Geographic Information System (GIS) Information Enhanced Land Use Planning

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INTRODUCTION

Geographic Information Systems (GIS) are the combination of spatially referenced data, appropriate computer hardware and software, and users competent to employ the data and technology to solve problems. GIS is typically used to store and analyze extensive information in a map-based format. This allows relatively easy retrieval and manipulation of information and provides new analytical capabilities based on spatial relationships between sites of interest and any combination of available data sets.

Accurate geographic information is an essential ingredient in nearly every aspect of state government planning and policymaking. In fact, all State of Michigan departments collect and/or use some form of geographic data to conduct their daily business practices, such as:

- Managing natural resources and protecting the environment
- Providing a foundation for Homeland Security, public health and safety, emergency preparedness and response
- Improving transportation, housing and community services, education
- Addressing economic development, social and demographic issues
- Enabling executive strategic planning and more efficient government operations
- Providing more effective communication between the state and citizens

GIS is quickly becoming the data management standard in planning the use of land and natural resources. Virtually all environmental issues involve map-based data, and real-world problems typically extend over relatively large areas. A GIS links observations and measurements to specific locations and specifies the relationships, actual or inferred, between data points. A GIS can pull together very different data types and allow quantitative analysis at the scale of landscapes or entire regions. For example, information on soils, hydrology, and vegetation might be combined in analyses of wildlife habitat needs, and this new data set could be used in planning a strategy for restoration of degraded ecosystems. GIS facilitates the integration of remotely-sensed images with data collected by more traditional means, such as field surveys of vegetation patterns or air and water quality measures, and it permits extrapolation from limited sample locations to larger areas. Because of its ability to handle these complex analyses at large geographic scales, GIS has become an indispensable tool for land and resource managers.

MICHIGAN GIS BACKGROUND OVERVIEW

The State of Michigan has brought GIS to the forefront of its information technology initiatives. In April 2002, the Michigan Center for Geographic Information (CGI) was established within the Michigan Department of Information Technology.

Michigan has a rich history in the development, use, and dissemination of digital geographic information. In many ways, the state has been a national leader. Projects in the 1980s and early 1990s like the Department of Natural Resources' Michigan Resource Information System (MIRIS), the Department of Transportation's base mapping efforts, and the Michigan Information Center's TIGER/Line File improvement projects created base maps that have supported various state and local GIS needs. While each of these efforts had inherent advantages, significant duplication occurred and valuable data was being created that was basically inaccessible for broad use within the information community.

In 1996 the Department of Transportation, Department of Natural Resources, Department of State, and the Department of Management and Budget, voluntarily came together to pool their resources to create a single, up-to-date, accurate, statewide base map and associated applications. It was agreed that such a product, with combined funding and support, would be much more extensive than any one department could accomplish alone, and all could benefit from future joint maintenance and enhancements to a common geographic framework.

Since that time the State of Michigan has invested more than $15 million in coordinated GIS. Support continues to grow not only at the state level but also through the establishment of many local partnerships.

The CGI provides leadership, technical expertise, and policy for the development, use, dissemination, promotion, and sharing of the state's geographic resources. The CGI coordinates statewide GIS activities through a monthly statewide GIS users meeting open to any interested organization. Formal meeting minutes are kept and posted to the CGI website at *http://www.michigan.gov/cgi.* These meetings are an opportunity to exchange information and views on current developments in GIS and to implement resource-sharing opportunities. Michigan also has two additional groups addressing GIS coordination: Improving Michigan Access to Geographic Information Network (IMAGIN) and Michigan Counties Association of Mapping Professionals (MiCAMP). Neither group has official status within state government; however both provide a forum for information exchange and networking opportunities.

MICHIGAN STATE GOVERNMENT GIS RESOURCES

The explosion of GIS in the 1990s has democratized decision-making systems that include processes open to all affected groups. GIS has eliminating real or perceived barriers to participation in decision making, including technological barriers such as

representation, access, training, even spatial literacy. The evolution could be described as moving from focus on a single agency to multiple agencies working in collaboration.

The state has amassed a large amount of geographic information invaluable to the land use planning process. Selected data holdings include: statewide school buildings, state owned and leased facilities, state land, state roads and bridges, hydrography, demographics, public drinking water supplies, health incidents, Detroit tax-reverted properties, storage tanks, FIA clients, wetlands, soils, forest cover, wildlife habitat, oil/gas wells, crash locations, transportation legal system, bridge IDs, National Functional Classification System, etc.

In April 2002, the state created a single portal for online GIS data and information administered by the CGI: *www.michigan.gov/cgi*. The site contains downloadable data, online maps, tutorials, imagery, and a wide range of contact information for federal, state, and local organizations in the Great Lakes Region.

The state has also made a significant investment in GIS web technology. Map Michigan is a web mapping service developed for the State of Michigan built on the Michigan Geographic Framework for both Internet and Intranet applications. It affects the way government services are delivered to the public and has the potential to impact the reengineering of internal government processes. Map Michigan provides users the ability to find accurate locations within the state of Michigan by address, by intersection, by community, by Zip code, or by coordinate and render an interactive map of that location.

The interactive map displays annotated political boundaries including county, city, township, etc. as well as the underlying road/street network within the area of the map. Users can zoom to different scales, re-center the map, identify attribute information for a specific location, find other features within a specified mile radius, redline map features, and save user-defined maps for use on a return visit. Map Michigan currently has over 36,000 points of interest categorized within business services; education and career development; family health and safety; licensing certification and permits; government facilities; and travel and recreation. Individual or multiple points of interest layers can be activated by the user and graphically displayed, or a single point of interest can be found by text search.

Map Michigan also includes a routing service. Upon submission of an origin and destination, the system renders a highlighted route including driving directions and mileage that can be printed by the user. The planned integration of construction data into the routing methodology and the ability to identify multiple destinations will enhance the usefulness of this service to the public.

STATUS OF LAND USE/COVER DATA FOR MICHIGAN

The Michigan Resource Inventory System (MIRIS) was created in 1979 by Public Act No. 204, which is currently embodied in Part 609, Resource Inventory, of the Natural Resource and Environmental Protection Act, Act 451 of the Public Acts of 1994. The program was to prepare two types of inventories about the state's land and water

resources: a current use inventory to illustrate land cover and land use and a land resource inventory, which would include resources, unique areas, areas hazardous to development, etc. An Inventory Advisory Committee (IAC), appointed by the governor, oversaw the entire program. The IAC was composed of representatives from the major land resource-based industries, utilities, local, state, and federal agencies, universities, and environmental groups.

The IAC's concern or goal was to find a mechanism that would promote better cooperation and coordination between the differing levels of decision making, on issues of statewide importance, without usurping the traditional authorities granted to local units by the legislature. The two mechanisms that met that goal were a consistent statewide inventory of land resources and current land use/cover combined with a technical assistance program to promote the use of the inventories in state, regional, and local land resource planning efforts.

The act, as it stands today, charges the Department of Natural Resources (DNR) with the responsibility of inventorying land resources and providing the information to state, regional, and local agencies to assist them in their planning and resource management programs. Resources that can be inventoried include essential agricultural, forestry, and mineral lands along with land areas with characteristics that pose problems for development. The DNR would also make or cause to be made a current land use inventory. The act promotes the participation of local units of government in the current use inventory process by allowing a 75 percent eligible cost reimbursement for current use inventories completed by regional planning commissions or local units of government.

The act requires the DNR to create a technical assistance program, which shall use the technical assistance programs of regional planning commissions, as much as possible, to help local units of government to effectively use the land resource and current use inventories. Technical assistance efforts specified by the act include: publication and distribution of inventories and land resource management manuals; conducting workshops; and providing an inventory information center and library function which local units of government, citizens and other public or private concerns could use.

The Current Use Inventory is the largest component of the Michigan Resource Inventory System (MIRIS). The Current Use Inventory was compiled from photo interpretation of color infrared aerial photography (1:24,000-scale or 1 inch to 2,000 feet) obtained in 1978–79. Aerial photography obtained in 1985 was used for the inventory of Detroit and seven highly urbanized counties in Southeast Michigan. Some counties and councils of governments (COGs) have updated the MIRIS 1978 land cover using very similar protocols as the original inventory. See Attachment A for a selected summary of available data resources.

LAND USE AND COVER INVENTORY METHODS

Land use and land cover inventory methods are generally accomplished in one of three ways. One method is based upon human interpretation of aerial photography. Using this

method an air photo interpreter would identify different classes of land use on the photography and draw boundaries around them. This method results in a map that depicts land use and land cover as a series of polygons. Another method is based upon the automated classification of satellite imagery. Using this method, the image interpreter uses complex software and knowledge of the specific location of different types of land cover in the image, to instruct the computer to classify the entire image into land cover classes. The third method involves the identification of sample points across the landscape and determining land use and cover at these points. Statistical methods are then used to make inferences about land use and cover across the entire landscape.

The aerial photo interpretation approach is generally best suited for inventories where land use is more important than land cover. The image classification approach from satellite imagery generally works well for land cover inventories and not as well as the aerial photo approach for determining land use. Both of these methods result in a spatially explicit map of land use/cover, however the satellite imagery approach may not have sufficient detail or accuracy to meet mapping requirements at the regional, county, and township levels. The point sampling approach can work well for both land use and cover but does not produce a spatially explicit map.

Examples of the air photo interpretation approach in Michigan include the 1978 MIRIS Current Use Inventory and the United States Fish and Wildlife Service's National Wetlands Inventory (NWI) Maps. Examples of the satellite image classification approach include The United States Geological Survey's 1993 National Land Cover Characterization Project and the DNR's Integrated Forest Monitoring Assessment and Prescription (IFMAP) land cover program. National examples of the point sampling approach include the Forest Service's Forest Inventory and Analysis (FIA) Program and the Natural Resource Conservation Service's National Resource Inventory (NRI) program.

It should be noted that with different land use/cover inventory methods it can be difficult to monitor change over time when improvements in technologies offer significant cost savings but may be so different from past technologies that inventory numbers are not comparable.

INVENTORY UPDATE

Attempts were made in the early 1990s to initiate an update program. Three update options were considered. The first option looked at using satellite imagery to perform change detection on 1978–79 inventory on a county-by-county basis over a five-year period. The second option was to redo the inventories using black and white aerial photography (or other sources such as the Agricultural Stabilization and Conservation Service 35mm yearly flights) through the funding mechanism available in the act, which provided for a 75 percent state/25 percent local match on the land cover/use inventory. And the third option was to begin a voluntary land cover/use update with technical manuals and standards provided by DNR.

A combination of the first two options was pursued. It was assumed that one-half of the counties would directly participate in a 75 percent/25 percent funding program (assuming $20,000 per county to do the update), $630,000 of which would be matched by local contributions of $210,000. Another $300,000 would have to be allocated for digitizing the update. The nonparticipating counties would be done through satellite imagery at a cost of $920,000. The total cost of the update was estimated at $2,060,000 in 1991 excluding imagery costs. Additional research using today's technology is necessary to re-evaluate these costs.

IMAGERY

The State of Michigan is currently evaluating a statewide imagery program that would consist of base products, which ideally would be 100 percent state/federal funded, and an array of options that can be selected and funded by local governments or agency partners. The options, if exercised, replace the base products and are priced at the difference between the base product and the upgrade. This program would offer very attractive upgrade pricing for local governments to tailor the digital orthoimagery products to meet their particular requirements, at far less cost than if they were to contract for these products on their own. Since the state would be contracting for large blocks of digital orthoimagery (thousands of square miles each year), the cost per square mile for the products would be considerably lower than what would be expected if a single county (typically 400–1,000 square miles) were to contract for the same products. Each block would be predetermined to cover significant contiguous geographic areas. Digital orthoimagery would be created for these areas on a yearly cycle that would enable the state to be covered every four years.

The base products, paid for at state/federal expense, would include natural color digital orthoimagery at a resolution of 1 ft. Ground Sample Distance (GSD, or pixel size) for urbanized areas, and panchromatic (black and white) digital orthoimagery at a resolution of 2 ft. GSD for the remaining areas. The imagery used to produce the 1 ft. GSD orthos will be flown at lower altitude than the imagery used for the 2 ft. GSD products. Spatial accuracies of the products will be very high, with the 2 ft. GSD products having an accuracy of +/- 8 feet at the 95 percent confidence level, while the 1 ft. GSD products will have an accuracy of 4 ft. at the 95 percent confidence level.

The Department of Natural Resources has sponsored three statewide aerial photography acquisition projects beginning in 1978. The latest flight occurred from 1997–99 and was done at a scale of 1:15,840 (1 inch = 1,320 ft.) with black and white infrared film during a summer acquisition window. Total cost of this flight was approximately $1,850,000, including acquisition cost, film processing, and photographic products. It is estimated that it cost of $3.2 million to initiate a new acquisition project with similar specifications that also included digital scanning of original film.

The latest coverage of the state under the National Aerial Photography Program (NAPP), U.S. Geological Survey was done from 1998 to 2000. This imagery was acquired at a scale of 1:40,000 with color infrared film during the months of March and April in an

effort to capture leaf-off conditions. The estimated cost for statewide film acquisition using similar specifications is $700,000.

Digital conversion and georectification of the NAPP imagery has been done in the past under the National Digital Orthophoto Quadrangle (DOQ) Program. Efforts to acquire these enhanced aerial products for the state are currently under way based upon the 1998–2000 NAPP imagery. The cost for DOQ production statewide, based on use of existing digital elevation models and existing DOQ ground control, is estimated to be $3 million.

DISCUSSION/CONCLUSION

During 1999/2000 IMAGIN formed a Land Use/Cover Work Group to evaluate the current issues surrounding the status of land use/cover data availability and development. The work group was made up of 26 individuals from various disciplines. In summary the findings of this group are as follows and remain for the most part unchanged today.

- **Status of Land Use/Cover Updating**—A current inventory of which areas of the state have had land use/cover updates completed and what procedures, products, or results are available should be completed.
- **Classification Issues**—Classification systems used for updating land use/cover need to be evaluated to insure that valid land use/cover changes can be mapped and technical procedures need to be clarified.
- **Data Layers/Mapping Issues**—Classification systems should take advantage of the availability of other data layers. Mapping procedures (such as topology, base features, and aerial photography including scale, resolution, and presentation) need to be developed.
- **Change Analysis**—Lack of consensus of change recognition, procedures, classification ambiguities, and differing classification schemes need to be resolved.

With the recent advances in geographic information technology, the state's investment in accurate and consistent statewide geographic information, and established local partnerships the state is poised to develop a decision support system to better manage its most valuable resource. Regardless of the policy decisions that will be made, it is clear that a consistent set of geographic information needs to be available to all researchers, policy-makers, government officials, businesses, planners, and citizens.

A GIS-based decision support system would provide an invaluable tool for all aspects of the land use planning process: conducting a land suitability analysis, projecting future land use demand, allocating this demand to suitable locations, and evaluating the likely impacts of alternative policy choices and assumptions.

The first step necessary to design a decision support system is to determine the kinds of outputs or range of decision types that could be useful for system users.

In concept, the system should function in four distinct decision-making areas to be of service to users. First, it should identify environmental constraints that could endanger or

limit particular types of development. Flood plains, soils with characteristics such as low-bearing capacity or which are corrosive to concrete or steel, unstable slopes or areas subject to subsidence should be delineated to assist communities in general planning or for specific project reviews.

The second area could be labeled as areas subject to policy or legal constraints. Lands enrolled in the Farmland and Open Space Preservation Act are subject to contractual constraints upon their usage. These should be incorporated and regularly updated as areas come into and go out of the programs. Publicly owned and managed lands have constraints upon their use that warrant their delineation. Designated historic and archaeological sites would be another class of area subject to legal constraints. These areas with policy and legal constraints need to be continually updated and provided to planning and management entities.

The third functional area for the inventory could involve the identification of environmental opportunities. The system should be promoted and used as a tool to assist in site location studies for public services—power plant sites, transportation corridors, solid waste facilities and recreational sites. Private and/or public ventures—industries, specialty recreational developments, residential developments—could avail themselves of the system to assist in location, feasibility, and site planning requirements. The decision-making arena in which the system would potentially have the optimum amount of utilization would be in the resource management realm. The identification of timber stands by type and volume will assist public and private concerns in identifying areas that could be harvested or need management attention. Land areas categorized by potential or actual agricultural productivity could be used in a multitude of ways. Mineral site identification, particularly for building materials, could be used by both private and public interests to identify and protect supplies of need resources.

The fourth and final function of the system is in change monitoring. Public Act 204 requires that the current use portion of the inventory be updated every five years. If the updating cycle closely coincides with the U.S. Census cycle, these synchronized information gathering efforts will greatly enhance the analytical capabilities available to land resource decision makers across Michigan. For the first time, adequate and consistent information will be available to assist in quantifying land use/cover changes, resource utilization rates, and the impacts that policy or legislative changes or initiatives have upon development patterns.

The program outlined in this paper is an ongoing effort that will require a close working relationship between all the planning and resource management entities in the state. This working relationship will be most critical in terms of gathering and using existing inventories as inputs to the system, working out consistent identification criteria and classification systems, and incorporating or promoting the inventories into planning and management activities. The benefits to all parties of the relationship in the future years will be substantial.

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