white photos, were inevitably approximate and most imprecise. Using rudimentary interpretation and projection techniques, the Equalization Department personnel, with CIR imagery provided by the MSU Program and MSU interpretative assistance, were able to produce a simple land characteristics map of Beaver Island as well as of several other islands in the County. All property valuations for the islands have been reassessed and changed where appropriate on the basis of these mapped data backed up with photographic evidence.

Appraisal of land value is becoming an increasingly complex and detailed process. Color infrared photography used here without sophisticated equipment provided an accurate and time-saving method which facilitated new value appraisal and assessment methods and achievements.

Case Study 7

Optimizing Agri-Business Processing Plant Locations.- In the Saginaw Bay area of Michigan, beans, corn and small grains are important crops requiring immediate processing for storage and marketing. For effective operations, it is economically and technically crucial that processing facilities be located within areas of high crop production. In addition, recent increases in both crop acreage and yields have created a need for expanded processing facilities at new sites. In the past, elevator location decisions were a "hit-or-miss" process based mainly on subjective and unscientifc procedures and criteria. Crop Reporting Service statistics regularly indicate production totals by counties. However, elevator service areas, with a radius of 13 to 16 kilometers, are areas substantially smaller than a county, and many include parts of more than one county. In the absence of data on the spatial distribution of specific crop acreages within each county, processing firms lack adequate information for their locational decisions.

The main criteria for optimizing processing plant and elevator locations are: (1) centrally located in relation to the county's largest crop production area; (2) adequate highway (Class A) accessibility; and (3) railroad accessibility. In the past, this information was acquired from windshield surveys by company personnel. No quantitative acreage evaluations were possible, and only a generally-defined service area could be identified. The business firm would seek an elevator site with adequate accessibility within this generally defined service area.

MSU Remote Sensing Program personnel, in cooperation with one particular large agribusiness firm are investigating the use of satellite and NASA research aircraft imagery to acquire an improved data base for corporate decisions aimed at optimizing the location of future elevator facilities with respect to crop production areas and to the criteria previously enumerated.

In the instance of this case study, the research work is in progress; a completed analysis with consequent decision-action results cannot yet be reported, except that in the fall of 1974 the MSU Program did a pilot study for this firm using whatever imagery was available and fitting in the analysis to meet very limited time constraints (placed on the user by market pressures). The business organization was most gratified with these particular results, and accordingly has concluded arrangements with the MSU Program to continue in 1975 with studies in other areas of the State in order to determine optimum locations for at least three additional processing plants.

Investigations by the MSU Program will be designed to meet these stated needs. For each county selected, four categories of information will be identified:

(1) amount and distribution of tillable land in the county;

(2) highway and railroad accessibility;

(3) identification of the present distribution of beans, corn and small grains;

(4) potential crop productivity based on soil management groups.

The investigators will use Skylab imagery to locate and define broad crop service areas containing intensive cultivated land and good transportation accessibility. In each broad service area the categories of information (previously cited) will be identified and delineated from NASA RB-57 high altitude color infrared photography. The mapped information as well as soils information for these selected areas will be gridded and coded for computer storage and then alternative plant sites will be selected.

For each identified potential site, a routine will calculate total area in each type of agricultural use and will estimate potential crop productivity for assigned service areas. Finally, recommendations for specific sites for the location of new processing plant elevators will be made. It is important to emphasize that during most of these analysis operations, the business firm personnel will be equally involved in the processes except where special technical skills are needed. Through participation, the user will learn more about the features of the business operation, perhaps discern new relationships of dynamics, etc. But, more directly important to the MSU involvement is that another user will have become knowledgeable of the appreciable utility of remote sensing.

SUMMARY AND CONCLUSIONS

The original intent of the remote sensing program at Michigan State University was to experiment with remote sensing technology to determine its usefulness as a means for deriving more complete and reliable information concerning characteristics of land cover and use than conventional methods provide. In addition, factors of economics of time, materials, and costs were important criteria for concomitant evaluation. Finally, it was hypothesized that remote sensing could provide information which had not heretofore been available in either kind or scope which could be derived from new generations or sets of "indicators".

The intended usage for such enriched intelligence was to provide public and private policy/decision makers with much more and greatly improved information upon which to formulate policies, make decisions, and take actions relative to the effective managment of land and other natural resources.

The efforts of the Program continue to be directed at this progression of objectives; however, intermediate application experiences have been utilized as means for developing needed knowledge and capabilities for investigators. A series of operational applications, of considerable variety, have been engaged and brought to conclusion which have been most valuable for advancement of wisdom and skills.

One important feature of these applications, or "case studies" was the realization that such endeavors are not all the same, that they are considerably different and have to be selected, designed, and executed by utilizing methods singularly appropriate to each. Repeated endeavors clearly indicated a broad primary classification, namely, those which generate prompt, direct responses in terms of decisions and implementing actions (categorized as "first generation"), and those which produce delayed and indirect reactions over time to the information garnered and generated (categorized as "second generation").

This primary distinction has proven very helpful in evaluating possible new engagements. After the first year or two of working at convincing possible users of the relatively unknown utility of remote sensing, the reverse is occurring, with multiple requests coming unsolicited to the Program for assistance in operational applications. It has become mandatory that selectivity be employed in the situations to which the investigators wish to become committed. Some applications are accepted on a contract basis with the user paying for the routine, repetitive kinds of work; but the majority of engagements selected are those which will allow further testing of methods and producing new competencies - both kinds of benefits are moving the Program closer to its objectives.

The illustrations utilized as "case studies" in this presentation are intended to demonstrate the essential distinctions between first and second generation applications and to share some lessons learned for selecting additional case studies and in the planning-design management and execution. As a final note, however, it is important to note that in all these applications, the user-agency was included as a participant in order to maximize understanding of the processes whereby information and findings are derived, allowing the progressive formulation of tentative decisions, and generating early anticipation of what actions might need to be taken as well as discerning other possible uses for the information. Additionally, the agency personnel were many times most helpful in pointing out the likely non-productivity of moving along certain lines and suggesting more promising directions. As each application experience is completed the investigators realize that new methods and capabilities have emerged and that new, important converts to remote sensing technology have been made.

TABLE 1. KALAMAZOO BASIN INVENTORY CHARACTERISTICS

Area	Land Cover/Use Classification	Photography Used	Minimum Type Size	Base Map	Land Use Area Tabulated By[a]
Upper Kalamazoo Basin (2,800 sq.km.)	1. Cropland 2. Orchards 3. Vineyards 4. Small Fruits 5. Pasture, Fallow Land, Forage Crops, Sod & Other 6. Deciduous Forest 7. Coniferous Forest 8. Mixed Forest 9. Brushland 10. Marshland 11. Urban Residential & Commercial 12. Urban Industrial 13. Urban Construction 14. Rural Built-up 15. Water 16. Open Pits 17. Sand Dunes 18. Roadway System	1:60,000 and 1:120,000 Color Infrared	4 ha	County Highway Maps[b]	Township, County, Sub-basin and Basin
Lower Kalamazoo Basin (5,800 sq.km.)	1. Cultivated Cropland 2. Hay, Pasture & Inactive Agriculture 3. Tree Fruits 4. Bush Fruits & Vineyards 5. Ornamental Horti-culture 6. Confined Feeding 7. Broadleaved Forest 8. Coniferous Forest 9. Mixed Forest 10. Brush 11. Forested Wetlands 12. Marsh 13. Shrub Swamp 14. Open Water Vegetated 15. Residential 16. Commercial, Services and Institutional 17. Industrial 18. Extractive 19. Transportation 20. Other Urban 21. Water 22. Barren Land	1:31,680 Color Infrared	4 ha	Mylar Copies of U.S.G.S. Topographic Quadrangles	County, Sub-basin, Basin and Soil Association

[a] Area calculations based on a 16 hectare dot grid.

[b] After the completion of the Lower Kalamazoo Inventory the Land Cover/Use delineations for the Upper Kalamazoo Basin were transferred to Mylar copies of U.S.G.S. topographic quadrangles.

TABLE 2. GRAND TRAVERSE COUNTY SPECIAL ENVIRONMENTS INVENTORY CHARACTERISTICS

Code	Land Use	Code	Special Environment (Flags)	Photography Used	Minimum Type Size	Output
11	Residential	01	Roadways	1:36,000 Color Infrared	4 hectare Cell Size	Computer Graphics
12	Commercial, Services, or Institutional	02	Railways			
13	Industrial	03	Airstrips			
14	Extractive	04	Bridge			
15	Transportation Communications and Utilities	05	Powerline			
18	Mixed Urban and Built-Up	06	Gas line			
19	Open and Other Land (outdoor recreation, cemeteries)	07	Oil or Gas Wells (and Storage)			
21	Cropland, Rotation, and Permanent Pasture	08	Confluence of Two Streams			
22	Orchards, Bush-fruits, Vineyards, Horticulture	09	Mobile Homes			
23	Confined Feeding Operations	11	Ponds			
29	Other Agricultural Land (farmsteads, green houses, exercise race tracks)	12	Great Lakes Shoreline Zone			
31	Broadleaved Forest	13	Inland Lakes Shoreline Zone			
32	Coniferous Forest	14	Linear Stream Zones			
33	Mixed Forest	15	Water Access Sites			
41	Forested Wetlands	16	Effluent in Lake or Stream			
42	Non-forested Wetlands	17	Impoundment Structures			
52	Brushland	21	Submerged Aquatic Vegetation			
61	Streams and Waterways	22	Emergent Aquatic Vegetation			
62	Lakes	31	Forest Plantation			
63	Reservoirs	32	Forest Fire Area			
92	Beaches	33	Drowned Forest			
93	Sand Other than Beaches	41	Irregular Topography			
94	Bare Exposed Rock	42	High Bluff or Cliff			
96	Transitional Areas	43	Low Bluff or Cliff			
		44	Sand Dune			
		45	Drumlin, Esker, Kame, Kettles			
		46	Sinkhole			
		47	Islands			
		48	Peninsula			
		50	Terraced			
		61	Cemetery			
		62	Sanitary Landfill			
		63	Junkyard			
		64	Scenic Turnout or Rest Area			

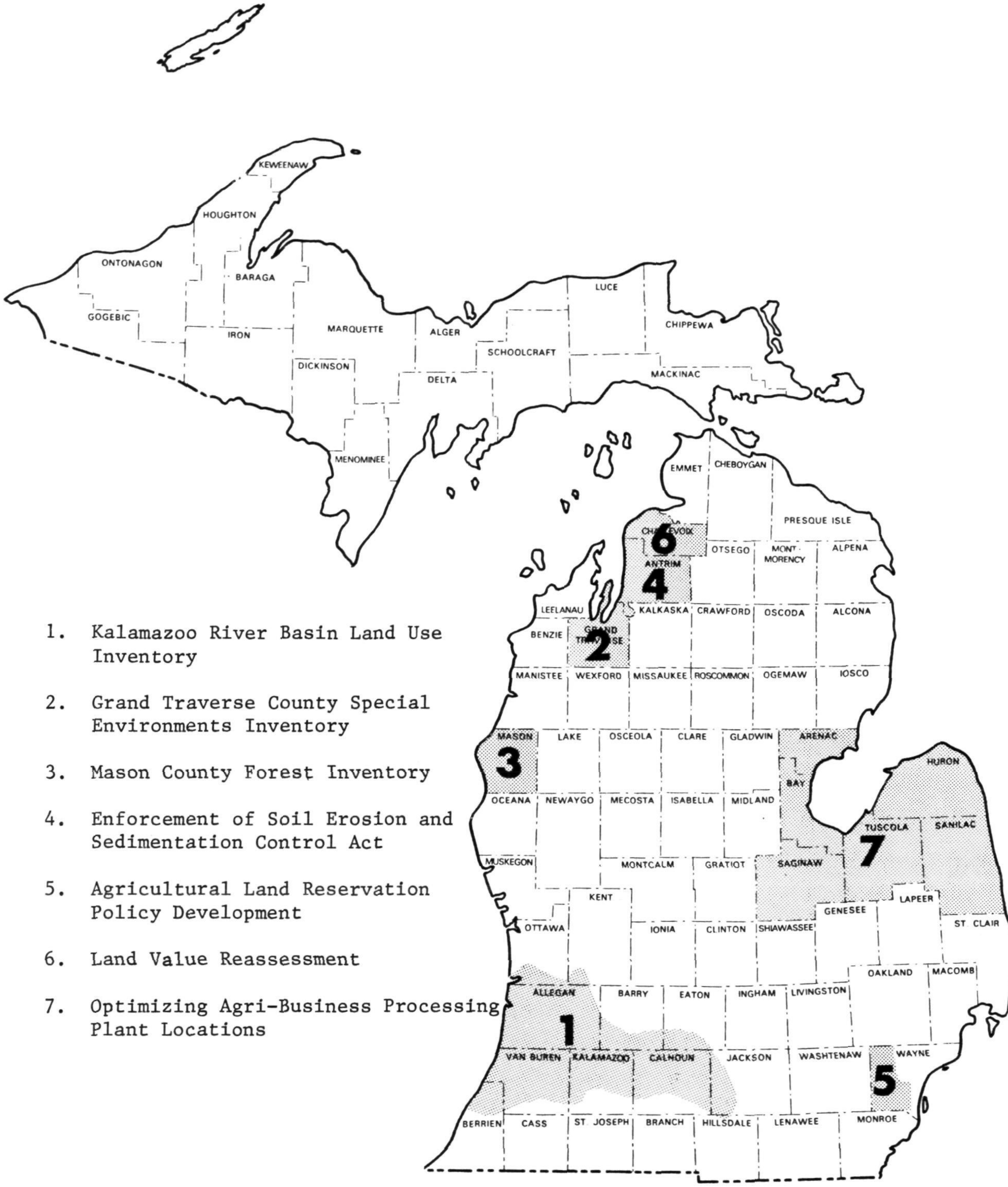


Figure 1. Location of Michigan Application Case Studies.

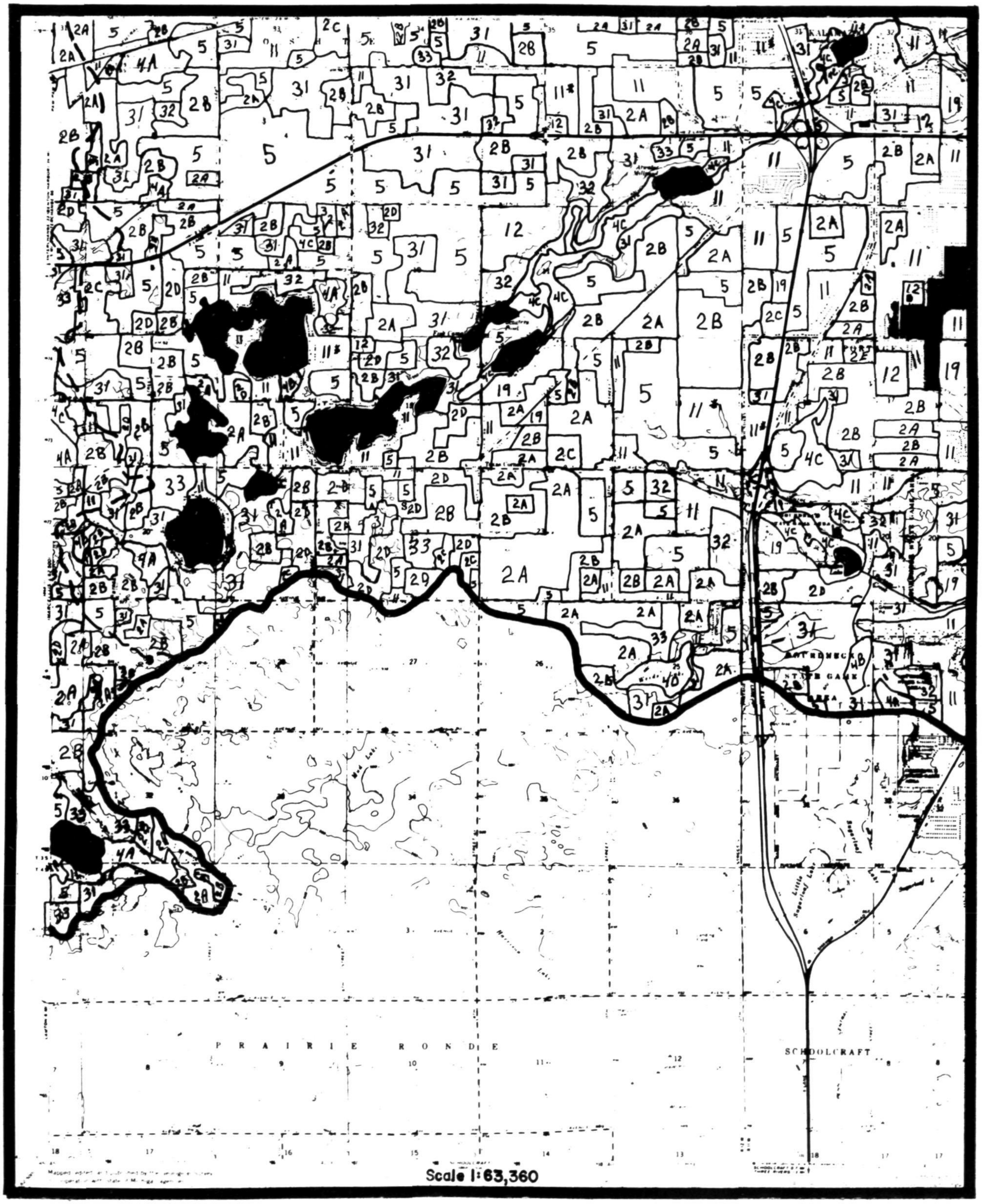
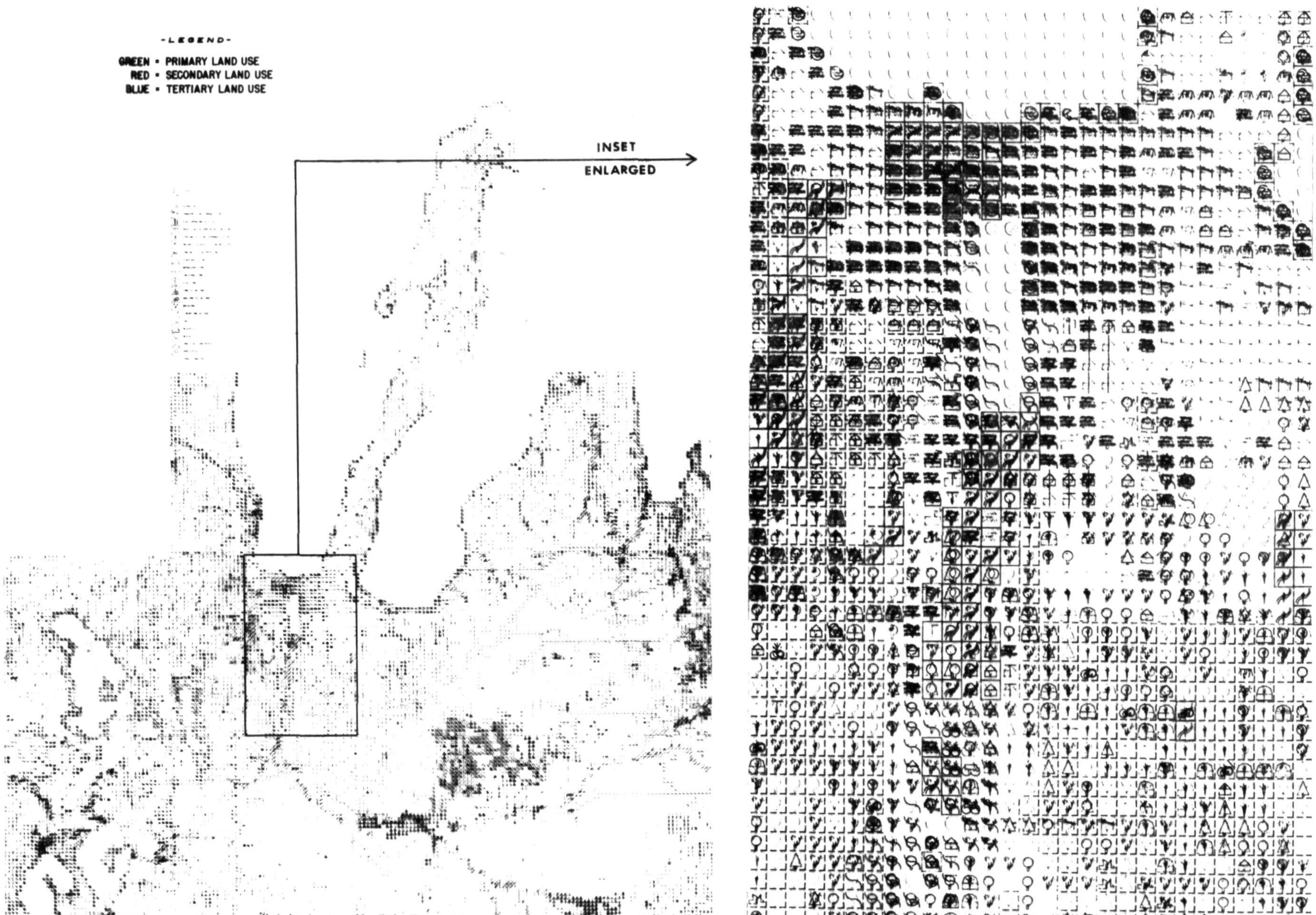


Figure 2. Kalamazoo River Basin Land Cover Map for
the Schoolcraft N.W. Michigan U.S.G.S. Topographic Quadrangle



(original in color)

Figure 3. Land Use and Special Environments Computer Plotter Map
Grand Traverse County, Michigan

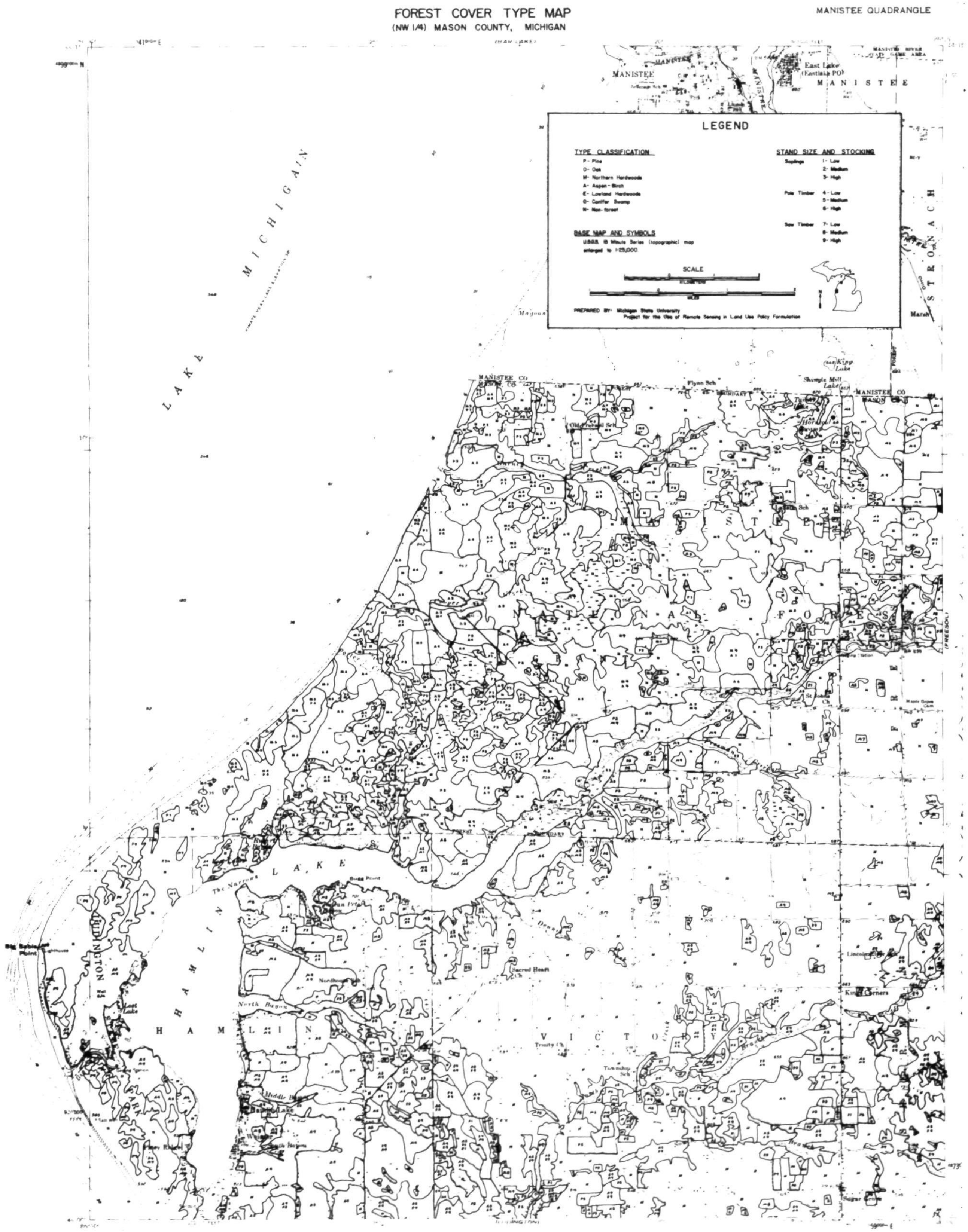


Figure 4. Forest Cover Type Map (NW¼)
Mason County, Michigan

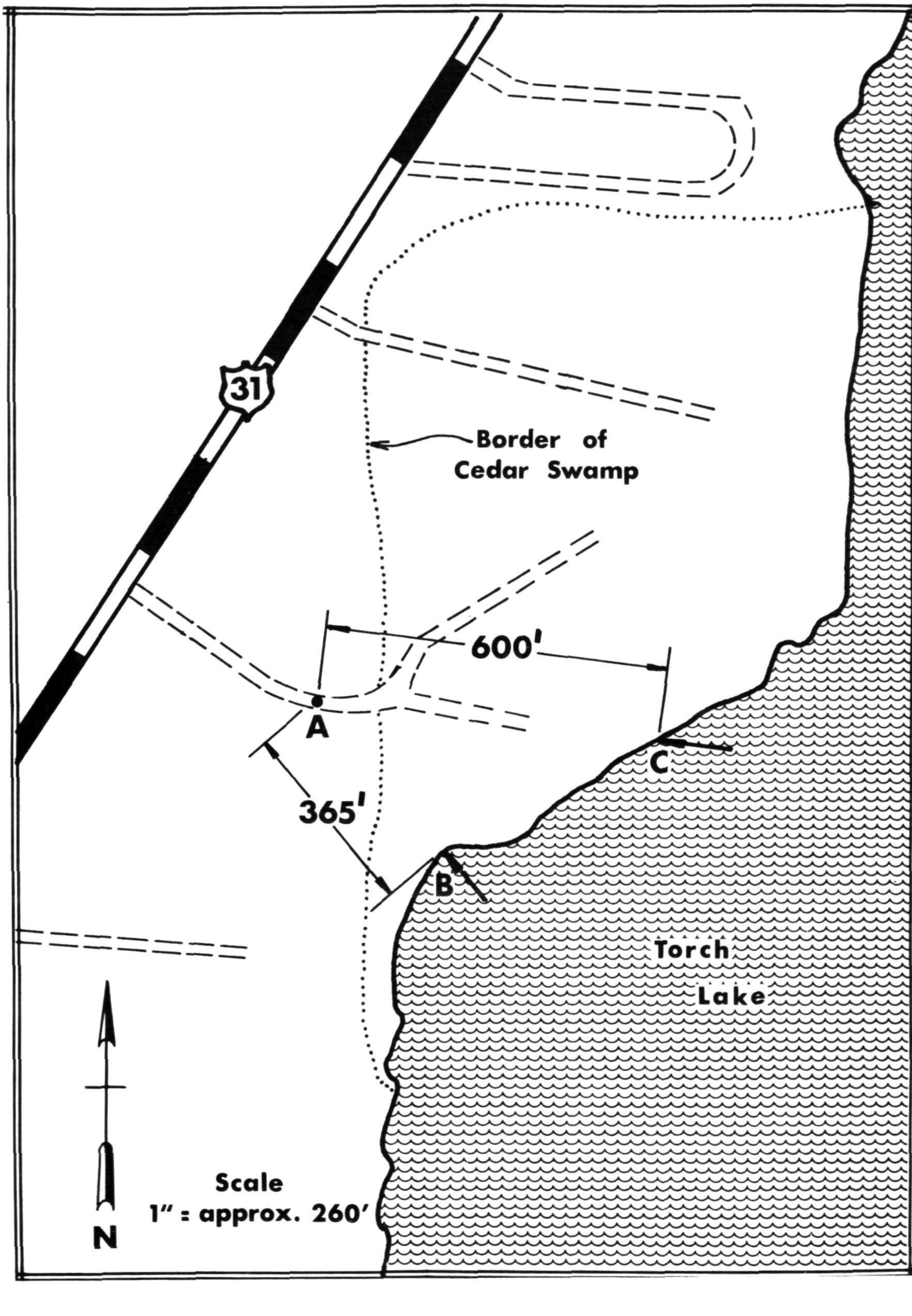


Figure 5. Site Location in Antrim County, Michigan.

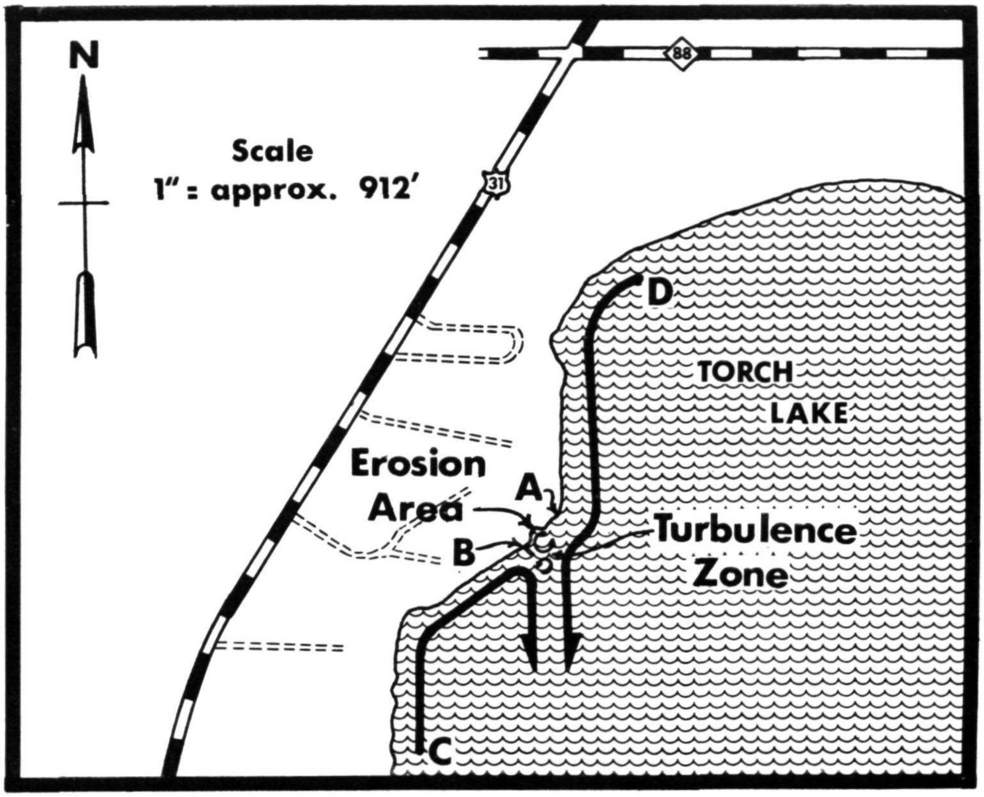


Figure 6.' Lake Current Dynamics
Torch Lake, Michigan

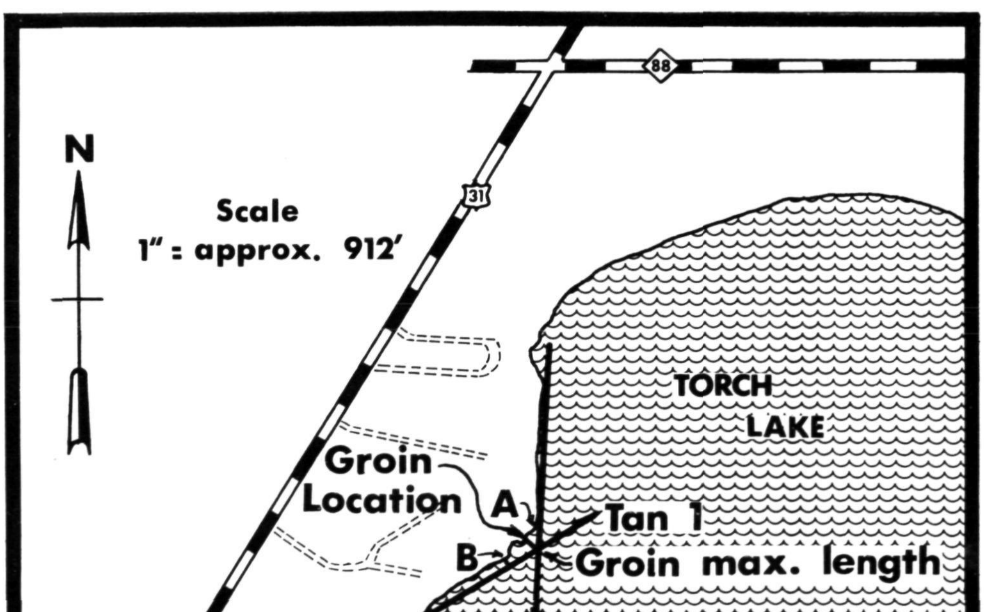


Figure 7. Determination of Groin Location and
Maximum Length