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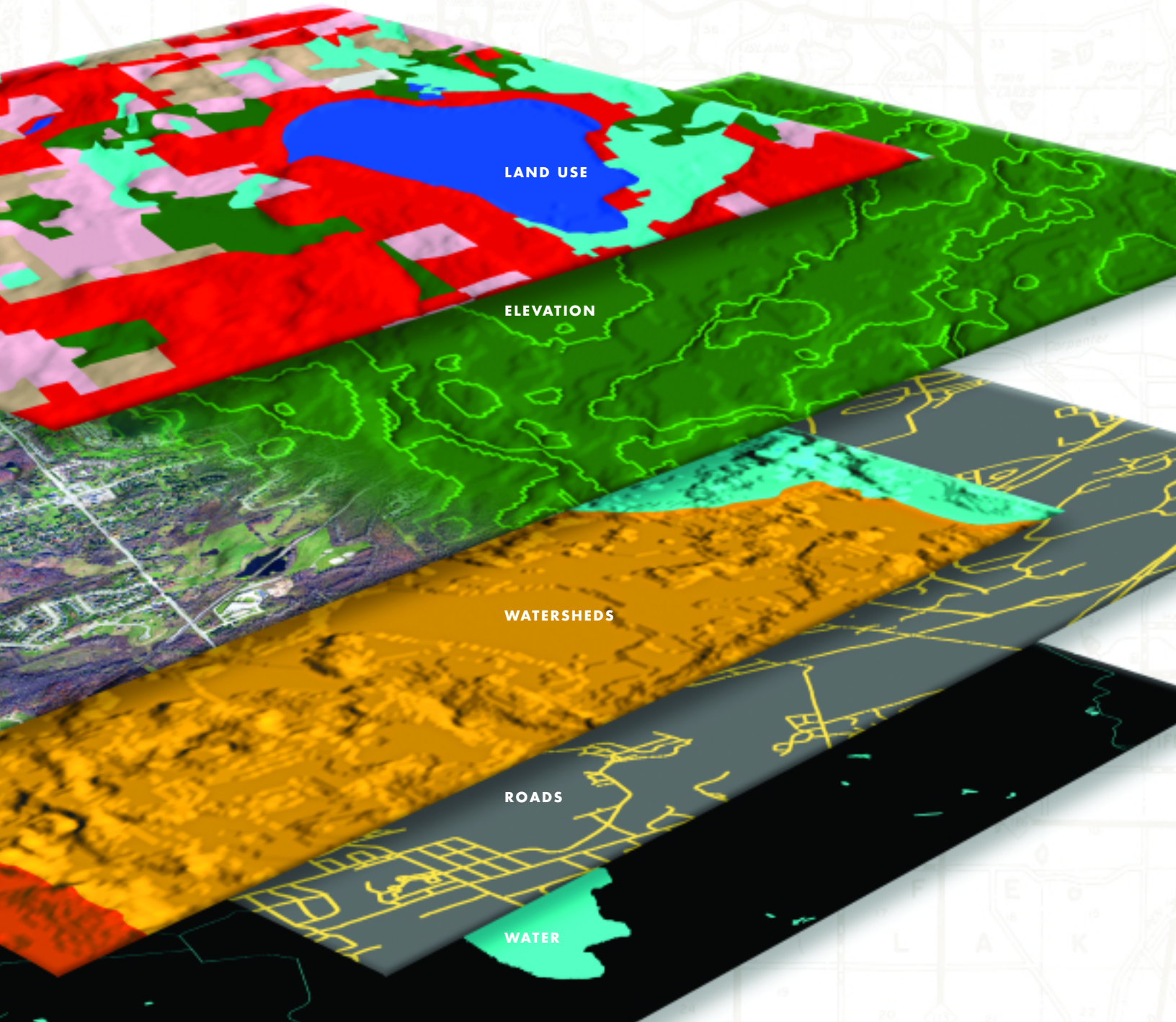
A Global Perspective: Spatial Decision Support Systems



looking into futures

A Global Perspective

GPS. GIS. SDSS. DEM. Much of what most of us know about spatial decision support systems, these geographic information systems (GIS) that analyze our world, is an alphabet soup of acronyms. We know that global positioning systems (GPS) are as close as the blue button in our vehicles and allow an adviser to contact us and provide directions if we're lost or help if we've been in an accident. We know that GIS involves satellites and computers and can help rescuers find mountaineers and skiers who are lost or disoriented. But how does it affect you and your day-to-day life, aside from the vehicle assistance?

Changes to the environment, such as land and water use, do not occur in a vacuum. A collection of MAES researchers and their affiliated institutes and centers are making sure everyone can look at the very big picture.

This technology offers amazing possibilities for analyzing the environment and our effects on it, both good and bad. Water quality, land use, transportation planning, endangered species — all these issues can be studied and evaluated in more detail with the help of GIS.

This issue of *Futures* examines a small portion of the MAES research involving GIS.

Because it is such a valuable tool, many MAES scientists have incorporated GIS technology into their research. Several institutes and centers funded in part by the MAES are located in the Manly Miles Building on the west side of campus. They work collaboratively in interdisciplinary teams to create spatial decision support systems (SDSS) and models that help local, state, federal and international agencies and other interested people make informed and cost-effective decisions on environmental issues and long-term strategic planning.

From entomology to fisheries and wildlife to crop and soil sciences, MAES researchers are using GIS to graphically represent layers of information that can then be stacked on top of one another to allow policy-makers to see everything at once instead of reading through a 3-inch-thick report with charts and spreadsheets. GIS helps people understand the big picture from a variety of perspectives.

On a personal note, I would like to reintroduce myself to *Futures* readers. I edited *Futures* from 1990 to 2000 and am delighted to be back. As editor, I aim to make *Futures* your source for useful, timely information about MAES research.

For the most up-to-date information about the MAES, I invite you to subscribe to the new, free MAES e-mail newsletter. Sign up by visiting the Web site at www.maes.msu.edu/news.htm. Scroll to the bottom of the page and complete the subscription form.

We hope you enjoy this issue of *Futures*. If you have comments or questions, please send correspondence to *Futures* editor, 310 Agriculture Hall, Michigan State University, East Lansing, MI 48824-1039, or send an e-mail to depolo@msu.edu.

I also would like to thank Robert Goodwin, GIS/remote sensing analyst in the Remote Sensing and GIS Research and Outreach Services image archive, for his gracious and patient assistance with the data layers for the cover of this issue.

::: Jamie DePolo

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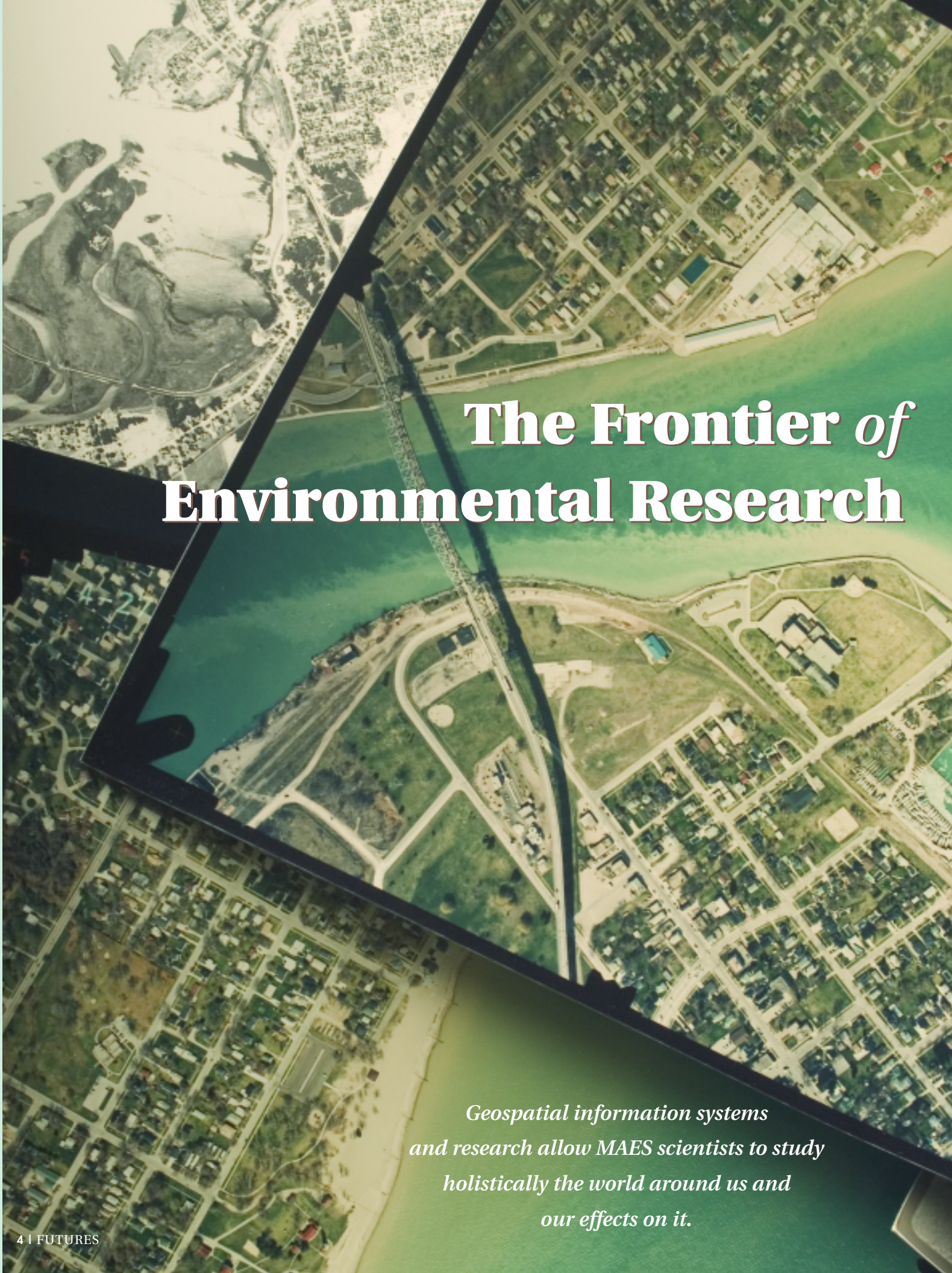

The Frontier *of* Environmental Research

Geospatial information systems and research allow MAES scientists to study holistically the world around us and our effects on it.

As humans, we are the architects of our environment. We build cities, subdivisions and shopping malls and decide where natural land will be preserved and where food will be grown. We decide how water will be used, who will use it and in what quantity. Each day we perform millions of actions — from driving to work to cooking dinner to recycling a newspaper — that affect the environment, both positively and negatively.

(continued on page 6)

»INSTITUTE of WATER RESEARCH

115 MANLY MILES BUILDING • MICHIGAN STATE UNIVERSITY
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The Institute of Water Research (IWR) provides important leadership on water resource issues and problems in the state. Established in 1961, the IWR has a reputation as an innovator committed to addressing multidisciplinary issues arising from the interaction of land and water resources.

Using cutting-edge information technologies and strategic team-building efforts tailored to specific needs, the IWR has pioneered the use of GIS to expand understanding of ecological problems across landscapes. Through the development of GIS-based decision support systems, the IWR helps planners, resource managers, policy-makers, citizens and stakeholders find effective solutions to contemporary water resource problems. The IWR collaborates with university departments and centers, state and federal agencies, local governments and stakeholders to perform innovative research and outreach on water issues with regional and national significance.

"We're flexible and agile in meeting real-world needs for information and assistance in solving environmental problems," said Jon Bartholic, MAES community, agriculture, recreation and resource studies scientist and IWR director. "And we believe in the power of technology to democratize information and data. The Web can now deliver data and analytical capacity that was only dreamed of five or six years ago. It's exciting and challenging. Remote Sensing and GIS Outreach Services [RS&GIS] and the IWR pushed the envelope a few years ago in developing GIS capacity in Michigan, but then ESRI and ArcView [a GIS software company and one of its principal programs] came along. That changed everything."

Jon Bartholic, director of the Institute of Water Research, helps planners, resource managers, policy-makers and citizens find effective solutions to water resource problems.

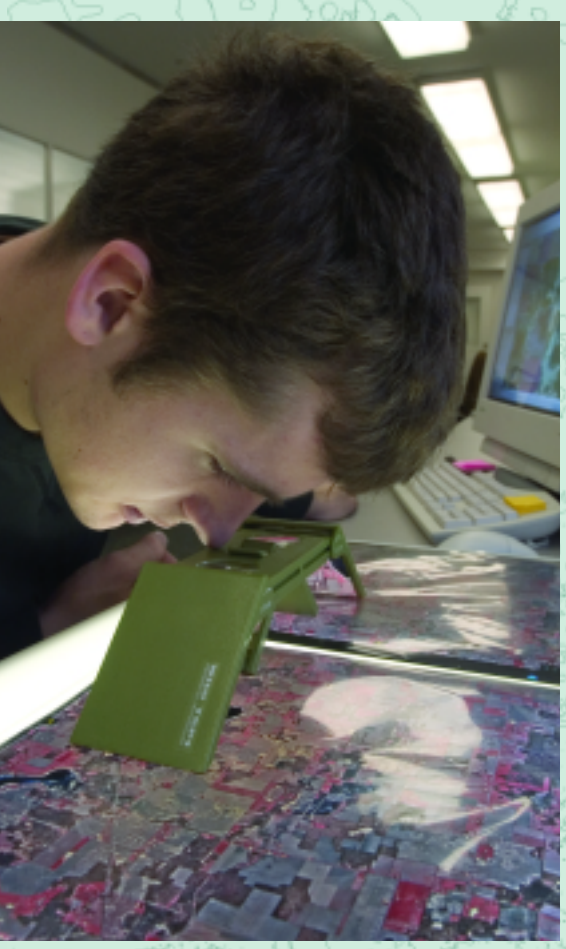
ESRI software is known for its quality and accuracy, but costs can be high and training is usually needed to use ESRI programs. The IWR and RS&GIS continue to play a nationally recognized role in pioneering GIS technology applications in environmental protection and resource management.

"Anyone can visit the IWR Web site and check out a number of interactive programs," Bartholic explained. "There is an interactive watershed information system called 'Understanding Your Watershed' [also called 'Know Your Watershed'] and an online soil erosion assessment called RUSLE. People can even create their own digital maps using EZ-Mapper or learn about watersheds through digital watersheds."

"Understanding Your Watershed: An Interactive Mapping Program to Explore Michigan Watersheds" is a convenient and versatile tool that provides access to data sets, maps and reports. Lakes, rivers and streams; drainage patterns; wetlands; topographic contour lines; roads and highways; and digital orthophotography are some of the data available in map form through this system. These data maps can be integrated or viewed separately.

The Web site was recently upgraded to include statewide aerial photography. Each county mosaic photograph was created from digital photos taken in 1992 and 1998. The images have 1-meter ground resolution, which provides a view of very small parcels in the selected area.

To ensure that the environment can continue to meet our needs, MAES scientists are creating and using geospatial information systems (GIS) analysis tools to study the important variables that affect the environment and to organize the data into a form that governmental agencies, communities and private citizens can understand and use when they are making decisions about land use, water quality and other issues. To plan for the future of the planet, we need knowledge and analysis of environmental information, from local to global, in scale.



A student in the RS&GIS image archive looks at a photo. The RS&GIS has the largest collection of Michigan aerial photography in the state.

GIS analysis sounds complicated, and the underlying technology and data are, but essentially it is a system that combines layers of information about a place to offer a better understanding of that place. The layers of information combined depend on the desired outcome:

"Aerial photography is the preferred backdrop for most GIS," said Chad Fizzell, IWR information technology specialist. "Aerial imagery with this fine a resolution lends a real-world perspective to developing your own spatial analysis. For first-time users, especially, this provides the visual means to reference themselves on the ground because they can see the actual landscape. That gives users a frame of reference so they can use the other data maps more effectively."

Ruth Kline-Robach, water quality coordinator and outreach specialist at the IWR, oversees many of the institute's educational efforts.

Using this innovative, Web-based GIS tool gives planners and citizens the opportunity to visualize and understand the complexity of land-water relationships critical to the development of effective watershed plans. The interactive GIS program can be used with a booklet produced by the IWR, "Developing a Watershed Plan for Water Quality: An Introductory Guide," to fully utilize the tools available through the IWR. Watershed planners can use scientific data located on the Web site to identify and prioritize areas at risk from erosion and pollutants.

The IWR also has collaborated with the USDA Natural Resources Conservation Service to develop the first online soil erosion assessment tool. This tool uses the revised universal soil loss equation (RUSLE) to estimate soil erosion from a specific site on the basis of site data and information.

The IWR also has developed an area on its Web site to help farmers, planners and citizens create their own digital maps. When a person enters a specific address, city and ZIP code, the EZ-Mapper Site Locator will provide a map for the area selected by the user that contains aerial photos, streets, streams and soils information. Users can zoom in and zoom out to view the entire map area. Users may also download selected digital maps with soil boundaries, labels and aerial photos.

"Users can print outlined areas of concern, draw field boundaries, label facilities and title their maps," said Jeremiah Asher, the site's developer. "It's pretty cool and easy to use."

Through a collaborative agreement with the Michigan Department of Environmental Quality, Fizzell trained wetland field staff members in GIS to enhance their analytical capacity.

"This project was ideal for strengthening and fostering cooperation between MSU researchers and DEQ staff faced with difficult issues every day," Fizzell said. "Cooperation between DEQ staff and the university will reduce redundancies, improve efficiency and increase shared knowledge."

»COMPUTATIONAL ECOLOGY and VISUALIZATION LABORATORY

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The Computational Ecology and Visualization Laboratory (CEVL) analyzes the dynamics of natural features and ecological functions at various scales — field, landscape or global — in spatial terms over time.

Using a multidisciplinary and systems approach, the CEVL conducts research that helps understand specific changes in the natural environment: species population increases or decreases, loss or fragmentation of habitat, and patterns of

species migrations, including those caused by human activities.

"We want to give people the capacity to visualize the world differently, in terms of both a richer knowledge and a deeper understanding," said Stuart Gage, MAES entomology researcher and CEVL director. "What humans do in natural landscapes has profound implications for all kinds of living organisms."

Specific projects include long-term monitoring of gypsy moth populations to slow the spread of the insect, recording environmental sounds and digitizing those data to monitor environmental health, and developing stressor-response land use models to assess watersheds.

"Computer technologies can help us understand the multiple effects of our actions and at multiple scales," Gage said. "With the effective use of these technologies, we can begin to achieve a deeper understanding of the full ecological impact of human activities."

Gage has worked with computers for most of his career, believing that computers could help our understanding of biological processes. He also became interested in biogeography in the 1970s and that remains a principal interest today.

Gage also knows that art can be created with computers, and that led him to this visualization laboratory to enhance ecological knowledge with a computer infrastructure. But CEVL research is not limited to just a single sensory perception. After creating visual images for analysis, Gage took another step and began using environmental sound as a new technique to measure ecological health.

"We need to identify appropriate measures that capture changes in biodiversity and biotic systems," Gage explained. "We have the technology to monitor biological field data. Sound acts as an interpreter, although it's a complicated signal to understand. In the Muskegon River watershed project, we monitor sounds at regular intervals, and these monitored sounds are made available on the CEVL Web site. We need to set up monitoring systems to measure data at scales that matter.

"All these organizations complement each other and produce synergistic results from their multidisciplinary approach and teamwork," he concluded. "In examining agricultural ecosystems, we realize they are vulnerable to single events. We need to think in terms of systemwide approaches because these are biological systems. We need to think about and analyze them as complex systems."

»CENTER for GLOBAL CHANGE and EARTH OBSERVATIONS

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WEB: www.globalchange.msu.edu

The Center for Global Change and Earth Observations (CGCEO) focuses on integrating knowledge of changes in the Earth's systems using measurable observations made at various levels, such as satellite-based remote sensing, human or automated monitoring, computer-based modeling, aerial photography and other measures. Using these diverse measures, scientists are able to identify patterns of change and explain the processes of these changes with clarity and understanding. Traditionally, scientists looked at one particular aspect of the earth system — water, air, land or biological species — and scientific knowledge tended to be limited by the boundaries of those areas. To achieve a greater understanding of climate and environmental changes, scientists at the CGCEO use interdisciplinary approaches to transcend traditional disciplinary boundaries.

"The dynamics of processes that occur at the interfaces of traditional disciplines — global/local, land/water, climate/land use — are the keys to greater understanding," said David Skole, MAES geography researcher and director of the CGCEO. "Interdisciplinary approaches allow us to examine the impacts of climate/land use on human health. More acute impacts may be discerned from the

finding the best location for a new store, analyzing environmental damage, viewing similar crimes in a city to detect a pattern and so on. For example, GIS can be used to help reach a decision about the location of a new housing development so that it has minimal environmental impact, is located in a low-risk crime area and is close to a population center. Layering groundwater data over crime data over topographic data over population data enables the information to be presented succinctly and clearly in the form of a map and accompanying report. Decision makers can then focus on the real issues rather than trying to read through pages of spreadsheets and understand the data. GIS analysis helps everyone understand the "big picture" from various perspectives.

GIS is a relatively young field. Although geography and cartography, fields upon which GIS is based, go back hundreds of years, GIS was developed about 40 years ago. In 1963, Canada Geographic Information Systems was created to analyze Canada's national inventory. In the United States, the Harvard Laboratory for Computer Graphics and Spatial Analysis laid the foundation with the development of general purpose mapping software in the mid-1960s. In the 1970s and '80s, its popularity increased, and today it is estimated that the GIS industry grows approximately 20 percent each year.

ENVIRONMENTAL RESEARCH TODAY

In the 21st century, the frontier of environmental research is taking place at what are called "edge" or "interface" issues. The changes and frictions that occur when urban, suburban and rural communities are right next to one another are one example of this. Others are biophysical and social issues, global change and changing local landscapes,

physical and biological issues, human use and natural environments, and land and water issues.

Because they encompass many variables, edge issues demand an approach that cuts across a number of disciplines. At MSU, several units funded by the MAES have coalesced to form a multidisciplinary collaborative team specializing in GIS technologies for natural resource and environmental data analysis and modeling. This analysis and modeling are designed to assist local, state, federal and international agencies in making wise and cost-effective decisions on current environmental issues and long-term strategic planning.

"This agile multidisciplinary partnership approach is designed to shape solutions that meet environmental challenges in the 21st century," said Jon Bartholic, MAES researcher and director of the Institute of Water Research (IWR), one of the partners.

The collaborative team includes MAES researchers associated with several units:

- Center for Global Change and Earth Observations (CGCEO).
- Computational Ecology and Visualization Lab (CEVL).
- Institute of Water Research (IWR).
- Remote Sensing and GIS Research and Outreach Services (RS&GIS).
- Victor Institute for Responsible Land Development and Use.

All of these units/entities have developed computer systems using GIS applications, and most are available on the Web. For example, the IWR developed a hydrologic/watershed system, the CGCEO created a land use transformation model, the CEVL developed an acoustic analysis system, the Victor Institute produced a land use planning decision support system, and RS&GIS created a public drinking water well mapping system.

combination of intensive urbanization and greater frequency of weather extremes (the interface of land use and climate), as evidenced by the high numbers of heat-related deaths during the summers of 2003 and 1995 in European cities and Chicago, respectively."

The CGCEO conducts interdisciplinary research sponsored by three MSU colleges: Social Science, Natural Science, and Agriculture and Natural Resources. Other MAES researchers and the Office of the Vice President for Research and Graduate Studies also collaborate on CGCEO projects.

Combining interdisciplinary research methods with earth observation satellite data enables researchers to measure, analyze and predict complicated human and physical processes of global environmental changes. These changes occur most significantly at the interfaces: land/water, global/local, climate/land use and others. Examples include land development and wetland destruction, the dispersion across continents of non-native species that disrupt local water bodies and systems, and increasing frequencies of climate extremes and the intensification of urbanization. The goal of the CGCEO is to strengthen interdisciplinary approaches for understanding global change at all scales by using the tools of both the social and physical sciences, including survey instruments, direct observation methodologies, GIS, computer-based modeling and remote sensing data.

David Skole, director of the Center for Global Change and Earth Observations, believes the interdisciplinary approach of the center allows greater understanding of the environment and humans' effects on it.

While taking a global perspective, the CGCEO promotes the coupling of global-scale environmental research with local applications and problem solving.

The CGCEO conducts research in Brazil, Ecuador, Costa Rica, Russia, Africa, Southeast Asia and China, as well as in the Great Lakes region and throughout the United States. Conducting research on a set of case studies, the CGCEO is defining the spectrum of cultural, institutional and climate influences in areas ranging from temperate to tropical, and from technologically advanced societies to frontiers of development. Data from temperate forests in North America and tropical forests in Costa Rica and Brazil are being used to provide a conceptual understanding of interaction between human and natural systems.

CGCEO researchers seek better methods for making global measurements of environmental changes and are developing new information system technologies, including satellite and ground-based systems.

These innovations in research are paralleled by innovative systems to distribute information that until recently was the domain of a handful of scientists. It is now possible for anyone to access Web sites that provide sophisticated tools for accessing and manipulating data in spatial (geographic) formats, so citizens can work on the same playing field as university scientists.

Data sets on weather, land use, land cover, population density and other key areas are collected by CGCEO scientists and then made available via the Web. As a result, teachers, researchers, government agencies, businesses, environmental organizations and citizens can use the information to learn about environmental resources in great detail and make intelligent decisions about public policies and private choices.

»REMOTE SENSING and GIS RESEARCH and OUTREACH SERVICES

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Remote Sensing and GIS Research and Outreach Services (RS&GIS), formerly the Center for Remote Sensing and Geographic Information Science, was established as the Remote Sensing Project in 1972, three years after U.S. astronauts had reached the moon. NASA had developed technologies that were the marvel of the world in the '60s.

"The center's original program was funded by NASA to act as an outreach center for NASA products," said Jessica Moy, RS&GIS director.

This basic mission evolved to provide multidisciplinary geographic information technology services and support to state agencies and local governments as well as to MSU scientists and private organizations. The technology is used by a number of disciplines, including soil science, entomology, geography, hydrology, zoology, botany, land use planning, urban studies and economics.

RS&GIS pioneered remote sensing and GIS initiatives in Michigan. Dave Lusch, RS&GIS senior research specialist, and Bill Enslin, RS&GIS manager, introduced GIS to many citizens and officials across the state.

"We were excited about the potential of GIS, and we wanted others to share that excitement and vision," Lusch said. "We wanted people to appreciate the capacity of GIS to present information in a spatial context. Over the past 20 years, we have demonstrated that GIS is a valuable tool in natural resource management and land use planning."

RS&GIS initiated early research applications of remote sensing data to analyze land use/land cover change and groundwater protection. RS&GIS played a pivotal role in assisting the Michigan Department of Natural Resources with the development of the 1978 Michigan Resource Information System (MIRIS), a statewide land use/land cover inventory based on interpreting color-infrared aerial photos.

David Lusch, RS&GIS senior research specialist, introduced GIS technology to many citizens and government officials in Michigan.

RS&GIS also led the way in the development of Michigan MapImage Viewer, a software program that provides users with a system to easily use and query GIS data. Several basic data layers that are useful to a number of audiences (e.g., roads, political jurisdictions, rivers, lakes and streams and others) make up the primary system, and other land use/land cover data and aerial imagery can be incorporated. This GIS software program provides mapping functions — users can display, measure and overlay multiple data layers (for example, soil types, wetlands and 2000 census urbanized areas). The software also allows users to query the database for location-specific information. For instance, a user could ask for a selection of all lakes larger than 10 acres in Ingham County (24 of 597) and see them highlighted on the computer screen.

"GIS enables us to see the nature and extent of landscape change over time," Moy said. "Having data in a spatial context allows decision makers and citizens to make informed resource decisions. GIS puts data and information into action. Putting information in this spatial context helps communities plan for projected change and develop smart policies to respond effectively to future impacts on the air, land, water. But research has shown that air, land and water are all connected, so what happens to one affects the others. Scientists know that the single-medium approach to environmental research is too confining to produce solutions to the complex problems that communities face today.

The MSU researchers work as a

But these represent just a small portion of what can be done with GIS technologies.

FRONTIERS OF GLOBAL CHANGE RESEARCH

Most environmental research during the past 30 years was based on a single discipline or medium —

MAES scientists are working in interdisciplinary teams to offer Michigan research-based land use planning tools.

team and study issues that cut across traditional disciplines: land use/cover change; biodiversity, agriculture and natural resources; climate and water supply/quality.

GIS applications can be used to determine land use and land cover patterns. Using GIS applications

The interface between rural and urban/suburban communities has made land use planning a top priority for MAES scientists, state legislators and Michigan residents.

with various data layers — topographical contours; rivers, lakes and streams; roads and railroads; political jurisdictions; and risk areas or contaminated sites — can create a clearer picture of the impacts of complex environmental processes.

These complex processes are easier to understand when the information is presented in a spatial context. GIS gives the process a space and a place. By using earth observation

landscape. GIS gives us the ability to make resource decisions on the basis of sound, scientific knowledge and understanding."

More than 50 data files containing maps and aerial images are included on a MapImage Viewer CD-ROM disc for each county (in most cases). The data include census geography, school districts, hazardous sites, public water supply wells, digital elevation data, land use/land cover, public land survey sections, jurisdictional boundaries, roads and railroads, watersheds, Landsat satellite imagery and digital orthophotography.

Jessica Moy, RS&GIS director, says GIS puts data and information into action, allowing more informed resource decisions to be made.

RS&GIS also compiled the state's first atlas of digital aerial imagery, consisting of 92 LandScan CDs. Each LandScan CD includes a set of high-resolution images extracted from original photos taken from nearly 10,000 feet above the ground. Organized by county, this atlas consists of 81,000 color photos, each of which covers 1 square mile. The RS&GIS aerial imagery archive also includes complete multiyear Landsat photographic and digital satellite images, as well as 300,000 black and white historical aerial photographs of Michigan dating from the 1930s. It is the largest collection of Michigan aerial photography in the state.

»VICTOR INSTITUTE for RESPONSIBLE LAND DEVELOPMENT and USE

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WEB: www.msue.msu.edu/victorinstitute

The Victor Institute for Responsible Land Development and Use was established in 1999 to provide outreach and practical research on land use issues. Part of MSU Extension, the Victor Institute uses an integrated, multidisciplinary approach to assist communities to reuse and redevelop contaminated or underutilized urban sites and to support conservation of limited land resources.

"The Victor Institute translates research conducted in university facilities, labs, centers and institutes into tools and applications for Michigan communities to use in grappling with natural resource management and land use planning issues," explained Phil Davis, the institute's first director, who now oversees outreach for the institute. "We're translating information at an appropriate scale."

"And we are translating the recommendations of the Governor's Land Use Leadership Council into our research and outreach agenda," added Adesoji "Soji" Adelaja, MAES scientist and newly appointed John A. Hannah distinguished professor in land use, who joined the Victor Institute as research director in January. "With mission-oriented research, the MAES, through the Victor Institute, delivers knowledge of land use issues to communities across the state. We need to build greater capacity in current land use and land cover information with GIS and evolving technologies."

The Victor Institute has used GIS applications extensively in collaborations with local governments as a combined research and outreach tool.

"We collaborate with other organizations to make things happen. The key is making linkages," Davis explained. "We worked with the U.S. Forest Service to develop a decision support system for Wexford County that was used to produce its countywide master plan. We won an Innovative Initiatives Award in 2001 from the federal Housing and Urban Development Department for our work in developing an interactive decision support system for the first master plan for Jackson County."

"With EPA support in 2003, we worked with the Michigan Natural Features Inventory to add data layers to Jackson County's decision support system for protection of species of concern," explained Michael Thomas, MAES community, agriculture, recreation and resource studies scientist and system developer. "We also helped Meridian Township develop a decision support system for its innovative, publicly funded open space preservation program."

"Our instrumentation for analyzing data on global scales has improved dramatically," Davis said. "So now we want to tease out techniques and data useful to the state and region. We've done that, but there's still more to do, especially with Michigan's new emphasis on urban revitalization, sprawl issues and protection of the state's natural resource base."

Michael Thomas, community, agriculture, recreation and resource studies scientist, helped Meridian Township develop a decision support system for its innovative open space preservation program.

"We will roll out the MSU land use research agenda at the Land Use Summit in February," Adelaja said. "Strategic policy problems will shape our agenda so we can provide focused research to inform the land use policy-making process. We must make absolutely certain we are using our research capacity in the most cost-effective ways possible. We must do more with less — that's the reality we are working with. Using geospatial technologies is one way to do this because they are cost effective, both in terms of conducting essential research and providing important benefits to the state and local communities."

The Victor Institute also has been extensively engaged in brownfield redevelopment policy research and outreach. A key part of future urban revitalization efforts, brownfields are properties that are contaminated or perceived to be contaminated, properties that can be redeveloped for commercial or industrial uses without applying the same cleanup standards that would be applied for areas to be used for housing and other types of redevelopment. Innovative state programs have been established to provide financial incentives to assist brownfield redevelopment.

The Victor Institute collaborated with other university units to sponsor workshops on brownfield policies and financial reporting requirements. It also developed information and training for local stakeholders in brownfield redevelopment and conducted longitudinal research on properties for which baseline environmental assessments were filed with the Michigan DEQ, a key eligibility requirement for state brownfield assistance. Findings suggested a viable real estate market for potentially contaminated properties was created.

systems (images taken by satellites) and comparing the images of a certain location over a 10- or 20-year period, scientists can detect patterns in land use and land cover change.

A UNIQUE POOL OF EXPERTISE

Field studies, models and other research methods complement earth observation systems. They are used to assess the processes of these changes and their impacts. By integrating all the data, scientists can create predictive computer models that can forecast changes to land use and land cover, as well as other ecosystem changes.

The sheer volume of data can be staggering. The production of real-time data, the broad range of satellite imagery and data, ground-level and atmospheric monitoring data and model-based data create huge challenges for those who have to analyze and manage these enormous amounts of information.

Because of their parallel innovations in GIS applications, these scientists have a unique pool of talent and expertise and can offer research, analysis and educational services to governmental and private groups across the state. They advocate "democratizing" the data by making it available to everyone through publicly accessible Web sites. As more people use GIS to make choices about land, water and air use, the scientists believe the decisions will become more holistic, and that means better decisions for everyone.

::: J.D. Snyder and Jamie DePolo

GLOSSARY

Accuracy
The degree of correctness attained in a measurement or degree of conformity with a standard. "Relative accuracy" defines the position of a point in relation to another point. "Absolute accuracy" defines the position of a point by a coordinate system. Building a GIS with absolute accuracy requires use of the global positioning system.

Base map
A map showing political, topographic, geological or hydrological boundaries, or road, street and highway information that may appear in many types of maps.

Digital data
Digits are used to numerically represent something in the real world — for example, temperature or time — so that counting and other operations can be performed precisely. Data represented digitally can be manipulated to produce a calculation, a sort or other computations.

Digital elevation model (DEM)
The digital equivalent of elevation data on a topographic base map; shows terrain elevations recorded at the intersections of a fine grid and organized by quadrangle.

Geographic information system (GIS)
A computer software system (often including hardware) with which spatial information may be captured, stored, analyzed, displayed and retrieved.

Global positioning system (GPS)
A satellite-based navigational system permitting the determination of the position of any point on earth with high accuracy. Satellites transmit signals that allow a GPS ground receiver to calculate its location.

Geospatial
Refers to data with geographic and/or spatial orientation.

Hydrography
Topography associated with water bodies and drainage features.

Hydrology
Scientific study of water and of the occurrence and character of groundwater, including the effects of precipitation and evaporation.

Openly distributed geographic information systems
Available to users through a Web browser.

Quadrangle
Four-sided area, bounded by parallels of latitude and meridians of longitude, used as an area unit in mapping.

Spatial data
Data related to the location of geographical entities with their spatial dimensions. Spatial data are classified as point, line, area or surface.

Spatial decision support system (SDSS)
Analytical procedures applied to specific geographic areas using GIS data layers.

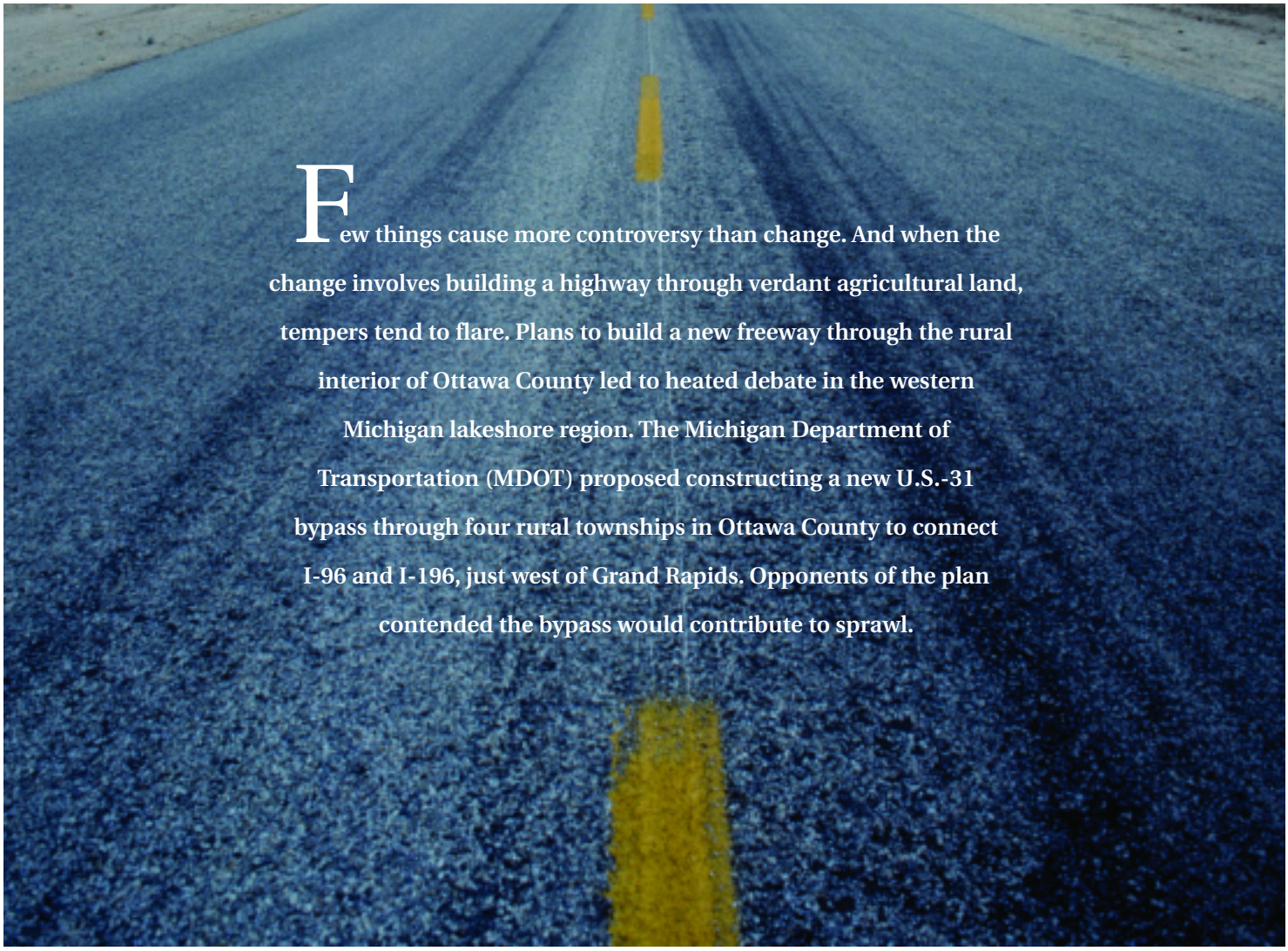
Remote sensing
Recording imagery or data and information from a distance, usually from airborne or satellite platforms. Remote-sensing satellites with sensors that can read various bands of the electromagnetic spectrum provide information on land cover, soils and geology.

Scale
The relationship between a distance on a map and the corresponding distance on the actual landscape. An often used scale is 1:24,000 — that is, one unit of measurement on the map equals 24,000 of the same units on the earth's surface.

Topographic map
A map of land features including drainage lines, roads, landmarks and elevation. Commonly referred to as a topo map.

ADDING SCIENCE TO THE DISCUSSION

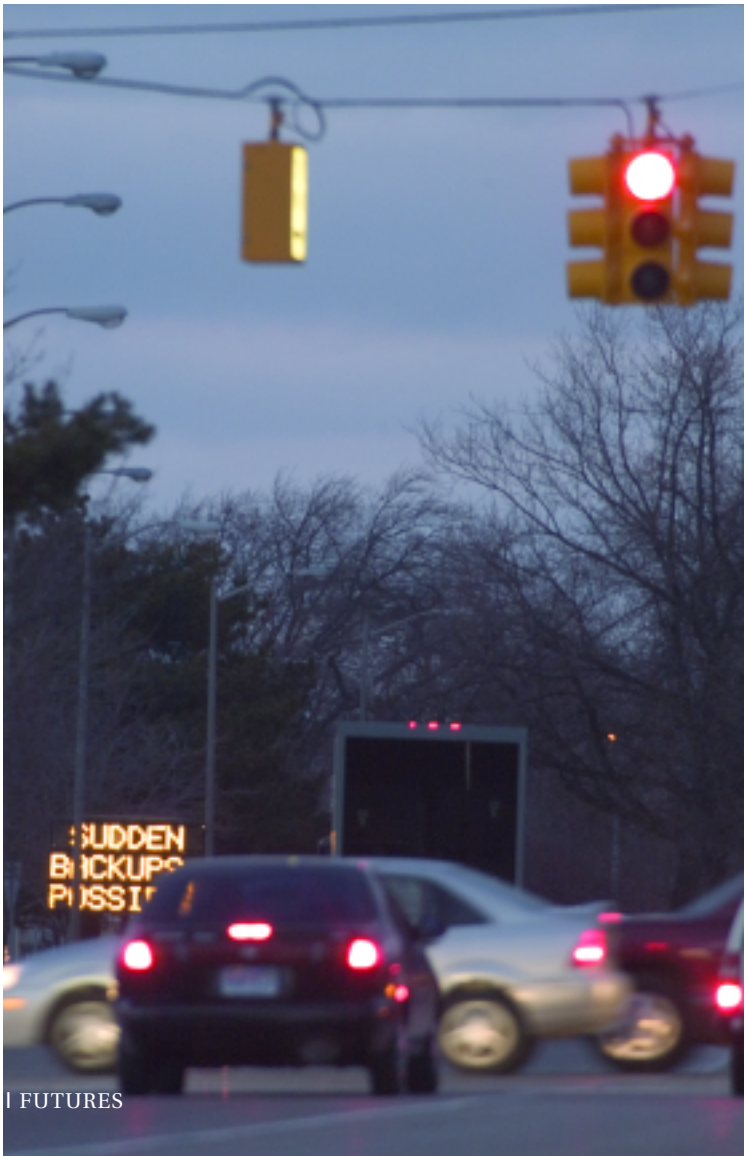
An MAES scientist uses geospatial tools to help MDOT and Ottawa County residents impartially assess the impact of a highway bypass



Few things cause more controversy than change. And when the change involves building a highway through verdant agricultural land, tempers tend to flare. Plans to build a new freeway through the rural interior of Ottawa County led to heated debate in the western Michigan lakeshore region. The Michigan Department of Transportation (MDOT) proposed constructing a new U.S.-31 bypass through four rural townships in Ottawa County to connect I-96 and I-196, just west of Grand Rapids. Opponents of the plan contended the bypass would contribute to sprawl.

The four counties most directly affected by the U.S.-31 bypass — Kent, Ottawa, Allegan and Muskegon — are among the most rapidly growing and most populous in the state. A triangular area between Grand Rapids, Holland and Muskegon called the "growth triangle" is experiencing rapid urban expansion.

MDOT and local planners and citizens have been deadlocked over construction of the 25-mile freeway bypass for decades. The bypass would move the current north-south U.S.-31 corridor east into central Ottawa County, along the rapidly growing area west of Grand Rapids. MDOT planners view the bypass as a means to alleviate congestion and reduce safety risks associated with the four-county region's existing road infrastructure. Opponents fear the bypass would exacerbate sprawl from Grand Rapids into highly productive farmland. As debate continued, the region became highly polarized over the issue. A neutral group was needed to provide unbiased, scientific information.



The Forecast Michigan Model

In 2001, MDOT began a study of the secondary and cumulative impacts of highway corridor development as a part of its environmental impact statement. MDOT representatives asked the MSU Center for Global Change and Earth Observations (CGCEO) to evaluate the impact of the various highway corridor alternatives on land use patterns.

"We wanted a predictive model developed by an unbiased third party," said Michael O'Malley, MDOT transportation planning manager. "We learned about MSU work that could provide us with what we needed. It was an opportunity for us to use new technology we needed, although we also knew it was quite a risk for us."

"We were in a position to really help the citizens of west Michigan by using our geospatial technologies and provide forecast information and analysis," said David Skole, MAES geography researcher and director of the CGCEO. "This kind of real-world opportunity was exactly what we wanted so the center could demonstrate the value and benefits of this decision support system."

To evaluate the alternative bypass options, Skole and his research team developed an analytical mechanism to weigh the impact on sprawl of each of five bypass options, including one proposed by a citizens' opposition group, as well as a no-build scenario:

- No action: Current and planned construction as outlined in the MDOT five-year plan.
- Option A: Freeway on existing U.S.-31 alignment.
- Option R: Free access boulevard on 120th Street.
- Option F/J1: Freeway bypass.
- Citizens' alternative: Freeway on existing U.S.-31 with Grand Haven/Zeeland bypasses and additional river crossing.

The scientists used a computer model called "Forecast Michigan" developed by the CGCEO to assess the impact of each alternative. This spatial decision support model incorporated a wide array of data to visualize the outcome of each option, including digital geographic layers, remote sensing data from satellites, economic forecast information, demographic projections, household transportation information, network routing information, and the relationship between changes in land values and changes in land use.

The computer digested all the data and the scientists analyzed the results.

The Results

The area in the CGCEO study is near Grand Rapids, the second largest metropolitan area in the state, and two other important urban areas, Holland and Muskegon. Three of the four counties — Kent, Ottawa and Muskegon — are among the 15 most populous in the state. Ottawa County is the most rapidly growing county in the region and the second most rapidly growing county in the state. The scientists found that increased land values in Ottawa County reflect the influence of metro Grand Rapids. The urban areas of Muskegon and Holland also influence land values from the west.

Land use trends in the four-county area showed a high rate of land conversion from agricultural/open to urban/commercial areas. Ottawa County saw a 19 percent increase in built area from 1988 to 2001.

In Ottawa County, the researchers found that changes in accessibility to economic centers caused by various road scenarios influenced the location of land use change. In the models for each highway option, improved access to economic centers translated into higher probabilities of urbanization than in areas where access did not improve. All of the options offer high access levels, so the differences between the highway options were subtle.

The researchers found that metro Grand Rapids growth is the single most important factor contributing to land use change in Ottawa County. Economic analysis identified this factor as the major influence on land use change over the next 20 years, not the selection of a particular bypass option. Land use change in this area results from a combination of factors including economic growth, population growth, land valuation changes and transportation.

Results suggested that the no-build option for U.S.-31 would still produce more than 80 percent of the land use change associated with any of the other bypass options. Differences among the various options amounted to less than 7 percent — in other words, the differences were far more subtle than expected.

The research also suggested that local planning efforts were seriously handicapped by large-scale regional pressures. Land use change in Ottawa County is linked to statewide trends and land use change in the entire Great Lakes region. As a result, the scientists reasoned that more comprehensive planning would more effectively serve the interests of all in the region.

The Future

"The MSU team did an outstanding job," said MDOT's O'Malley. "I hope the study opened a lot of eyes and that the results will be used effectively in local and regional planning. The economic engine in west Michigan was shown to be the greatest influence on land use change."

Michael O'Malley, MDOT transportation planning manager, turned to MSU for unbiased, scientific information.

MDOT is still waiting on the "record of decision" from the federal Highway Administration, which will incorporate feedback on the CGCEO study and other matters before moving forward with the U.S.-31 bypass project.

"Sound land use planning on a regional basis is the best way to influence and direct land use change," Skole said. "That was our single most significant finding. Uncoordinated local planning tends to harm many interests."

::: J.D. Snyder

Looking Up Close at the

The Institute of Water Research Develops High-tech Tools

Because their state is surrounded by the Great Lakes and teeming with streams, rivers, ponds and smaller lakes, water quality is an important issue to Michigan residents. Many remember in the 1970s when Lake Erie was declared "dead," its shores littered with dead fish and its water murky with algae blooms.

Dramatic improvements have been made in water quality since the passage of the Clean Water Act in 1972, primarily through the permit system set up to control discharges to lakes, rivers and streams from industrial and municipal point source facilities. Those improvements, however, have not been matched by efforts to control what is known as nonpoint source pollution.

Control of nonpoint source pollution has proven to be stubbornly elusive. Causes of nonpoint source pollution seem to be nearby but somehow manage to slip through the defensive lines set up to stop pollution.

"We can't get away from it, and the worst part is we are the culprits who create this stubborn and serious water pollution problem," said Jon Bartholic, MAES community, agriculture, recreation and resource studies scientist and director of the Institute of Water Research (IWR). "We passionately want clean water, but we insist on clinging to behaviors that cause pollution."

The problem rests largely on the diffuse and pervasive origins of nonpoint pollution. A myriad of land uses contribute to the issue: agricultural production, malls with acres of parking lots, large industrial complexes with pollutants in runoff water, construction sites with floods of sediment-laden waters, chemically treated lawns and golf courses, and forest harvesting practices that fundamentally disturb natural landscapes. Sources of nonpoint pollution are virtually everywhere human activity occurs.

"Millions of individual decisions affect water quality," Bartholic explained. "Our teams build decision support systems on the premise that wise local management and informed decision making about local land use ordinances for wetlands and setbacks, for example, will result in improved water quality or at least avoid further degradation. Working with townships and counties to provide them with science-based research is critical to water quality. We won't have clean water until everyone is working together to make sure that happens."

So the work of persistently looking for scientific answers to questions about nonpoint source pollution continues.

The IWR is one of the main groups studying solutions for this issue.

"We want to look at ecosystems and resources in an integrated way," Bartholic continued. "Historically, scientists have used numerous piecemeal approaches to control pollution, but now we are seeking a more unified vision of water quality and ongoing, high-level strategic planning to achieve it. It's really important that state and federal agencies work together. We try to help make that happen. We have new and more powerful tools. Using digital data and rapidly changing information technologies brings new opportunities every day to work more effectively."

Based on its philosophy of interagency cooperation and ecosystemwide management approaches using information technologies, the IWR is engaged in several important projects to design and build information systems in cooperation with federal agencies such as the Environmental Protection Agency, the U.S. Army Corps of Engineers, the U.S. Geologic Survey and the USDA Natural Resources Conservation Service, as well as an ongoing collaboration with the Michigan departments of Environmental Quality and Agriculture.

Developing geographic information systems (GIS)

Big Picture of Water Quality

for Watershed Managers

Jeremiah Asher, IWR system developer, developed the EZ-Mapper technology on the IWR's Web site. Users can create their own digital maps for a specific location in Michigan and then add selected information to it.

and analytic modeling creates new decision support tools for watershed managers and planners to use in efforts to reduce the impacts of land use on water quality. With computer models that allow them to understand the impacts of human activities on water quality, managers and planners can evaluate various management practices to reduce undesirable impacts on water quality.

Tracking Sediment

"It is well known that sediment and nutrient loadings from nonpoint source pollution are the major contributors to water pollution in the Great Lakes region and throughout the world," Bartholic said. "But we need to know, really know, where the most significant loadings originate. We've made a start, but a lot more needs to be done."

Sediment loadings cause two highly unfavorable economic impacts: reduced productivity from unnecessary soil loss due to erosion and the cost of dredging sediment for navigational and environmental purposes. Sediment loadings also degrade water quality. This degradation affects fisheries, swimming and other recreational uses, and the aesthetic quality of the water. In the most extreme cases, pollution can result in the loss of drinking water supplies.

Working with the Army Corps of Engineers and local soil conservation districts, an IWR team is developing a computer model that can be used easily by field personnel to predict erosion and sedimentation. This model will be Web-accessible and provide field personnel with a complete spatial analysis tool for watershed management. It will enable agency field personnel and local stakeholders to identify high-risk erosion areas and help select the most cost-effective management methods to reduce sediment flow to bodies of water.

"Practices deployed in a watershed can be monitored, and the cumulative impacts of these practices on reducing erosion and sediment transport can be aggregated across that watershed," Bartholic said. "Evaluation of the cumulative potential reduction of sediment movement downstream over time will be feasible."

This project builds on work completed by the IWR in 2003 that provided "big picture" scenarios analyzing comparative loadings and ranking estimated soil erosion and sediment loadings in the Great Lakes Basin. That project used large watershed areas on which to build its analysis.

The current project, to be completed in 2004, refines that earlier work. A digital elevation model with finer resolution will provide more precise identification of erosion-prone areas and estimate sediment loadings based on modeling augmented with crop residue management data.

"We know sediment loadings vary greatly as a function of tillage practices along with other important factors," explained Da Ouyang, IWR system developer. "The combination of the finer resolution scale and field survey data will result in a more practical and robust model for incorporation into a new spatial analysis tool."

This integrated spatial analysis tool and its use will be easily adapted to other regions across the country.

Creating Tools for Managers

The IWR has pioneered development of GIS-based watershed mapping tools accessible on the Web. They include "Understanding Your Watershed" <www.iwr.msu.edu/water> and "Digital Watershed" <www.iwr.msu.edu/dw>. In addition, the IWR developed the first online soil erosion assessment tool by making RUSLE — the revised universal soil loss Equation — available on the Web at <www.iwr.msu.edu/rusle>. RUSLE was brought

"We want to look at ecosystems and resources in an integrated way."

online by the IWR four years ago to assist farmers in controlling erosion and reducing sedimentation in waterways.

"Digital Watershed" allows users to delineate a watershed anywhere in the region by typing in a street address.

"Users have the opportunity to interact with 'Digital Watershed,' not just look at a static map," said Lois Wolfson, IWR outreach specialist.

Other efforts to delineate watersheds across the region have generally been limited to areas that are 800,000 acres or larger, too large to be useful to Environmental Protection Agency staff members, watershed managers or local planners in the field.

The IWR also recently partnered with Purdue University to integrate watershed information systems and GIS Web capabilities into a single integrated, Web-based decision support system. Purdue developed a system called Long-Term Hydrologic Impact Assessment (L-THIA) that is available on the Web. L-THIA has the capability to delineate watershed areas down to less than 100 acres. Based on community-specific climate data, L-THIA estimates changes in recharge, runoff and nonpoint source pollution resulting from past or proposed development. In addition, this system offers a complete regional database and meshes with many other tools.

EPA Region V (Michigan, Ohio, Indiana, Illinois, Wisconsin and Minnesota) is funding this project through the Midwest Partnership for Watershed Management Decision Support Systems. This partnership has identified 13 decision support tools in the region, and one of the goals of the Midwest Partnership is to integrate these tools to address watershed management from a multimedia perspective: water, land and air.

"We envision users being able to select a particular site on a stream and then the system will delineate the watershed that encompasses that site. That will help managers select areas on which to focus pollution control efforts," said Jeremiah Asher, IWR system developer. "Our immediate challenge is to integrate the currently independent systems, principally RUSLE, L-THIA and the 'Digital Watershed' interface."

This integrated model could become the principal tool to help local and state agencies meet total maximum daily load (TMDL) requirements for specific water bodies. A TMDL is the amount of a pollutant (e.g., sediment, nitrate or pathogens) from all of the contributing point and nonpoint sources that a body of water can receive and still meet water quality standards. With this new integrated model, users would be able to identify the subwatersheds that contribute heavy pollutant loadings.

Training is Critical

Making the technology available and training people to use it are critical components of this new model because its ability to improve water quality increases as more people use it. To facilitate this technology transfer, a user-friendly interface will be designed with interactive menus and help tools. Users will be able to provide minimal data inputs to assess the potential impacts of management practices that reduce sediment loads. The scientists are also creating Web-based educational modules.

The ultimate goal is development of a watershed decision support system that integrates a number of databases, simulation models, decision models and user interfaces. With this new tool, watershed managers would be able to measure and evaluate the economic and environmental impacts of various land use and watershed management scenarios. This kind of system, with multi-disciplinary GIS data and dynamic modeling of pollution impacts, is essential to the practice of science-based watershed management.

According to Bartholic, this kind of system is the essence of watershed management: an integrated assessment of physical, biological, social and economic forces and impacts. The traditional academic discipline approach and media-specific approaches in environmental management have slowed development of more holistic, systemwide watershed management approaches.

"This type of decision support model cuts across disciplines and provides an effective vehicle to transform environmental management," Bartholic explained. "The trick is to balance some level of pollutant loadings, which you can't get rid of entirely, and still achieve water quality goals, which is the objective of TMDLs.

"Having the right tool isn't the same as waving a magic wand, but it can get us closer to our environmental goals," Bartholic concluded.

::: J.D. Snyder

Cutting-edge Technology Protects Michigan's Drinking Water

Successful eradication of infectious diseases such as cholera and typhoid in the late 19th century came from a new scientific understanding of the relationship between unsanitary water conditions and outbreaks of these dreaded diseases. Research discovered the connection between dumping raw sewage in the same bodies of water that supplied drinking water. The new scientific data led to the establishment of local health departments to improve sanitary conditions.

Local and state public health departments are justifiably proud of their nearly century-long record of protecting public health from waterborne diseases and other serious health threats. The Michigan Agricultural Experiment Station is equally proud to have collaborated with these groups and to fund research that helps protect Michigan's water supply. When new scientific information indicated the need to protect groundwater from contamination, many local health departments were in the forefront of actions to assure the health and safety of this largely hidden water resource. And MAES scientists were working with them, providing the necessary data and decision-making tools.

About 43 percent of the state's residents obtain their drinking water supplies from groundwater, water stored beneath the ground in an aquifer. An aquifer is a zone of rock or soil saturated with water. Aquifers can range in size, holding millions to quadrillions of gallons. The water may have recently entered the aquifer or may have been there for several decades or centuries, depending on the depth and geology.

The Institute of Water Research (IWR) and Remote Sensing and GIS Research and Outreach Services (RS&GIS) [formerly known as the Center for Remote Sensing], both funded in part by the MAES, have a long history of working on groundwater research and protection programs — most notably the Groundwater Education in Michigan (GEM) program, which provides communities with groundwater resource information.

So it was natural for these two groups to team up and lead a five-year source water assessment program (SWAP) in Michigan, a federally-required program to assess the quality of all public drinking water supplies. RS&GIS and the IWR worked with the Michigan Department of Environmental Quality (DEQ), the agency responsible for ensuring that Michigan meets the requirements of the 1996 Safe Drinking Water Act amendments, as well as the U.S. Geological Survey and GEM centers on the program, which concluded in 2003.

"Having five years to phase SWAP in worked well for us," said Bob Godboldt, director of environmental health for the Ingham County Health Department. "It made the program manageable."

Two Types of Water Supplies

In Michigan, public drinking water is regulated for public health and classified in two categories: community water supplies (Type I) that serve more than 25 people for residential uses yearround, and non-community water supplies (Type II) that provide water to restaurants, churches, rural schools and campgrounds for non-residential use. Of the 10,800 Type II non-community water supplies in the state, nearly all of these are groundwater.

"Given the huge number of these non-community water supplies, DEQ resources historically were not sufficient to monitor and assure their safety and quality," said Elgar Brown, chief of the Groundwater Supply Section of the DEQ. "Working with the Institute of Water Research and RS&GIS was a natural step for ramping up capacity to conduct more than 10,000 source water assessments."

SWAP was designed to provide funding for inspection and assessment of Type II water supplies by local health departments. SWAP was linked to a sanitary inspection program that required annual inspections of 20 percent of the water supplies in each local health jurisdiction. Wells were evaluated for cross-connections, well casing deficiencies and other potential causes of contamination.

DEQ staff members developed a detailed and robust inspection protocol for conducting source water assessments, including determining the location of each well and intake (for surface water supplies) using global positioning system (GPS) technology. The protocol also includes a

review of well record information to determine the geology and area hydrology around intakes to estimate sensitivity of the source to contamination, and the date of drilling, pumping rate, and a review and examination of wells to evaluate construction details and physical condition and integrity of the wells. Finally, assessments included a determination of the source's susceptibility to contamination. A scoring system was created to help rank systems for vulnerability to contamination.

How SWAP Works

In SWAP, local health departments systematically evaluated water quality and reviewed the landscape for potential causes of contamination, such as storm sewers, grouting deficiencies, septic systems, intensive agricultural animal production, underground storage tanks, bulk chemical storage and large-scale waste disposal facilities.

"The DEQ invested millions of dollars in local infrastructure capacity to protect groundwater and created a real legacy of statewide groundwater protection," said Dave Lusch, RS&GIS scientist. "No other state matched the public benefits achieved in Michigan from SWAP."

Michigan MapImage Viewer, a GIS program developed by RS&GIS, was made available to local health departments so the agencies could assess the quality of all public drinking water supplies in the state.

The DEQ, RS&GIS and IWR helped local health departments build their GIS capacity for SWAP, which resulted in long-term groundwater protection benefits.

At the county level, GIS technology is frequently underutilized because education and training needs may be beyond local budgets or pose logistical challenges that cannot easily be overcome. The SWAP team made GIS available to local health departments by distributing CDs containing MapImage Viewer, a GIS program developed by RS&GIS, to each county.

"MapImage Viewer is wonderful," Godboldt said. "For example, you can click on a well location to bring up information on sources of potential contamination in the area of that well. We like it a lot and we use it a lot, and not just for SWAP. MSU did a really good job."

With SWAP-funded deployment of GPS technology, more than 90 percent of the Type II wells have been mapped using GPS coordinates. The accuracy of the well locations is within 3 to 5 meters, offering decisionmakers excellent geospatial information.

"RS&GIS developed excellent maps that included data such as the depth of the water table across the county and the location of private wells, in addition to municipal and Type II wells, and related geology and hydrogeology. The maps also include known contaminated sites. It just made our job a whole lot easier," Godboldt said.

The accomplishments of SWAP are being continued by voluntary efforts by local governments to protect wellhead areas of their public drinking water supplies. Ninety community public water supplies have approved wellhead protection plans and 80 community water supplies have approved area delineations.

"SWAP is an excellent example of a state agency, counties and MSU working together to produce benefits in a cost-effective way with truly long-term benefits," said the DEQ's Brown.

Beyond SWAP

RS&GIS is now developing a new statewide water table map showing the depth of subterranean water, direction of flow and gradient of the water table.

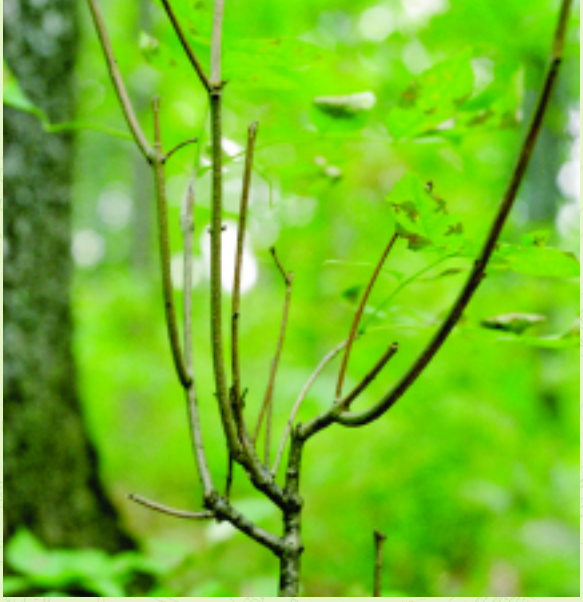
"Our current task is to develop a protocol that identifies the most vulnerable public water supply wells in the state," Lusch said. "Our goal is to build a decision support system that provides an environment rich with data for accurate identification of the most vulnerable wells."

"We want to prioritize those public water supply systems that are most vulnerable," said Brown. "We want to assure there are long-range management tools for adequate protection. Those systems would tend to be pumping water from karst outcroppings or fractured bedrock within 25 feet of the surface. Those areas lack adequate natural filtration processes provided by layers of sand and gravel and other materials at sufficient depths."

A karst is a highly sensitive limestone geologic formation. Over the years, some of the rocks below the surface dissolved and cavities formed. These cavities provide a direct channel for contaminants to enter the aquifer.

"The Institute of Water Research is doing a great job in conducting outreach on the wellhead protection program," Brown continued. "We want to implement adequate protection measures now that we have completed the source water assessments."

::: J.D. Snyder



Mapping Living Populations

GIS is an increasingly important tool for MAES scientists in a number of disciplines.

PHOTOGRAPHS ON PAGES 22–23: ED LAURENT

As software becomes more sophisticated and the types and the amount of data collected increase, GIS has become a valuable and standard piece of many MAES research programs. From lakes to caterpillars to crops, MAES scientists are using GIS and related technology to describe more fully the relationships between the environment and the living things that depend on it.

SLOWING THE SPREAD (STS) OF THE GYPSY MOTH

In 1869, an enterprising Leopold Trouvelot introduced the gypsy moth to Massachusetts from Europe to breed with other moths and produce a new strain of silkworms. The experiment failed, but gypsy moths found their new North American home very much to their liking. Abundant forests and few natural enemies provided an ideal and extensive habitat for the species. Oak tree leaves are their favorite food, but they also devour the foliage of more than 600 other species of trees, shrubs and vines.

MAES fisheries and wildlife scientist Jack Liu is leading a team of researchers using GIS to build an integrated ecological-economic computer system model to predict the relationships between deer density and bird abundance, forest regeneration and plant diversity, as well as their economic value, in the Upper Peninsula.

Gypsy moths have spread extensively with some inadvertent human help. Female moths lay their egg masses on outdoor equipment, cars, trailers, campers, trucks, firewood, etc., which are then moved by people. Gypsy moths are found in every county in the Lower Peninsula and most areas of the Upper Peninsula. In 1992, gypsy moth caterpillars were responsible for the largest total area of defoliation in state history. In addition to the loss of shade from defoliated trees, the hungry creatures also hurt Michigan's tourism, forest product and Christmas tree industries.

"Organisms operate at scales larger than a backyard or farm, although that may be the scale we are most interested in," said Stuart Gage, MAES entomology researcher. "In the case of gypsy moths, we are looking at the flow and movement of organisms at multiple scales. These moths are epidemic in several states. Our interdisciplinary research aims to increase our understanding of the regional dynamics of these organisms. From that understanding, we hope to develop more effective suppression strategies."

Led by Gage, the Computational Ecology and Visualization Laboratory (CEVL) is the Michigan partner in the national gypsy moth Slow the Spread (STS) project implemented by the U.S. Forest Service in 1999.

The goal of this 10-state cooperative project is to limit the new territory invaded by the gypsy moth by detecting and eradicating or suppressing isolated colonies formed just ahead of the approaching gypsy moth population front. GIS is critical to this effort to slow the spread of this pest by mapping gypsy moth areas of infestation and tracking their movement across the landscape.

"We identify three zones for our research," Gage said. "First, there's the infested zone continuously occupied by gypsy moths. Second, there's the transition zone where isolated colonies of gypsy moths become established. Then there is the uninfested zone where the probability of finding gypsy moth colonies just getting established is close to zero. We know that as the isolated colonies grow, they coalesce and contribute to the expansion of the population front. The rate of spread can be reduced if isolated colonies in the transition zone are detected and suppressed or eradicated before they grow too large."

By combining GIS technology and statistical modeling techniques with diligent fieldwork by state cooperators to place and monitor traps, Gage and his research team are providing data analysis that allows management efforts to be targeted in the transition zone.

"This allows us to avoid largely ineffective and costly broadcast approaches," Gage said.

STS state cooperators gather data on moth populations by trapping moths in pheromone-baited milk cartons (pheromones are chemical substances that animals and insects produce to attract others of the same species by smell). The transition zone is divided into two subzones: a monitoring zone that is behind the approaching gypsy moth population front and an action zone that encompasses the front.

In the action zone, isolated gypsy moth colonies are detected and eradicated. In the monitoring zone, moth population boundaries are mapped. Results in the monitoring zone are used to evaluate the effect of the project on the rate of population spread.

"GIS helps us understand and integrate planning and policies much easier," Gage said. "We can't continue to work on isolated areas — we need to know about how all of these systems are interrelated and interacting. And if we know how ecosystems work, we can manipulate and manage them for future sustainability.

"Perhaps more important is imparting our knowledge about ecosystems to students so they will be able to lead the next generation toward a sustainable future," Gage added. "As we move through the 21st century, all of us need a better understanding of our role in the biosphere. It is one of my goals to promote that understanding at Michigan State University."

MAES fisheries and wildlife scientists Pat Soranno (left) and Mary Bremigan are using GIS data to create a lake management classification system.

Soundscapes and Landscapes: Potential Indicators of Ecosystem Health

Gage is also studying the relationship between sounds and ecosystems.

"Sounds are an untapped source of rich and sensitive data about the ecology of landscapes," he explained. "The range of sounds in a particular place depends on the type of habitat, interrelated habitats in the landscape, the time of day and the season of the year."

Sounds caused by human activity — mechanical activity and oral communication that may be stationary, either continuously or periodically, and occur over time, either briefly or in some undefined pattern — occupy the lower ranges of frequency. Biologically based sound is classified as either intentional — communication between organisms — or incidental — signals caused by organisms.

The patterns of acoustic signals reflect the dynamics of biological, social and physical systems in the landscape.

"Defining the meaning of these signals in terms of the processes and interactions they represent between social and biophysical systems is a major challenge," Gage said.

Gage and other CEVL researchers have developed a GIS system that records and analyzes environmental acoustic data. The system was developed using data recorded in Sequoia National Park and the Muskegon River watershed. Sounds were recorded at specific sites for 30 seconds every 30 minutes 24 hours a day for 12 to 24 months. The system used transmitters to relay the acoustic information to CEVL computers on campus.

Acoustic signals emitted by the environment change depending on the place, time of day and season of the year. A specific soundscape reflects the complexity of acoustic signals in time and space from that specific place. That complexity depends on the interactions between biological and physical components of the landscape.

"These signals may represent the 'heartbeat' of an ecosystem," Gage explained. "We can learn about variations in the environment by studying the origin and character of these acoustic signals."

With greater understanding of the relationship between a landscape and its soundscape, it may be possible to correlate the integrity of an ecosystem to the complexity of the soundscape.

"Environmental acoustic data and analysis may offer a useful set of ecological indicators," Gage said. "Environmental acoustics might have the right balance between specificity to satisfy technical requirements and the broad range of ecosystem variables we want to measure and understand."

Managing Lakes with GIS

In addition to the Great Lakes, Michigan has more than 20,000 inland lakes larger than 1 acre. Of these, approximately 2,000 are 50 acres or larger. The lakes are used for fishing, swimming and other recreation, irrigation and some drinking water.

For the state governmental agencies that manage the inland lakes — primarily the Department of Natural Resources (DNR) and the Department of Environmental Quality (DEQ) — sampling and cataloguing all these lakes is a daunting but extremely important task. Lake managers oversee fish stocking, fishing regulations, herbicide applications for control of aquatic plants and impact assessments for development. They depend on data collected from lakes by technicians and citizen volunteers. The DNR groups lakes into various clusters on the basis of surface area and geographic region of the state. Managing the lakes as groups streamlines the process. The lakes, however, are affected by more variables than surface area and geographic region. Land use around the lake, soil makeup, bedrock geology and a number of other landscape features may determine how a lake responds to management. Two MAES aquatic scientists using GIS data are working to create a

lake management classification system that ranks multiple variables according to the extent of their influence on lake management response.

"What we want to do is develop a way to classify lakes into groups, with those that appear to be similar and respond similarly to management actions together so they can be managed as a group," said Patricia Soranno, MAES fisheries and wildlife scientist, who has extensive GIS experience.

"Inland lakes are an important natural resource for Michigan," said Mary Bremigan, also an MAES fisheries scientist, who is funded through the Partnership for Ecosystem Research and Management (PERM) program, a partnership with the DNR. Bremigan's area of expertise is fish management, a large component of lake management. (For more information on the PERM program, see sidebar at right.) "The lakes are primarily managed to meet goals that are related to their chemistry and biology. Our results will provide managers the conceptual models and computer tools to extrapolate information from a few well-sampled lakes to lakes that have not been sampled, something managers currently have limited ability to do."

Using Technology to Build Databases

The scientists' first step in the project is to build databases of all the variables for each lake in the state. The variables range from data describing the landscape around each lake — the ecoregion, the lake's position in the landscape, shoreline features, hydrology, groundwater connectivity, depth, size, land use, damming, etc. — to characteristics in the lake — fish growth, water quality and chemistry. For each lake, they build a 500-meter buffer zone to characterize features of its watershed.

"We are building a GIS lake landscape database that we have obtained from landscape maps (digital or paper) alone," Soranno said, "What makes our work unique is that we will build our lake classifications from these maps alone — which means we do not have to sample a lake to identify its unique grouping. This is a much more cost-effective approach than sampling every lake in the state.

"GIS isn't perfect," she added. "There are some things it can't do yet. But even since the beginning of this project three years ago, the technology has improved. We can do many things much more easily today."

PERM Partners MSU and State Agencies for Ecosystem Management

On Earth Day 1993, the leaders of MSU's College of Agriculture and Natural Resources and the Michigan DNR signed a joint operating agreement called the Partnership for Ecosystem Research and Management (PERM). Originally a partnership between MSU and the Fisheries and Wildlife divisions of the DNR, PERM has expanded to include the DNR Forest, Mineral and Fire Management Division, the Great Lakes Fishery Commission and the Great Lakes Science Center, which is part of the U.S. Geological Survey. PERM work is led by researchers who are MSU faculty members in the MSU departments of Agricultural Economics, Fisheries and Wildlife, Forestry, and Geography. Many of these scientists are also affiliated with the MAES.

"In the past, much of fisheries and wildlife management was species-specific," said Tom Coon, associate dean of the College of Agriculture and Natural Resources and former chairperson of the Department of Fisheries and Wildlife. "MSU and the DNR saw that resource management was moving toward management on an ecosystem level. As we recognized this need to manage on a larger scale, we also recognized that there was a lot of basic information we needed and that this information needed to get in the hands of the resource managers. The PERM program opened the door for new research and makes it possible for the results to be distributed quickly and efficiently."

William Taylor

PERM scientists are located at the university but maintain strong ties to the other funding partners.

"PERM allows our partners the capacity to build programs toward the effective and efficient management of natural resources and the environment," said William Taylor, chairperson of the Department of Fisheries and Wildlife. Taylor was one of the architects of the PERM program, along with John Robertson, Rick Clark and George Burgoyne, of the DNR. "There's no gap between research and implementation. Through their joint efforts, PERM researchers have heightened awareness of and responsiveness to issues such as infectious and emerging wildlife-borne diseases, exotic and aquatic nuisance species, the Great Lakes fishery and water quality, public opinion and human dimensions of fisheries and wildlife management. PERM is successful because it combines a shared vision with hard work and promotes dialogue and cooperation among our partners."

"The PERM program brings new tools and a multidisciplinary approach to our research efforts, enhancing our understanding of wildlife and wildlife management practices," said Bill Moritz, assistant chief of the DNR Wildlife Division, who serves as the PERM liaison for the Wildlife Division.

Phil Robertson, MAES crop and soil scientist and director of the Long-Term Ecological Research site at the Kellogg Biological Station, says presenting data in spatial contexts is an extremely effective way to convey the information.

Once the databases are completed, the researchers will model the relationships between lakes and their landscapes and develop the lake classifications, studying the various landscape variables to see which is tied mostly closely to fish growth and water quality. Ultimately, they may not need to use all the variables to classify the lakes accurately.

"For example, ecoregion is one variable we're using," Soranno said. "It's a classification of land. Michigan has a number of ecoregions, which makes the state a great place for this type of research. We have a highly diverse landscape, so we can look at a variety of relationships and variables."

"Lakes within ecoregions are not always that similar, even though ecoregion is often suggested as an effective way to manage lakes," Bremigan explained. "We can sometimes use ecoregion to classify lakes but not always. As our research progresses, we want to rank the landscape variables to see which is most related to the lake groups."

After the classifications are developed, the researchers will use data collected from the lakes to test the accuracy of their groupings. Then the classifications will be made available as computer models and other tools for lake managers to use.

The scientists are also paying close attention to the relationships between fish growth and water quality because some of the variables are managed by different entities. For instance, what the DNR does to manage a specific lake for fish growth may affect water quality, which is managed by the DEQ.

"We hope this research will provide tools for managers to use and to communicate better with each other," Bremigan said. "We're not telling them what to do, we're giving them better tools, so they can see how each of their actions affects the other variables that influence the lake."

The researchers' classifications will also help Michigan determine universal reference conditions for its lakes. A universal reference condition is the lake's condition if there were no human impacts on it — essentially the ideal zero pollution level. Because Michigan has such a diverse landscape, it has been very difficult to calculate universal reference conditions for all the state's lakes.

"This research will help determine universal reference conditions for each group of lakes," Bremigan said. "This will be helpful because the Environmental Protection Agency has told each state that it has to come up with a way to determine universal reference conditions. Many states are concerned about this, so we think this research may have applications that are broader than just Michigan."

As the research moves forward and the modeling progresses, Bremigan and Soranno will be relying on input and comments from an ad hoc advisory group of DNR Fisheries Division, DEQ and Michigan Natural Features Inventory representatives.

"We'll look to this group to discuss the applications of the research as we create the models," Soranno said.

Using GIS to Understand Agricultural Relationships

The Kellogg Biological Station (KBS) Long-Term Ecological Research (LTER) site is one of 20 sites in the LTER network established by the National Science Foundation in 1980. The LTER Network provides long-term research in ecology and environmental biology to improve understanding of ecological phenomena in both natural and managed ecosystems. The KBS LTER site focuses on the agricultural ecosystem. The research is studying the ecological interactions underlying the productivity of field crops such as corn, soybean and wheat rotations, as well as forage crops such as alfalfa and agroforestry crops such as poplars.

"One of our key themes is the role of biodiversity in the agricultural landscape," said G. Philip Robertson, MAES

crop and soil scientist and director of the LTER. "Our goal is to understand the functional significance of diversity in the overall ecosystem. If agronomic management reduces the structural complexity of various ecological communities, then we must answer some critical questions. The consequences of changes in complexity will be expressed at the ecosystem level as changes in primary productivity and in nutrient cycling."

GIS technology is being developed for the LTER. The LTER database management system will be linked to the GIS so spatial data can be displayed on maps. A GIS of the Kalamazoo River watershed is also being created so LTER research data may be incorporated into maps of the southwestern Michigan landscape.

The GIS includes aerial photographs, digital elevation maps, soils, vegetation and field instruments. It provides a system to compile information on experimental conditions, sampling points and spatial data, such as crop yields.

Scientists are also using GIS to analyze 14 years of data collected for a landscape-level investigation of eight insect predator species.

The 444,000 observations of insect abundance are stored in databases and linked to 14 years of daily weather observations. These linked databases provide information on a landscape-scale response to treatment and plant community regimes and have produced 2,600 maps showing species distribution. The database analysis allows scientists to model insect populations' response to changing plant communities, cropping patterns, various management practices and weather conditions.

"Presenting data in spatial contexts — for example, relating ladybird beetle populations to changes in plant growth — is the only effective way to convey that information," Robertson said. "In a lot of cases, using GIS is even better than being at the actual locations because you have a better perspective, a better knowledge of your geographic context."

The Impact of Forest Management

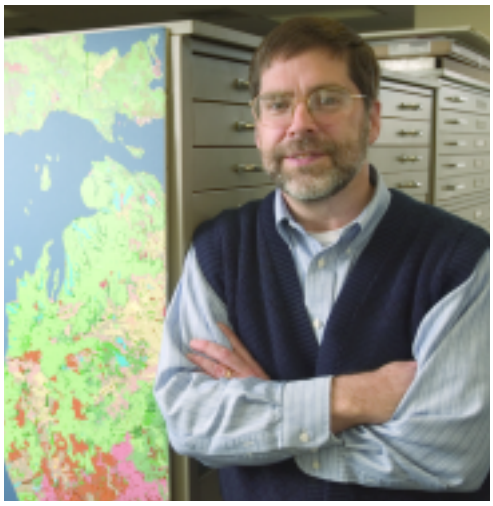
In a project of ambitious scope and scale, MAES researchers are using GIS to build an integrated ecological-economic computer system model to predict the relationships between deer density and bird abundance, forest regeneration and plant diversity, as well as their economic values. The area

Michigan Natural Features Inventory Preserves Biological Diversity

Established in 1980, the Michigan Natural Features Inventory (MNFI) is an MSU Extension program administered in partnership with the Wildlife Division of the Michigan DNR and The Nature Conservancy, a private nonprofit environmental organization.

MNFI's work focuses on preserving the state's biological diversity, and the group has built a comprehensive statewide natural heritage database that currently contains 12,300 records of the state's most sensitive species and natural features. This GIS database tracks the location and status of threatened, endangered and special concern species as well as natural communities.

"This is applied conservation work, and we use our database to protect our natural heritage and history," said Patrick Brown, MNFI director.



Patrick Brown

The database contains dates of sightings, global and state species status rankings, and a quality/viability ranking of individual occurrences. Federal and state-protected species, as well as those of special concern that do not have legal protections, are included.

Michigan is home to a number of rare species and natural features, all of which are in the MNFI database. The sand-colored piping plover, one of the rarest birds in the Midwest, nests on wide, sandy beaches with sparse vegetation during spring and summer. Michigan's 3,200 miles of Great Lakes shoreline provide habitat to more of these rare birds than any other state in the region. The dwarf lake iris, named the state wildflower in 1999, is found only on the shores of Lake Michigan and Lake Huron and along the edges and openings of coniferous forests. Alvar grassland, one of the rarest habitats in the world, features grasses and sedges growing on flat limestone bedrock in open landscapes. This unique habitat occurs only in the Great Lake region, northwestern Ireland and Europe's Baltic region.

A substantial amount of MNFI's work focuses on places where land and water meet: wetland areas, dunes, Great Lakes tributaries and various riparian communities.

"These areas are very diverse biologically and frequently under development pressures," Brown said.

MNFI has developed GIS methods to produce data layers that can be incorporated into local land use planning without disclosing highly specific information about sensitive species. These methods avoid jeopardizing species vulnerable to human exploitation while protecting private property owners from disclosure of what some owners regard as sensitive information.

MNFI recently partnered with the Victor Institute to incorporate natural heritage data layers into the Jackson County master plan.

"We want to empower decision makers in protecting the natural environment," Brown said.

Members of the team working on the Upper Peninsula computer model are (left to right): Frank Lupi, MAES agricultural economics and fisheries and wildlife researcher; Michael Walters, MAES forestry researcher; Jianguo (Jack) Liu, MAES fisheries and wildlife researcher and principal investigator; Kimberly Hall, fisheries and wildlife post-doctoral researcher; Joseph LeBouton, forestry doctoral student; Laila Racevskis, agricultural economics doctoral student; Ed Laurent, fisheries and wildlife doctoral student; and Haijin Shi, fisheries and wildlife post-doctoral researcher.

being studied reaches across six Upper Peninsula counties for a total of 2.5 million acres. When it is completed in 2005, resource managers and decision makers will be able to use the model to assess the impacts of various forest management practices on relationships at both the stand and landscape scales.

"We want to measure the impacts of changes in wildlife habitat on wildlife populations," said Jack Liu, MAES fisheries and wildlife scientist. "It's an important step in linking land use/land cover change with wildlife response in a forest ecosystem. Our focus is on the analysis of habitat changes using both field survey and GIS data to develop a powerful model. This model will predict future changes in habitat and wildlife resulting from various management scenarios."

The vast majority of the study area landscape — 83 percent — is covered by hardwood, conifer and aspen-birch forests. The area has been managed for timber harvesting for decades. Various types of harvesting have been used, including single-tree/group selections, patch cuts, clear cuts and no harvesting.

Previous research has shown that deer populations respond positively to some harvest levels. Other research suggests that browsing deer may hinder tree regeneration for some forest types. The full extent of these impacts, however, is not currently known.

Deer hunting is a major recreational and economic activity in the region. On average, 100,000 hunters are active in the region for more than 1 million deer hunting days per year. Approximately 45,000 deer are harvested each year.

In addition to timber and deer, other important ecological and economic features include several rare and threatened plants. Species vulnerable to deer grazing include wildflowers such as jack-in-the-pulpit, trillium and the lady slipper orchid, as well as ecologically important tree species such as eastern hemlock and yew.

Forest birds breed in the region. Some species have experienced dramatic declines that are often attributed to timber harvesting. Bird species of special concern in the area include the black-throated blue warbler, blackburnian warbler, wood thrush and chestnut-sided warbler.

"Our study will be able to demonstrate important ecological relationships," Liu said. "There is large variation in

deer densities and different patterns of tree harvests, harvest types and stand types over time that give us an ideal setting for testing various management scenarios."

Because the area is predominantly forest, there are minimal agricultural and urban effects on wildlife-forest interrelationships, so scientists can gather and analyze substantial long-term data for the area.

Liu just completed the first year of the project. He and his doctoral students conducted fieldwork to classify a vegetation map of the area based on satellite images. Forest and deer inventory databases were obtained, and preliminary data for all field variables were collected, including bird censuses, forest vegetation and deer pellet counts.

The researchers will study the data and analyze forest harvesting-vegetation-deer-bird interrelationships. Quantifying the analysis of these relationships will enable them to be incorporated as parameters in the simulation model.

GIS maps and analysis will show the location of wildlife and tree varieties to determine the relationships between various forest characteristics and patterns of wildlife distributions. Deer density data will be used to test bird-deer-harvest-vegetation relationships. Managers will be able to see how the interplay of forest management and harvesting affects habitat attributes and the corresponding impacts on deer and bird populations.

"Having the ability to assess multiple variables over time will provide a valuable new tool for forest management," said Richard Hausler, environmental forestry specialist with the Michigan DNR Forest, Mineral and Fire Management Division.

Liu and his research team also will quantify the economic value of wood products, deer hunting, aesthetics, and forest bird and plant diversity. This analysis will include both market and non-market costs and benefits of forest products, white-tailed deer hunting and other key ecosystem attributes. The economic values then will be linked to the various management practices so the forest managers can determine the economic impacts of each practice.

"This will be a very complete model," Liu said. "It will have the flexibility to analyze a great many variables in several combinations so that multi-objective forest management can be practiced in meaningful ways."

::: *J.D. Snyder and Jamie DePolo*

PHOTOGRAPHS ON THIS PAGE: KIMBERLY HALL

This maple tree's leaves have been eaten by deer, above left. Previous research suggests that browsing deer may hinder tree regeneration in some forest types. A blue warbler sits on nest, above right. MAES scientists are measuring the impacts of changes in wildlife habitat on wildlife populations.

Research *in the news*

Farm Managers Engage in Civic Agriculture to Help Local Communities

Farm managers at a number of on-campus farms and outlying MAES field research stations are working to distribute surplus produce to local community groups, according to a recent research paper by Kimberly Chung, community, agriculture, recreation and resource studies (CARRS) scientist, and Sherill Baldwin, CARRS graduate student.

The MAES field station network encompasses 15 outlying stations and the on-campus farms. Eleven of the farms produce crops that can go directly to consumers without further processing, but three were eliminated from the research project because they had less than 5 acres devoted to these crops. The scientists found that staff members at the remaining eight farms were involved in providing fresh produce to food banks and other groups that then distributed the food to those in need.

"As part of her research for her master's thesis, Sherill became interested in the concept of civic agriculture on the university research farms," Chung said. "Normally, university research farms are not cited as examples of civic agriculture — people think of farmers' markets, community gardens and small specialty producers. But we found that there are some extraordinary people working for the Michigan Agricultural Experiment Station involved in civic agriculture."

The scientists found strong connections between the farm managers and local food banks and other groups. These activities were not considered part of the job description, but many of the managers, did not want to waste food. They wanted to be sure it was going to people who needed it and not competing with local farmers.

"They don't get a lot of credit for this," Chung said. "It's something they do because it is personally important to them. They make these activities fit in around the rest of the work they have to do."

All the farm managers emphasized that supporting research is the most important aspect of their jobs. But if they could work with a community group and find an outlet for leftover food and still accomplish the research goals, then the managers were enthusiastic about the win-win situation.

In addition to their paper, Chung and Baldwin have written an MSU Extension bulletin on how these types of partnerships can work successfully for both farm managers and local community groups. In it, the researchers describe the work done by Cliff Zehr, farm manager at the campus plant pathology research farm; Bill Chase, farm manager at the campus horticulture farm; and Ron Goldy, MSU Extension vegetable agent at the Southwest Michigan Research and Extension Center in Benton Harbor, as examples. All three have successful partnerships with local food banks that allow them to provide fresh produce to hungry people.

"The Garden Project has been very helpful in that it will have people come out and help us harvest for research projects," Chase said. "They know when they get done, the material goes out, gets weighed and is given to the food bank."

The Garden Project is a part of the Greater Lansing Food Bank and distributes the produce to local agencies, including food banks, soup kitchens and low-income housing units.

For a copy of the "Fresh Food Recovery at Michigan Agricultural Experiment Stations" MSU Extension bulletin, contact Chung at kchung@msu.edu.

Scientists Go Back to School to Understand Ecosystems

A groundbreaking discovery that shows that fisheries ecosystems and educational systems have a lot in common stands to give natural resource managers tools to keep environments healthy.

What seems like an unlikely marriage of social science and aquatic resource management has shaken up the food chain. Applying social science principles changes the traditional view of food webs and their management.

Food webs are a network of interconnecting food chains. Each chain consists of a sequence of organisms eating another and being eaten by other organisms. Scientists have found a way to describe food webs in compartment rather than hierarchical contexts.

In a paper published in November in the international science journal *Nature*, scientists from MSU, the Great Lakes Fishery Commission (GLFC), the University of Maryland and the Great Lakes Environmental Research Laboratory show that food webs are more like high school — a complex web of relationships and cliques.

Instead of progressively bigger fish making lunch of the little guys, food webs are more about compartments of plants and animals and the strength of their bonds to form groups within the food web. Changes or stresses to one species within the compartment are going to hit its compartment members — think of them as a clique — harder than other species or groups that do not interact as much.

"Bringing in a social science perspective has given us a whole new way to look at the food web," said William Taylor, chairperson of the Department of Fisheries and Wildlife and a paper co-author. "This shows us a whole different picture of how changes reverberate through the system. It gives us new tools to understand how changes affect the system."

The paper, titled "Compartments Revealed in Food-Web Structure," pulls Ken Frank, associate professor in the Department of Counseling, Educational Psychology and Special Education, from the study of social structures of organizations and systems — mostly those of schools — into the domain of ecosystem ecology and management. He teamed with doctoral student Ann Krause, who was working as a graduate student in Fisheries and Wildlife at MSU and with the GLFC to understand how changes had an impact on the of the Great Lakes ecosystems.

"There is a common perspective here," said Chris Goddard, GLFC executive secretary. "From the unique combination of social science and environmental science comes a new way to study ecosystem health, and a new way to better address the ecosystem response to stress. Now we can break the system down into components."

The research team of Krause, Frank and Taylor from MSU; Robert Ulanowicz

from the University of Maryland; and Doran Mason of the National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory, studied five food webs in locations ranging from the Chesapeake Bay to a forest on St. Martin Island in the Caribbean.

"Ken developed a scientifically sound method for identifying cliques in social networks which works well to identify whether compartments existed or not in these five food webs," Krause said. "In addition, we mapped out the food web to provide a tangible picture of these compartments for ecologists."

Taylor and Goddard explained that this method offers natural resource managers a different and more holistic way to evaluate stresses on ecosystems — invasive species such as sea lampreys, zebra mussels and Asian carp in the Great Lakes, for example. It also holds promise of more targeted and more efficient ways to manage changes in the food web, with more specific ways to address which groups of species are most likely to be strongly affected and which may have minimal impact. Krause is already applying the research to a food web in Lake Michigan.

This research was funded by the Great Lakes Fishery Commission, the National Institute of Child Health and Human Development, and the National Science Foundation.

Using Winter Rye as an Interseeded Companion Crop May Help Organic Soybean Farmers Control Weeds

Organic soybean producers may be able to use winter cereal rye as an interseeded companion crop to control weeds in their crops, according to research led by an MAES crop and soil scientist published in the January-February 2004 issue of *Agronomy Journal*.

Traditionally, organic growers have used only mechanical cultivation to control weeds, but this method has been shown to cause soil erosion and lead to poor soil structure. Conventional soybean growers have used cover crops successfully in conjunction with herbicides to reduce cultivation and control weeds. The scientists hypothesized that an adaptation of this technique could also be useful for organic growers.

"Organic growers needed new techniques that meshed with organic systems and had a more positive effect on soil quality, particularly soil structure," said Kurt Thelen, MAES crop and soil sciences researcher. "Our research looked at two types of planting systems for organic soybeans to determine if interseeding winter cereal rye in the soybeans could help control weeds."

Thelen, who worked on the project with Dale Mutch, MSU Extension district field crops agent, and Todd Martin, research assistant, found that interseeded winter cereal rye decreased the number of weeds in the soybeans and increased soybean yield in years when soil moisture was not a yield-limiting factor. Two years of the three-year project were drier than the 30-year average, which resulted in decreased soybean yields.

"Our results suggest that some means of terminating the interseeded rye is necessary for effective management across a range of precipitation levels," Thelen said. "In 76-cm-row organic soybean production systems, mechanical cultivation would be an approved practice for terminating rye growth. However, in 19-cm drill-planted systems, new technology that meets the regulatory criteria for organic production is needed to effectively terminate the interseeded rye and alleviate moisture-stress-related concerns."

MAES Horticulture Scientist Wins National Award for Contributions to Wine Industry

G. Stanley Howell, MAES professor of horticulture and coordinator of MSU's viticulture and enology program, won the Lodi-Woodbridge Winegrape Commission's annual Wine Integrity Award.

Howell, an internationally recognized plant physiologist and viticulturist, received the award at a special dinner in his honor Oct. 14 at the Wine and Roses Inn in Lodi, Calif. Created in 1998, the award honors those individuals who have conducted their careers with integrity while making significant contributions to the world of wine.

Howell was chosen for his more than three decades of dedication to the expansion and improvement of the Michigan wine industry.

"Stan could have chosen to take his research to any number of institutions around the world," said David Miller, winemaker and viticulturst for St. Julian Wine Co., Inc., of Paw Paw, Mich. He worked for Howell while getting his doctoral degree at MSU. "Instead, he chose to stay in Michigan and tackle the more difficult challenge of helping to build an industry in a region that is 'climatically challenged' — Michigan. Stan's efforts are well appreciated by those who choose to stay abreast of the cutting edge in viticulture both at home and abroad."

"Much of Stan Howell's research has been conducted here in Michigan, where our industry has been fortunate to benefit from the close proximity to leading research on vine physiology," said Linda Jones, executive director of the Michigan Grape and Wine Industry Council. "While his research contributes to the body of knowledge globally, he and his staff take time to offer educational programs and consultation with the local industry. Two of his doctoral students are now prominent winemakers in Michigan."

"It is hard to know where the Michigan wine industry would be without Stan's guiding hand," said Jim Wolpert, head of the Enology and Viticulture Department at the University of California, Davis. Wolpert worked with Howell as a graduate student and field technician in his viticulture research program at MSU. "The impact of his work is felt in every aspect of the industry."

Howell came to the MSU Department of Horticulture in 1969 as a Michigan Agricultural Experiment Station researcher and MSU Extension specialist. Since then, his efforts have helped Michigan expand its total grape holdings to 13,500 acres, making it the fourth largest grape-growing state in the nation. In 2001, Howell launched the two-year viticulture and enology program within the MSU Institute of Agricultural Technology. The program is designed to train students in grape and wine production, focusing on cool-climate grape varieties. It is the first program of its kind east of California.

Research *in the news*

MAES Scientist Leads International Team Developing More Nutritious Crops

MSU and MAES scientists will play a key role in a new initiative to improve the health of poor people in developing countries by working to create staple food crops that are enriched in micronutrients.

MSU is the coordinating institution of a team of three that make up the nutritional genomics team of HarvestPlus, a global research initiative to breed and disseminate crops for better nutrition.

Using an innovative approach called biofortification, agricultural and nutrition scientists will work together to breed and engineer crops that provide higher levels of essential micronutrients such as iron, zinc and vitamin A.

The project seeks to bring the full potential of agricultural science, genetics, molecular biology and genomics to bear on the persistent problem of micronutrient malnutrition in the developing world, explained Dean DellaPenna, MAES biochemistry and molecular biology scientist.

"Micronutrient malnutrition affects more than half of the world's population, especially women and children," DellaPenna said. "The costs of these deficiencies in terms of lives lost, forgone economic growth and poor quality of life are staggering."

Malnutrition contributes to more than half of child deaths in the developing world, and the United Nations estimates that nearly one-third of the world's population suffers from severe deficiencies in one or more micronutrients. Even less severe levels of micronutrient malnutrition can damage long-term cognitive and physical development, lower disease resistance in children and reduce the likelihood that mothers survive childbirth. Iron deficiency alone affects more than 3.5 billion people in the developing world and is responsible for 100,000 maternal deaths during childbirth each year. Vitamin A deficiency causes more than 500,000 children to go blind each year and is a leading cause of child mortality.

"You can eat all the rice you want, and you still won't get your daily requirement of provitamin A (beta carotene); it's produced in rice leaves but is not accumulated in rice seed," DellaPenna said. "But one member of our nutritional genomics team, Peter Beyer, already has shown that rice can be engineered to produce provitamin A in seed. Similar approaches using breeding and genetic engineering, when appropriate, can be employed in rice and other crops to positively affect the micronutrient quality of food in the diet of the world's poor. The impact has the potential to truly change the daily lives of more than half the world's population."

The first crops targeted for development by the HarvestPlus initiative include those most widely consumed in the developing world — rice, wheat, maize, beans, cassava and sweet potato.

HarvestPlus is spearheaded by the International Center for Tropical Agricultural Research in Cali, Colombia, and the International Food Policy Research Institute in Washington, D.C.

The nutritional genomics team — which includes Beyer at the University of Freiburg, Germany, and Michael Grusak at the USDA/ARS Children's Nutrition Research Center in Houston — will focus on the biochemical processes involved in the synthesis of vitamins and accumulation of minerals to determine how to biofortify edible plant parts with new or increased micronutrients.

MAES Scientist to Direct $10.2 Million NIH Grant on Infectious Diseases

The National Institutes of Health has awarded a $10.2 million research contract to a team of researchers at the MSU National Food Safety and Toxicology Center to explore the genetics of microorganisms that cause food- and waterborne infectious diseases.

Thomas Whittam, MAES scientist, Hannah distinguished professor and member of the departments of Food Science and Human Nutrition and Microbiology and Molecular Genetics, will lead the MSU research team.

"It is exciting for MSU to be a part of this newly established network," Whittam said. "By creating a multidisciplinary network like this, NIH hopes to foster new capabilities to identify, prevent and treat food- and waterborne diseases threatening public health."

Whittam and four co-investigators will conduct research in the following areas:

- Advance molecular techniques and databases to identify pathogenic strains of microorganisms including *E. coli* O157:H7, *Campylobacter*, and *Salmonella*.
- Investigate factors involved in the emergence of new *Salmonella* strains.
- Develop animal models for understanding *Campylobacter* infection and pathogenesis.
- Develop microarray technology specifically targeted for rapid detection of diverse pathogens.

A secondary emergency role for the co-investigators will be to respond to national needs. In addition, five MSU faculty members will serve as liaisons and consultants for clinical studies and interaction with the other research units.

Co-investigators include MAES large animal clinical scientist Linda Mansfield, and liaisons include MAES pathobiology and diagnostic investigation scientist Carole Bolin, MAES microbiology and molecular genetics researcher Roger Maes, and Joan Rose, MAES crop and soil sciences and fisheries and wildlife researcher who holds the Homer Nowlin Endowed Chair for Water Research.

The MSU team of scientists will also be working with researchers at the University of Michigan, the University of Maryland and the Michigan Department of Community Health.

The award is part of the newly formed Food and Waterborne Diseases Integrated Research Network (FWD IRN), a network of research laboratories launched by the National Institute of Allergy and Infectious Diseases (NIAID). The Microbiology Research Unit (MRU) at the MSU National Food Safety and Toxicology Center will be one of two such units nationwide. NIAID will establish eight such research units nationwide in four research areas: microbiology, immunology, clinical, and zoonoses (animal diseases that are transmissible to humans).

Whittam also will participate as a member of the FWD IRN executive committee.

The NIH contract will run through Sept. 29, 2010.

"I believe NIH considered us because

we have the multidisciplinary team, we have the center in place with first-class facilities, and we have a reputation of doing quality science," Whittam said.

Whittam was appointed a Hannah distinguished professor at the NFSTC in 2001. The John A. Hannah distinguished professorships were established in 1969 to expand and maintain excellence in the faculty across broad areas of MSU. Whittam, who is best known for his extensive work on the evolutionary factors associated with pathogenic *E. coli* O157:H7, is a member of the American Academy of Microbiology and a recipient of the Research Career Development Award from the National Institutes of Health.

MAES Scientist Directs Life Science Corridor Grant Project

MSU has earned a grant from the Michigan Life Sciences Corridor (MLSC) initiative to help design microchip DNA technology that can help detect dangerous microorganisms in food and water.

The $1.1 million grant will help researchers develop a DNA chip that will serve as a genetic screen or sieve to assist in the detection of thousands of microorganisms.

"The need for such a comprehensive and broad-range screening tool has been recognized for years in many areas, including diagnostics, air, water, food, animal and plant safety; waste treatment; and now bioterrorism," said James Tiedje, MAES crop and soil sciences and microbiology and molecular genetics scientist. Tiedje, a university distinguished professor, is director of the project.

Partnering with the University of Michigan and Xeotron, a Houston-based biotechnology company, the MSU Center for Microbial Ecology will work to develop the chip, which could be capable of detecting all known pathogens.

History of Michigan Forests Penned by MAES Scientists

In 1871, wildfires that practically dwarf the 2003 California fires swept through much of Michigan, Wisconsin and Illinois, charring millions of acres of forests, killing thousands of people and nearly wiping out the Midwest's largest city — Chicago.

A new book written by two MAES forestry researchers takes a comprehensive look at the history of Michigan's forests, including the devastating fires of the late 19th century, as well as the ecology, management and economic importance of today's woods.

Donald Dickmann and Larry Leefers initially planned to write *The Forests of Michigan* as a textbook for the forestry course they teach, but they quickly decided this was information anyone interested in Michigan's forests could use.

"There is really no other book out there that puts together the whole story of Michigan's forests," Dickmann said. "It's written in a non-technical style, designed for a wide audience."

In fewer than 300 pages, the authors present a comprehensive history of the state's forests. It begins nearly 14,000 years ago when a half-mile thick sheet of ice covered what would become Michigan, and it ends today, when proper management is actually adding to the forest cover in Michigan.

"The history here is unique, especially the magnitude of the disturbances that have occurred here, including logging and fires," Dickmann said.

It was in the autumn of 1871 that what became known as the Great Michigan Fire moved quickly through the state, destroying millions of acres of woods and wiping out towns such as Glen Haven, Holland and Manistee.

Even East Lansing's Michigan Agricultural College — now MSU — was threatened. The authors recounted the efforts made to save the school.

"Excused from the afternoon worship services, crews of young men from the college were formed, under the leadership of Drs. Robert Kedzie and Manly Miles. They staved off flames approaching through the surrounding forest by working in relays throughout several long days and nights. By Tuesday evening the fires were under control and the campus was saved. The students were rewarded by the faculty with an oyster dinner."

The Forests of Michigan also focuses on the economic impact of the woods. Between lumbering, recreation and businesses such as the selling of Christmas trees, Michigan's forests represent a multi-million dollar industry.

"There are a lot of wood-using industries in this state, including paper and furniture," Leefers said. "Wood is still a very important raw material and creates a lot of jobs and economic prosperity."

Two Scientists Receive MAES Appointments

The MAES is pleased to welcome two new scientists to campus.

Lorraine Sordillo was named the first Meadowbrook Endowed Chair in Farm Animal Health and Well Being and professor of large animal clinical sciences Jan. 1. One of the nation's top experts in bovine health, Sordillo's research focuses on innovative ways of treating and controlling mastitis without using antibiotics.

"We're looking at enhancing the natural defenses of mammary glands," she explained.

Sordillo has received several patents for novel methods to treat bovine mastitis, including one using interferon. She is an active member of numerous professional associations and serves as the editor of the "Physiology and Management" section of the *Journal of Dairy Science*.

Before joining MSU, Sordillo was a veterinary science professor and researcher at Penn State University from 1992 to 2003. From 1988 to 1992, she was a research scientist in the Immunology Group in the Veterinary Infectious Disease Organization at the University of Saskatchewan and from 1986 to 1988 she was a postdoctoral research associate in the Department of Animal Science at the University of Tennessee.

Sordillo received her doctorate in immunology from Louisiana State University in 1987 and her master's degree in lactation physiology and bachelor's degree in zoology from the University of Massachusetts-Amherst in 1984 and 1981, respectively.

Kevin Walker was named assistant professor of biochemistry and molecular biology and chemistry Jan. 1. His research interests are organic synthesis, mechanistic evaluation of enzyme-catalyzed processes, classical biochemical analyses and use of molecular genetic tools to elucidate natural product pathways. These natural products are typically plant-

derived and have current or potential application in nutrition and human health care. His current research is investigating the biosynthesis of the complex diterpene salvinorin A.

Walker was most recently an assistant scientist and laboratory manager in the Institute of Biological Chemistry (IBC) at Washington State University (from 2001 to 2003). From 1997 to 2001, he was an NIH postdoctoral research assistant and laboratory manager, also in the IBC.

During his tenure at the IBC, he received a patent and scripted several continuations-in-part for his work on the isolation and characterization of five cDNA acyltransferase clones involved in taxol biosynthesis.

Walker received both his doctorate in bioorganic chemistry and his bachelor's degree in chemistry from the University of Washington in 1997 and 1988, respectively.

Three MAES Scientists Honored by Crop and Soil Science Societies

In recognition of their contributions to research and teaching, three MAES crop and soil science researchers received honors and awards at the joint annual meeting of the American Society of Agronomy, the Crop Science Society of America and the Soil Science Society of America (ASA-CSSA-SSSA) in Denver last November.

Paul Rieke, turfgrass management scientist emeritus, was presented the Fred V. Grau Turfgrass Science Award by the CSSA for significant career contributions in turfgrass science. An international authority on turfgrass, Rieke conducted innovative research on soil fertility and physical soil problems for turfgrass at MSU for more than 40 years. He also coordinated the turfgrass extension program and taught turfgrass and soils courses.

Douglas Buhler, chairperson of the Department of Crop and Soil Sciences, was named a CSSA fellow for his career achievements and service to the community. Buhler's research focuses on the ecological and environmental aspects of weed management systems for agronomic crops and turfgrass systems. He is also a fellow of the ASA and the North Central Weed Science Society.

G. Philip Robertson, crop and soil sciences researcher, was named an SSSA fellow for his career achievements and service to the community. Robertson's teaching and research focus on agricultural ecology, particularly nitrogen biochemistry in agricultural landscapes and the mechanisms that regulate nitrogen retention and loss in field crop ecosystems. Robertson is the lead principal investigator on the Long-Term Ecological Research site at the Kellogg Biological Station in Hickory Corners.

MAES Associate Director Bokemeier Named Sociology Chairperson

Janet Bokemeier, associate director of the Michigan Agriculture Experiment Station, who has been on special assignment serving as transition leader for the Department of Community, Agriculture, Recreation and Resource Studies (CARRS), was named chairperson of the Department of Sociology in January.

As of Feb. 1, she also has a 25 percent appointment as program assistant director for the MAES, with special responsibility for the MAES priority area of family and community vitality. This appointment will be reviewed each year. In this role she will continue as co-director of the Family and Communities Together (FACT) Coalition; convene a university-wide advisory committee of chairs, directors, and associate deans for family and community vitality; coordinate MAES strategic planning and program development around family and community vitality; and serve as the administrative adviser of the North Central Region Center for Rural Development.

A noted authority on rural sociology and farm families, Bokemeier has been a professor of sociology at MSU since 1991. She has received numerous awards for her scholarship and service.

MAES Scientist Heads Animal Health and Homeland Security Project

Michigan State University, the Michigan Department of Agriculture and the state's largest veterinarian organization have come together to form the Michigan Emergency Veterinary Network, or "Vet Net," as part of Michigan's homeland security efforts in the animal health and protection arena. The program will be overseen by an MAES scientist.

Michigan's Vet Net, one of the first programs of its kind in the country, is a comprehensive education and training program aimed at improving awareness, preparedness and response to animal disease-related emergencies.

The program will include two main components: a general education series for all veterinarians and an in-depth emergency preparedness training program for those who sign up to serve as volunteers.

This volunteer corps will be a group of private veterinary practitioners trained to identify and handle a wide variety of animal diseases that will help supplement state and federal veterinarian/agency efforts and further ensure the health and safety of the state's livestock and domestic animals.

"Our role in this joint project is to provide the expertise and training for the participating veterinarians," said Daniel Grooms, MAES large animal clinical sciences researcher who is heading up the university's role in the project. "It's important they have this resource to tap into, especially if they are dealing with emerging diseases that they aren't familiar with."

Vet Net will be implemented in three phases. The first will focus on the development and distribution of a resource binder and emergency contact information for all licensed veterinarians in Michigan.

Phase II of the program entails specialized training for Michigan veterinarians. The first training session, to be held this spring, will focus on the incident command system and biosecurity practices.

Phase III of Vet Net is ongoing training opportunities for Michigan veterinarians on foreign animal diseases, emerging infectious diseases, bioterrorism agents and emergency response.

Vet Net partners include the MDA, the MSU College of Veterinary Medicine, Michigan Veterinary Medical Association, the Michigan Department of Community Health, MSU Extension, USDA and private practitioners.

Veterinarians who wish to register for the Vet Net training program can contact the MDA's Animal Industry Division at 517-373-1077.

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