Session V
11:40 - 12:00

The UW/LTC Approach: Questions and Answers

Steven Hendrix, Stephen Ventura, James Gage, and Stephen Leisz

The Land Tenure Center and its partners at the University of Wisconsin-Madison have taken a comprehensive technical, organizational and educational approach to the integration of spatial information technologies and land and natural resource tenure issues. Over the last 18 months, faculty, staff and graduate students at LTC and Spatial Information Analysis Consortium (SIAC) have organized a number of different initiatives to investigate different aspects of this integration process. Specific activities have included informational workshops, project proposals, and the formation of a weekly informal discussion seminar. The experience of bringing together disciplinary faculty and students for solving multidisciplinary research questions will be of great advantage to the Latin American context as many of the countries consider land administration and cadastral reform.

Geographic Information Science
at the
University of Wisconsin-Madison (UW-Madison)
Submitted by the
Spatial Information and Analysis Consortium (SIAC)
to the
University Consortium for Geographic Information Science (UCGIS)

1. History and Purpose

As a land-grant institution, the UW-Madison has been a major participant in and contributor to the emerging discipline of Geographic Information Science (GIS). This history can be traced from instructional and research programs in cartography and surveying during the early years of UW-Madison, to one of the first courses in photogrammetry offered in the United States during the 1930s, to leadership in the earliest attempts to define the nature of cadastral and land information systems (LIS) issues in the 1960s. In the early 1970s, UW-Madison introduced instruction in computerized LIS and transfer of these technologies to state and federal agencies and private utilities. UW-Madison did seminal research on the design of multi-purpose land information systems and the application of remote sensing to a host of environmental problems during the 1970s, and has demonstrated the application of LIS/GIS technology to local land records use and management since the late 1970s.

The overall societal intent of UW-Madison programs in GIS - as with every land-grant institution - is to provide instruction, research, and outreach (technology transfer) to its students and constituents throughout the world. Campuswide leadership in advancing and transferring theories and methods in spatial information management is provided by the Spatial Information and Analysis Consortium (SIAC). Since its formation by UW-Madison faculty in 1991, SIAC's primary mission has been to provide coordination of those programs and activities that address the collection, management, analysis, and application of spatially-referenced information about our natural and cultural environment. SIAC arose from UW-Madison's response to the National Science Foundation call for the establishment of a National Center for Geographic Information and Analysis (NCGIA) in 1988.

SIAC provides support for the many disciplines that acquire, transform, and use spatially-referenced information, facilitating interdisciplinary cooperation among these groups and coordinating development of shared concepts, techniques, and facilities. SIAC's program stresses development of effective GIS methods whose applications span the continuum from local land records modernization to global geo-science, including socio-economic analysis, natural resource assessment and management, and infrastructure management.

SIAC now includes 35 faculty in 18 departments. It is managed by a nine-member steering committee with representatives from the more involved academic units: Civil and Environmental Engineering, Geography, Landscape Architecture, and the Institute for Environmental Studies.

2. Funding Sources

External funding derives from competitive grants from a variety of federal, state, local, and private sources. Examples of federal funding include National Science Foundation support for north temperate lake long-term ecology research, soil-landscape process modeling, and object-based spatial data modeling; National Cooperative Highway Research Program support for GIS

in transportation research; National Aeronautics and Space Administration support for the investigation of lakes as indicators of global change; U.S. Department of Agriculture support for efforts to expedite the mitigation of soil erosion and non-point source pollution; and support from the National Park Service for its Midwest GIS Technical Support Center.

Examples of state funding include the Wisconsin Department of Natural Resources (DNR) support for a variety of efforts such as land cover determination for rural and urban non-point source pollution. The DNR's Bureau of Research provides faculty and financial support to address wildlife and bio-diversity research. The Wisconsin Legislature supported development of a user-friendly interface to U.S. census and state election geography for legislative analysis. The Wisconsin Department of Administration and NCGIA-Santa Barbara supported longitudinal research into the extent, rate, and type of LIS/GIS diffusion and adoption by Wisconsin local governments. Native American tribes selected UW-Madison for the GIS Technical Center Research Program of the Great Lakes Indian Fish and Wildlife Commission. The Wisconsin Department of Transportation supports research in digital photogrammetry and applications of the Global Positioning System.

Examples of local funding include Dane County Land Conservation Department support for rural non-point source pollution and surface erosion modeling research, individual Wisconsin county support for technology transfer, and support from the City of Madison for GIS-based transportation safety research. Examples of private funding include Nature Conservancy support for songbird GAP analysis to assist in strategic land acquisition in the Baraboo Hills; Wisconsin electrical utilities support for adaption of GIS technology for on-site management of natural resources; and software, hardware, and financial support from IBM, Environmental Systems Research Institute, and ERDAS to aid in technology transfer to local governments through a multi-year effort. Over the past four years, total funding (not including software or hardware grants) amounts to several million dollars from non-university sources.

3. Impact on Constituents

Impact upon UW-Madison's constituents who received the benefits of research, education and training, and outreach over the past 30 years and since the establishment of SIAC has been considerable. UW-Madison students of Geographic Information Science can be found in a variety of private and public enterprises ranging from major corporations to governments throughout the world. Land information professionals at all levels have bolstered their skills through many UW short courses. Former UW-Madison students have helped accelerate the adoption and diffusion of technology and expand the employment base into a variety of public and private settings. Faculty and students have also provided leadership and have actively participated in related professional organizations. They have committed energy and ideas to the overall national and international user community.

Specific examples of the constituents impacted include the following:

- the transportation planning constituency and associated Department of Transportation workers who are responsible for the implementation of information management provisions of ISTEA;
- the Native American constituency in the Midwest responsible for long-term management of their timber, fishery, and wildlife in tribal and ceded territories;
- the various state entities responsible for a variety of spatial analyses ranging from legislative redistricting and impact analysis, to K-12 school-district planning, to priority watershed selection and management; and
- the local government constituency, from those responsible for assessment and control of

soil erosion from agricultural lands, to those responsible for the conceptualization of a plan for a state land information program, assisting in its legislative passage and funding (at the rate of $6 million annually), and providing education and technical assistance for its implementation.

4. Research Accomplishments

Seminal research, during the 1970s, in land information system design, costs, and impediments led to publication of "Need for a Multipurpose Cadastre" and "Procedures and Standards for a Multipurpose Cadastre" by the National Research Council in the early 1980s. The multipurpose and interdisciplinary focus of cadastre research provided background for creation of the Wisconsin Land Records Committee and ultimately led to development of the Wisconsin Land Information Program which has become a national and international model. Research is now underway to document the rate of diffusion and adoption of spatial technologies within local Wisconsin governments.

In remote sensing and photogrammetry, UW-Madison researchers have been active since the 1960s. They were involved in digital image processing through scanning microdensitometric analysis of aerial photographs. They performed substantial exploratory research in airborne thermal scanning during this same period. Early 1970s research included work on quantitative aspects of color and color infrared film, digital image correlation for model construction, and analytical photogrammetric methods. The 1970s also saw a statewide water quality survey based upon ERTS imagery. During the 1980s, UW-Madison researchers made refinements in image processing and digital photogrammetric techniques and developed new technologies for data collection. Some of the earliest work in the application of small computers to remote sensing problems was conducted at UW-Madison. UW-Madison researchers were among the first to merge satellite data with ancillary GIS information in an expert system context for forest type mapping and condition assessment. They also performed some of the earliest research with land-oriented applications of AVHRR data. Today, UW-Madison researchers are striving for the integration of image processing, digital photogrammetry, image-based mapping, and GIS. A major effort is underway to provide statewide, 30-meter, land-cover mapping. Researchers are using satellite observations of lake ice phenology as a climate indicator, assessing the impact of Hurricane Andrew, participating in the NSF-sponsored Long Term Ecological Research Program, and developing algorithms for use in the analysis of imaging radar and hyperspectral scanning data.

During the 1980s, experimental research in spatial data quality led to the development and refinement of testing methods. Models and methods were developed for automated mapping of dynamic aspects of three-dimensional objects and a fundamental model for cadastral data was described. In the 1990s researchers have derived new three-dimensional data and functional models, feature-based models, and object-oriented models.

1970s research in automated spatial analysis applied to infrastructure management led to adaptation of linear optimization algorithms for electrical corridor selection. More recent research resulted in development of a technological framework for GIS in transportation, a generic data model for linear referencing systems, GIS-based subsurface characterization methods, and the application of GIS to transportation safety and construction management problems.

Environmental and natural resource management have also been important components of the UW-Madison research agenda since the 1970s when spatial analytical methods were used to identify critical resources throughout Wisconsin and environmental corridor concepts began to emerge. Through the 1980s, UW-Madison researchers applied GIS to a variety of resource

management problems, including groundwater contamination, non-point source pollution, soil erosion, habitat suitability, and invasion by exotic species. In the 1990s, ecosystem management and biodiversity issues have led to the integration of GIS into new disciplines such as landscape ecology. Recently-arrived faculty at UW-Madison are making important contributions in forest succession modeling and in prediction of land use changes and their impacts on landscape patterns and processes.

5. Educational Accomplishments

SIAC coordinates development of course content, schedules, curricula, internship programs, recruitment, instructional facilities planning, and professional training opportunities across various departments and institutes now offering degrees that provide an LIS or GIS focus. These include Bachelor's, Master's, and Ph.D. degrees administered by Geography, Civil and Environmental Engineering, and the Institute for Environmental Studies. The "Surveying Option" at the Bachelor's level in Civil and Environmental Engineering and the "Cartography and GIS" Bachelor's and Master's degrees offered by Geography provide specialization in LIS/GIS. Soil Science and Landscape Architecture have Master's degrees that allow a specific focus on spatial information. Students in the Environmental Monitoring program typically concentrate on technical aspects of LIS/GIS, usually in conjunction with remote sensing. Programs in Land Resources, Water Resources Management, and Conservation Biology typically use LIS/GIS as a tool for natural science research or policy analysis.

Five kinds of LIS/GIS courses are now offered across campus:

1. There are two introductory hands-on courses such that there is an offering each semester and during the summer session.

2. Six courses in five departments have a central focus on LIS/GIS.

3. At least a dozen application-oriented courses in six departments use LIS/GIS as a tool.

4. More than 25 courses in five departments contribute to components of LIS/GIS such as data, methods, and processes.

5. More than 20 courses have some lectures devoted to LIS/GIS, generally as a brief exposure to applications in their particular discipline.

UW-Madison's educational programs have provided numerous scholars and researchers to the overall research and educational community. In recognition of its contribution in this regard, the Land Information and Surveying program within the Department of Civil and Environmental Engineering was recently presented with a special award from the North American Surveying and Mapping Teachers' Conference.

The external demand for LIS/GIS education is high. The Wisconsin Land Information Program is helping drive a burgeoning need for educated managers and professionals. Various training programs and short courses are offered by the Departments of Engineering Professional Development and Civil and Environmental Engineering, and by the Land Information and Computer Graphics Facility. They attract professionals from within Wisconsin and from across the nation.

On-going educational program development activities include preliminary planning for an undergraduate curriculum in Geographic Information Science with participation from the Colleges of Engineering, Letters and Science, and Agricultural and Life Sciences. Also being implemented is an undergraduate certificate program in Land and Social Information Systems within the College of Agricultural and Life Sciences.

6. Extension/Outreach Technology Transfer Accomplishments

UW-Madison faculty and academic staff have implemented a wide variety of outreach and extension programs and technology transfer projects, and have been involved in formulating state and federal legislative policy for the use and impact of LIS/GIS technology (e.g., the Wisconsin Land Information Program). This rich and productive history of public service in Geographic Information Science is in the tradition of the "Wisconsin Idea": that the boundaries of the University are the boundaries of the State and Nation. Public service programs have involved a mix of government agencies at all levels as well as professional organizations and private sector interests. A variety of approaches and techniques have been used, including case-by-case assistance, professional development course work, workshops, consortia, seminars, and pilot projects. Dissemination mechanisms include commissioned reports, newsletters (e.g., Wisconsin Land Information Newsletter and Wisconsin Mapping Bulletin), use of distance education technology, lectures, on-site meetings, videos, guidebooks, and committee memberships.

Current activities include a series of seminars, discussions, and presentations, an integrated series of professional development courses, hands-on training with LIS/GIS technology, screening and answering of public inquiries, a county-based technology-transfer project focused upon land records modernization and design and implementation of local land information systems (Project LOCALIS), training modules for local and legislative redistricting using the 1990 census, participation and leadership at the behest of the Chancellor and County Executive on a multi-organizational land information systems strategic planning committee for Dane County, facilitation and implementation of the Wisconsin Land Information Program, facilitation of legislative adaptation of a modern geodetic datum for Wisconsin, and a recently completed information modernization study by the U.S. Department of the Interior mandated by the U.S. Congress.

7. Personnel

The resumes of 35 faculty and academic staff appear in the Appendix. They represent 15 academic and administrative units in three colleges and an institute.

8. Facilities

In 1992, the College of Engineering developed an introductory LIS/GIS Teaching Laboratory. The Lab contains 18 student computers and an instructor's computer with full-screen projection. A variety of LIS/GIS and digital mapping software is available. The Lab receives network and equipment maintenance support from Computer-Aided Engineering (CAE). The facility is managed jointly by CAE and the Department of Civil and Environmental Engineering. The facility is dedicated to instruction in LIS/GIS and is available to any such course that is cross-listed with Civil and Environmental Engineering. The Lab supports instruction in 12-15 courses per

semester. Recently, the Department of Landscape Architecture implemented a laboratory for its instructional programs. This includes desktop LIS/GIS course work and applications.

There are four primary facilities, administered by members of the SIAC Steering Committee, for advanced teaching, research, and outreach in Geographic Information Science:

1. The Environmental Remote Sensing Center (ERSC), within the Institute for Environmental Studies, provides a physical and intellectual focus for interdisciplinary research on development and application of remote sensing in natural resources management and environmental monitoring. The research agenda for ERSC is broadly based, dealing with the application of remote sensing across the local-to-global continuum, and involving the merger and synthesis of remotely sensed data with other sources of land-related information in a GIS context.

2. The Geography Microcomputer Laboratory, in the Department of Geography, emphasizes spatial theory, geographic analysis, visualization, geographical reasoning, and related areas. The facility is equipped with 20 microcomputer-based workstations and a RISC-based workstation, all with image processing and GIS software. Peripheral equipment includes pen plotters, a raster color printer, a digitizer, and a scanner.

3. The Laboratory for Spatial Data Acquisition and Analysis (LSDAA), in the Department of Civil and Environmental Engineering, provides a physical and intellectual setting for research and instruction in land and geographic information systems, cadastral systems, geodetic engineering, and photogrammetry. LSDAA is a resource not only for broadly-based, systems-oriented research, but also for applications of LIS/GIS and spatial analysis to specialized problems in engineering and infrastructure management.

4. The Land Information and Computer Graphics Facility (LICGF), within the College of Agricultural and Life Sciences, makes land information accessible through current technology by investigating public land records modernization and natural resources information management as they relate to the concept of a multipurpose land information system. LICGF provides a venue for both interdisciplinary, multi-agency projects, and individual faculty and student research and outreach efforts. On-site cooperators include the National Geodetic Survey, the Sea Grant Program, Great Lakes Indian Fish and Wildlife Commission, the WDNR research group, and the IES-affiliated Midwest Technical Services Office of the National Park Service.

SIAC also carries out its instruction, research, and outreach in cooperation with other facilities. Close affiliation has been established with the Land Tenure Center, the Applied Population Laboratory, and the State Cartographer's Office through joint research and outreach projects.

The Land Tenure Center (LTC) encourages and supports multidisciplinary research in land tenure and agrarian structure on a worldwide basis. LTC administers active research and training abroad as well as on campus, administers the Ph.D. program in development studies, offers fellowships for graduate research, sponsors lectures and discussions by scholars working actively in the field, and maintains a library specializing in international agricultural development, agrarian reform, and social, economic, and political changes associated with rural development.

The Applied Population Laboratory (APL), within the College of Agricultural and Life Sciences and UW-Cooperative Extension, performs a wide variety of demographic research and outreach services. These activities include spatially-based socio-economic

analyses, presentation and analysis of census data, research in small area estimation and forecasting models, and programs of education through the University and Extension. APL has demonstrated leadership in the application of GIS to demographic analysis at the national, state, and local levels, and is active in the integration of demographic information with natural resource management.

The State Cartographer's Office functions as an information clearinghouse and University outreach arm on issues in mapping, geodetic control, GIS, and the Wisconsin Land Information Program. The office produces a quarterly newsletter, "Wisconsin Mapping Bulletin", and periodically publishes various guides and handbooks on mapping and geographic information topics. Office staff chair a variety of committees and make presentations on statewide LIS/GIS organizational and technological issues.

In addition, SIAC works cooperatively with other campus and Madison entities such as the Cartography Laboratory, the Arthur H. Robinson Map Library, the Wisconsin Geological and Natural History Survey, the Madison Academic Computing Center, Computer-Aided Engineering, and the Water Resources Division of USGS.

UCGIS must encourage the development of an understanding of how LIS/GIS products affects individuals, communities, agencies, land and resources, so that rational decisions about using and guiding the technologies can be made. A greater understanding of the social effect of these systems' products, including how people use the products, is necessary in order to justify expenditures, demonstrate value before investment, and continue the growth of those systems at all levels despite changing political and social ideologies.

The products of spatial information technologies are changing (and will continue to change) the economic, legal, political, and cultural status of adopting agencies, decision- makers using the products, and the people and organizations affected by the decisions. While early impacts of GIS/LIS are becoming evident, little is known or understood about the long- term effects that the products of these technologies will have on the communities and organizations that implement them. We should observe, and ultimately be able to predict how spatial information technology and products alter decision- making processes within organizations, interactions between agencies, citizen's relationships with government agencies, and people's beliefs and actions in regard to management of land and resources.

EXAMPLES OF SPECIFIC PROPOSED RESEARCH PROJECTS

Several types of research projects in combination are needed to fulfill this research priority. Three general areas are needed: 1) research that extends adoption/diffusion theory to include an understanding of how organizations change with the use of technology, particularly how decision- making processes evolve; 2) research that develops a theory of how systems' products influence land decisions to include less quantifiable aspects of system benefits, such as assessment of effectiveness and equity; and 3) studies of the impacts of spatial technology products in particular domains and applications.

Since technology adoption is occurring at a rapid rate throughout the country, the initial activity under 1) is to generate baseline data - - to understand the present situation. The work should begin with a census or survey of the status of implementation of spatial technologies in government agencies throughout the country, especially at the local level. The survey should focus on how organizations are using technology and spatial data, how and under what conditions people develop and use the products of these systems, and how the technology and its information products are or are not meeting expectations or generating benefits. Because the rate of implementation and type of use are also important measures, this aspect of the research should be continued on a longitudinal basis.

The second type of research should be focused on developing and validating a model of how systems' products influence land decisions and management that includes components of efficiency, effectiveness and equity, and also incorporates antecedent expectations of technology (e.g., demand for products, decision support information, social or procedural justice, access, etc.). The theoretical elements come from various areas including economics, organizational theory, and social theory. Evidence comes both from long- term surveys conducted as part of technological change research (1) and case studies as part of impacts research (3).

It is important to isolate a number of systems in their communities and measure their impact on people, land and resources (3) (e.g. the effect on land tenure issues). This is best accomplished by in- depth case study research, including participant/observer studies, and by specific case experimentation such as intervention studies which observe groups differentiated by access to or supply of information.

A case study method relies upon active observations of disputes and how information is actually used by participants, or not used, to resolve their problems. An intervention study establishes and observes control groups which work on the same dispute, issue or problem but are provided with different information supplies. A project is proposed, relying on the intervention study method. This method will be applied to a common activity which attrac the attention of many in the community, is contentious, and relies on significant amounts of not always compatible data. An common example of this is the expansion of a facility into a stable community.

Significant power differences generally exist between groups, arising from differences in access to education, capi l, and technology. For spatial technologies to become a means of social justice and democratization, we must understand how technology- based land tenure systems affect access to information, tenure security, resource protection, and other social issues. A specific study of the application of these products on land tenure involves th identification and protection of land rights and long term observation of systems throughout the world.

We believe that these differences are most important at the local level of decision making. The local level provide: broad and rich palette to sample from - - many kinds of decisions involving many types of organizational structures, institutional relations and actors. The anecdotal evidence accumulating about costs and benefits must be collected and verified in a systematic way to provide useable evidence about impacts.

ESTIMATED DURATION

The theory and models of this priority can be specified in the course of a few years. Evidence to refine and validate these can be collected in the mid- term, perhaps five to ten years. The obligation to monitor the impacts of technology should never end.

[University of Wisconsin Index]

THE UNIVERSITY OF WISCONSIN-MADISON'S NOMINATIONS FOR NATIONAL RESEARCH PRIORITIES IN GEOGRAPHIC INFORMATION SCIENCE

Preparation Coordinated by the Spatial Information and Analysis Consortium at the University of Wisconsin-Madison

Submitted to the University Consortium for Geographic Information Science, March, 1996

THIS DOCUMENT AND ITS PREPARATION

This document constitutes the University of Wisconsin-Madison's nominations for national research priorities in Geographic Information Science, prepared and submitted in response to a call from the University Consortium for Geographic Information Science. Preparation of these nominations was coordinated by the Steering Committee of the Spatial Information and Analysis Consortium (SIAC) at the University of Wisconsin-Madison. The Steering Committee of SIAC has ten members from the faculty of eight departments and programs in the Colleges of Agricultural and Life Sciences, Engineering, and Letters and Science and the Institute for Environmental Studies. The nomination process included an initial campuswide solicitation of abstracts, followed by selection of five topics for development of the statements that appear herein. In some cases, preparation of the final statements involved synthesis of multiple initially-submitted abstracts and integration of ideas received after a second campuswide solicitation on the five selected topics. Included with the statements are the names and affiliations of the researchers who contributed directly to their development. One of the statements is co-authored with researchers from the Ohio State University. The nominations are unranked and are lettered A-E merely because they must be presented in some order.

SIAC Steering Committee

March, 1996

E. THE SOCIAL IMPACTS OF SPATIAL INFORMATION TECHNOLOGIES

KEYWORDS: Social Impacts, Decision-Making, Implementation, Equity, Economics

Bernard Niemann (Landscape Architecture and Institute for Environmental Studies),

Stephen Ventura (Soil Science and Institute for Environmental Studies),

David Tulloch (Land Information and Computer Graphics Facility)

James Gage (Land Tenure Center)

University of Wisconsin- Madison

Earl Epstein (School of Natural Resources),

Craig Davis (School of Natural Resources)

Roy Lewicki (Department of Management and Human Resources)

The Ohio State University

STATEMENT OF PRIORITY

The objective of this priority is to advance understanding of the societal implications of spatial technologies throu improved theoretical models and research methods coupled with monitoring the status of implementation and use o land and geographic information systems (LIS/GIS) and their products.

DESCRIPTION OF PRIORITY WITHIN THE GIS RESEARCH CONTEXT

The considerable investment, both public and private, in spatial information technologies are accompanied by gre uncertainty surrounding the value and impact of this investment. The value of this investment needs to be justified i terms of benefits to society. Our current understanding of benefits and impacts is primarily in the realm of measu of efficiency - - financial benefits to implementors arising from improved means to produce information. Measure benefits must be developed that incorporate an understanding of the role of the technology and the information it provides in decision- making about land and resources. Assessment of technological impacts must include issues equity, including the distribution of costs and benefits among individuals and between components of society.

Previous research in this general area has been directed toward implementation processes and benefit measures i terms of efficiency. For example, we have measured the status of implementation on a state- wide basis and assesse the impact of LIS/GIS in terms of efficiencies that the technology brings to traditional activities. However, societ implications cannot be fully understood without studying the impact of systems' products in terms of expectation arising from the broader economic, legal, political, and cultural context. We need theory of how spatial informatio influences land decisions that incorporate concepts of effectiveness and equity as well as appropriate measureme tools and techniques.

IMPORTANCE TO THE NATIONAL RESEARCH SITUATION AND NEEDS

As creators and purveyors of technological systems, we cannot ignore the societal impacts of what we have enable