Contents

Mission
Better Understand and Predict Earth’s Systems and Develop Geospatial Technologies that Promote their Stewardship, Sustainability, and Contributions to Prosperity

Vision
Advance Discovery, Knowledge, and Education using Multi-Disciplinary, Geospatially-driven Innovation to Improve Decision-Making and Contribute to Sustainable Resource Management

The Future is Unmanned
Research Helps NOAA with Environmental Monitoring
MSU Scientist creates ‘Super-ranking’ System to Highlight Best Forecast Models
MSU and NOAA Design Next Generation Management Tool to Evaluate Ocean Health
MSU Scientist Uses GIS Technology to Answer Tough Conservation Questions
Habitat Suitability Modeling Helps Protect One of Earth’s Most Valuable Resources
Research Goes Beyond the Color and Light Spectrum to Detect the Invisible
Global Research that Provides Enhanced Flood Protection, Clean Water and Hydropower
GEO is the Largest Outreach Project of its Kind in the United States
GRI by the Numbers
Publications
The Future is Unmanned

The statistics are in and the future is unmanned. In an investor like manner, Robert Moorhead, director of the Geosystems Research Institute, is positioning the Mississippi State University unmanned aerial systems scientific team as one of the leading research authorities on UAS. And rightly so, because economic development experts and business investors proclaim that when the unmanned aerial systems industry finally finds a state to call home, that area will become the next Silicon Valley.

The statistics to back up all this excitement is stated in a report conducted by the Association for Unmanned Vehicle Systems International. The AUVSI findings show that in the first three years of integration more than 70,000 jobs will be created in the United States with an economic impact of more than $13.6 billion. This benefit will grow through 2025 when they foresee more than 100,000 jobs created and an economic impact of $82 billion. However, much of this success rides on the Federal Aviation Administration’s ability to implement guidelines to allow UAS entry into the national airspace system. Flying well below regular aircraft, roughly between 100 and 800 feet—a space hotly contested right now—the aerial equipment has only been approved, to date, for commercial use in a very limited capacity in the Arctic regions. Hence, the FAA is developing regulations for UAV’s commercial use, and Congress has issued a deadline of September 2015 for the regulatory body to establish rules specifically for small unmanned aerial systems.

Meanwhile, Moorhead and his GRI colleagues are working to incorporate the use of unmanned aerial vehicles in site-specific agricultural research. Mississippi State currently holds certificates of authorization from the Federal Aviation Administration to operate UAVs for research purposes only. Campus scientists are using the aerial equipment in the research of plant growth, nutrient management, irrigation, and herbicide application.

As Moorhead explained technology has evolved. “Scientists are using small UAVs to gather remotely sensed data compared to the more traditional ground instrumentation devices or the more expensive fixed-wing, manned aircraft and satellites.” Moorhead’s team can fly small UAVs at 100 feet and get resolution within 1/8-of-an-inch of a crop leaf. Creating the potential for a farmer to inexpensively detect if a plant is under stress and determine whether it needs fertilizer or water before it is too late. “We’re working with 15-pound or less unmanned aerial vehicles that can cover 1,000 acres an hour collecting visual and multispectral data to assess crop health,” Moorhead said. “Precision agriculture is a data-driven and UAV technology adds another significant layer of data for researchers and ultimately crop consultants and producers to assess and utilize in a meaningful way.”

The research has an environmental impact as well. When farmers can determine the exact amount of water and fertilizer to apply, it could revitalize aquifer levels and help reduce hypoxia levels downstream that kill fish and other underwater organisms.

- AUVSI findings show that in the first three years of integration more than 70,000 jobs will be created in the United States with an economic impact of more than $13 billion. (AUVSI, 2012).
- AUVSI predicts that economic benefits from UAVs will grow through 2025 when they foresee more than 100,000 jobs created and an economic impact of $82 billion. (AUVSI, 2012).

GRI Scientists are working with NOAA to help the U.S. become a “Weather Ready Nation.”

On the hydrology research side, GRI experts are using UA Vs to assess the speed and rate of how rivers flow and rise, and where the water goes, especially in flood type conditions. In an effort to help prevent loss of life and property, one of NOAA’s goals is to help the U.S. become a “Weather Ready Nation,” before, during and after natural disasters, such as flooding, created by tropical storms and hurricanes. Partnering with GRI scientists NOAA is gaining invaluable environmental and situational data along the lower Pearl River water shed, south of Bogalusa Louisiana, all the way down to what is called the tidal plain.

“We plan to fly the UA Vs twice a month over that 80-square-mile terrain and they will compare that information to the data collected from a network of river gauges located in the area,” explained Moorhead. “Then the few river gauges can be used to indicate the extent of flooding throughout the area. In a coastal watershed, you can get flooding from either direction—severe storms coming ashore or the rain upstream.”

Experts say that flooding is one of the most common disasters and the latest data available states that more than 120,000 lives were lost between the years of 1991 and 2005. The prediction is that more extreme weather events will happen around coastal areas because of Global Warming. The UAV’s also have the potential to help reduce the number of drowning casualties during a natural disaster by providing NOAA accurate flood maps to distribute to the population in real time. And finally another consideration is the geography codes embedded in the data that create high resolution images combined with queries by address and latitude can help emergency management leaders assess the safety of an area to assist in faster rescue efforts by first responders.

“Of course reducing loss of life is the number one priority, but this research has an economic impact too; it’s expensive for state and federal governments to implement evacuation plans. As a result, more accurate predictions translate into budget savings.” Moorhead made another important point, “It also translates into lower insurance rates. We are paying for a risk. The lower the risk, the lower the insurance cost.”

The UAV’s also have the potential to help reduce the number of drowning casualties during a natural disaster by providing NOAA accurate flood maps to distribute to the population in real time.
MSU Scientist Creates ‘Super-ranking’ System to Highlight Best Forecast Models

Discussions about manipulating vast, ocean model datasets and writing complex validation computer algorithms creates “dry” conditions for interesting conversation. Yet, when connecting this validation process to improved hurricane forecast predictions, a room’s atmospheric condition changes into a conversational storm about the execution of evacuation routes, stocking emergency safe-houses and the availability of alternative energy resources. Suddenly, Pat Fitzpatrick’s research in comparing different ocean forecast models matters, because it ultimately saves lives.

NOAA’s Office of Oceanic and Atmospheric Research entrusted the Mississippi State University researcher to study two versions each of the Naval Coastal Ocean Model (NCOM) and the Hybrid Coordinate Ocean Model (HYCOM), - their global and Gulf of Mexico adaptations. Fitzpatrick analyzed data from instruments tethered to floating and moored buoys, as well as unmanned gliders that look like miniature submarines. The goal was to determine the accuracy of the four model forecasts, as well as their ranking with respect to each other. NOAA must understand where the forecast inaccuracies are, which models are worth further investment to improve, and which have become outdated. The current practice is to look at individual metrics such as biases and absolute errors, along with some advanced metrics. As the validation process proceeded, Fitzpatrick noted a problem with this approach: three of the four models were similar in accuracy, and tended to “flip-flop” with individual metrics. This makes it difficult for NOAA to understand improvement trends, and where to put their future investments.

“On any given day, any one of those models’ data might be better than the other.”

After a year-and-half of studying and comparing each model’s individual data, Fitzpatrick and his team wrote a unique code called the super-ranking technique that allowed them to consolidate and compare all the ocean models.

“A lot of these models’ improvements are very incremental making it difficult to look at just one metric and distinguish one model from another,” said Fitzpatrick. “Once you accumulate a variety of validation metrics and consolidate them together, then you start seeing a separation.”

Fitzpatrick’s research identified the Gulf of Mexico version of the NCOM model as the best ocean forecast system for NOAA to invest its valuable resources. The broader perspective is that the research provides a succinct method to compare different forecast models’ accuracy. This ensures more accurate weather and ocean prediction, especially for exceptional events such as hurricanes where both the atmosphere and ocean forecasts need to be correct. In turn, coastal industries and residents benefit.
MSU and NOAA Design Next Generation Management Tool to Evaluate Ocean Health

NOAA’s next generation tool for ocean and coastal management design is getting an upgrade with the help of ongoing studies conducted by GRI scientists. Steve Ashby, GRI associate director, manages the team that is carrying out research at four sites in the Northern Gulf of Mexico; they include Perdido Bay, Florida; Mississippi Sound, Mississippi; Barataria Basin, Louisiana; and Galveston Bay, Texas.

The Integrated Ecosystem Assessment (IEA) tool was implemented as part of an overall Ecosystem Approach to Management (EAM). It looks at all the indicators, such as tourism and recreation, climate change, fish populations, and conservation and energy demands to evaluate ocean health. In the past, scientists, because of the limits of scientific knowledge and technology could only concentrate on individual segments and species of the ocean. This EAM approach using the IEA management assessment tool allows them to combine data and look at the ocean as a whole.

“We’re using what we call a Drivers-Pressures-States-Impact-Response (DPSIR) framework to evaluate the ecosystem assessment process and to set management goals,” said Ashby. “We really haven’t had a good system that combines and compares all the indicators that allows us to look and ask, ‘Are we going in a positive direction, and how do we find the balance between sustainable healthy uses and a sustainable healthy ecosystem when it comes to ocean health?’ This system will enable us to do that.”

All of us have enjoyed a magnitude of bounty from the sea. Rewards such as a variety of seafood, opportunities for recreation, and avenues for transportation and commerce are just a few of the many ways we depend on our oceans. IEA will help managers make decisions on how to best protect resources on a local scale and the implications of those conclusions when considering the broader regional and global context of ocean health.

“This is a great opportunity for policy makers to get a better snapshot of our ecosystem,” explained Ashby. “Our next step is to more fully explore the ecosystem services at the Northern Gulf’s four sites and ‘translate’ them into measurements of human well-being.”

“This is a great opportunity for policy makers to get a better snapshot of our ecosystem,” explained Ashby. “Our next step is to more fully explore the ecosystem services at the Northern Gulf’s four sites and ‘translate’ them into measurements of human well-being.”
MSU Scientist Uses GIS Technology to Answer Tough Conservation Questions

In today’s world of tightening budgets and a rapidly changing landscape, it has never been more important for the conservation community to work together toward a shared vision of more effective and efficient conservation. The Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative (GCPO LCC) provides the much-needed forum for the conservation community to pool minds and resources to strategically define, design, and deliver conservation across today’s landscape. The GCPO LCC is among a network of 22 LCC’s nationally and consists of a consortium of state, federal, and tribal conservation agencies, partnered with university scientists, non-governmental organizations and other entities within a 10 state area in the southeastern U.S. The goal of the LCC’s is to think and act smarter to ensure the sustainability of our nation’s most precious natural and cultural resources.

Kristine Evans, GCPO LCC and GRI geomatics coordinator, offered some insight, “It’s important that we all develop the ability to work across boundaries and with people that have diverse interests and yet share a common goal of protecting our resources.” She continued, “There isn’t just one entity that has the power to cross land and water boundaries to make these decisions. This collaboration allows us to close the gap in governance by creating informal and formal ways of working together to answer critical conservation questions and solve issues.”

The Geosystems Research Institute (GRI) at Mississippi State University recognized this great opportunity and partnered with the GCPO LCC from its inception to provide critical LCC research and computing capacity for LCC activities. As a research hub for the GCPO LCC, GRI has agreements with the U.S. more than 20 different LCC for projects by nine

LCC from its inception to provide critical capacity for LCC activities. As a research established over $4 million in cooperative Fish and Wildlife Service to fund research projects, including support MSU faculty and staff. This diverse research program includes exploration of ecosystem health, resilience to climate change and urbanization, and interrelationships among species and their habitats.

GRI also provides dedicated staff to address LCC geospatial data priorities and has several ongoing landmark geospatial projects underway. These include development of the first consistent fine-resolution land cover map across the GCPO geography to replace older cover maps developed differently east and west of the Mississippi River. These detailed land cover maps provide the foundation for all assessment of ecosystem health and conservation planning within the GCPO geography.

“There are several conservation challenges that need to be addressed simultaneously because the decisions we make have a local, regional and global impact,” Evans said. “The issues of water conservation, land use patterns, biodiversity protection and adaptation to climate change require the latest GIS and geospatial data technology approaches to come up with the best solution for all involved.”

In addition, GRI serves as the center for GCPO LCC geospatial outreach through development and coordination of the GCPO LCC Conservation Planning Atlas (http://gcpolcc.databasin.org/). The Conservation Planning Atlas system gives users the opportunity to pull up different datasets onto a single map and uses simple GIS functionality to make decisions on where to design conservation reserves.

“For instance, we were able to help our colleagues find the best areas to target expansion of a particular national wildlife refuge. This system allowed us to point out and identify very specific areas where multiple data layers indicated the best places to go to work,” Evans explained.

Evans said in the past most of these datasets were difficult to find, and often found on a dozen different locations on the internet, if they were available at all. “So one of the greatest benefits so far has been what we are calling ‘discoverability’ of data. It’s a one-stop-show where people are now able to find and overlay different datasets on top of each other to see if they can better design conservation reserves in the future.”

The data center is publicly available and serves as an easy to navigate spatial data clearinghouse, as well as a mapping platform for conservation partners. There are many other exciting projects currently underway at GRI as the GCPO LCC redefines the way we do conservation.

For more information visit: http://gcpolcc.org.
As the population of the Earth continues to grow, water shortages are going to become more common. We need to find ways to make our freshwater resources go further. Sixty-three trillion tons of groundwater loss in the west due to drought, and the Mississippi Delta’s alluvial aquifer water levels dropping a foot every year since the introduction of irrigation in the 1950s and ‘60s is putting a higher priority on water conservation. Although the aforementioned are grabbing headline attention, there is another more subtle and growing challenge to maintaining sustainable water resources. Researchers like Gray Turnage study organisms that live in these water bodies, specifically aquatic invasive plant species, in hopes of finding ways to further conservation efforts. Some of these species can actually cause reduction in the volume of water that a reservoir can hold, as well as affect the native organisms, like fish, that live in them.

The GRI research associate uses “Habitat Suitability Modeling” which uses computer algorithms to manipulate data that create models to predict, control and narrow the expansive search area required for detection of new nonnative species or the likely avenues for the spread of existing plant populations. “We have four ways to control aquatic invasive species. They include chemical, biological, physical, and mechanical methods that control or eradicate invasive plant species in an area. First we need to know where the plants are so that we can predict where they might potentially spread. Then we can start looking at management options.”

The Invasive Plant Atlas of the MidSouth database houses almost 12,000 records of plant information collected from GRI scientists and volunteers. “This along with environmental data collected from public sources like U.S. soil maps, the National Land Cover Dataset, and the U.S. Geological Survey stream gauge data have enabled the GRI team to build landscape-explicit models for predicting the establishment and success of invasive species like hydrilla and giant salvinia,” explained Turnage. “Both of these species are causing serious problems in Southeastern U.S. water bodies.”

Most of Turnage’s invasive plant research is done in freshwater settings. For instance, managing a species known as Flowering Rush in the freshwater, Detroit Lakes, of Minnesota has been in progress for the past five years. Samples of the species were brought back to Mississippi State where studies testing the most effective herbicide were conducted. Turnage tests herbicide formulations and concentrations against invasive species in order to find the best management options. After determining the best chemical application, the method is utilized in the field. In the Detroit Lakes, Flowering Rush is almost eradicated.

Less than one percent of the water on earth is fresh, and in sufficient quality and quantity it can provide great health, economic, and aesthetic benefits. Often people find themselves in situations where the quality of water is inadequate for a desired use. As progress is made on how best to control or eradicate aquatic invasive species, GRI researchers also help lead the charge in how to best safeguard one of Earth’s most valuable resources.

“We have four ways to control aquatic invasive species. They include chemical, biological, physical, and mechanical methods that control or eradicate invasive plant species in an area. First we need to know where the plants are so that we can predict where they might potentially spread. Then we can start looking at management options.”

Photos by Megan Bean

Habitat Suitability Modeling Helps Protect One of Earth’s Most Valuable Resources

As the population of the Earth continues to grow, water shortages are going to become more common. We need to find ways to make our freshwater resources go further. Sixty-three trillion tons of groundwater loss in the west due to drought, and the Mississippi Delta’s alluvial aquifer water levels dropping a foot every year since the introduction of irrigation in the 1950s and ‘60s is putting a higher priority on water conservation. Although the aforementioned are grabbing headline attention, there is another more subtle and growing challenge to maintaining sustainable water resources. Researchers like Gray Turnage study organisms that live in these water bodies, specifically aquatic invasive plant species, in hopes of finding ways to further conservation efforts. Some of these species can actually cause reduction in the volume of water that a reservoir can hold, as well as affect the native organisms, like fish, that live in them.

The GRI research associate uses “Habitat Suitability Modeling” which uses computer algorithms to manipulate data that create models to predict, control and narrow the expansive search area required for detection of new nonnative species or the likely avenues for the spread of existing plant populations. “We have four ways to control aquatic invasive species. They include chemical, biological, physical, and mechanical methods that control or eradicate invasive plant species in an area. First we need to know where the plants are so that we can predict where they might potentially spread. Then we can start looking at management options.”

The Invasive Plant Atlas of the MidSouth database houses almost 12,000 records of plant information collected from GRI scientists and volunteers. “This along with environmental data collected from sources like U.S. soil maps, the National Land Cover Dataset, and the U.S. Geological Survey stream gauge data have enabled the GRI team to build landscape-explicit models for predicting the establishment and success of invasive species like hydrilla and giant salvinia,” explained Turnage. “Both of these species are causing serious problems in Southeastern U.S. water bodies.”

Most of Turnage’s invasive plant research is done in freshwater settings. For instance, managing a species known as Flowering Rush in the freshwater, Detroit Lakes, of Minnesota has been in progress for the past five years. Samples of the species were brought back to Mississippi State where studies testing the most effective herbicide were conducted. Turnage tests herbicide formulations and concentrations against invasive species in order to find the best management options. After determining the best chemical application, the method is utilized in the field. In the Detroit Lakes, Flowering Rush is almost eradicated.

Less than one percent of the water on earth is fresh, and in sufficient quality and quantity it can provide great health, economic, and aesthetic benefits. Often people find themselves in situations where the quality of water is inadequate for a desired use. As progress is made on how best to control or eradicate aquatic invasive species, GRI researchers also help lead the charge in how to best safeguard one of Earth’s most valuable resources.

“We have four ways to control aquatic invasive species. They include chemical, biological, physical, and mechanical methods that control or eradicate invasive plant species in an area. First we need to know where the plants are so that we can predict where they might potentially spread. Then we can start looking at management options.”

Photos by Megan Bean
Research Goes Beyond the Color and Light Spectrum to Detect the Invisible

Hyperspectral Imaging is a way of seeing what is invisible to the human eye. Haibo Yao, associate research professor at the Geosystems Research Institute, uses hyper-spectral imaging to detect biological and chemical toxins that contaminate crops. He does this by splitting the electromagnetic spectrum into many spectral bands that expose hidden information invisible to the natural eye. The GRI researcher is working to help improve the biosecurity that safeguards America’s food supply and feed crops. The specific contaminant Yao is studying is a fungal metabolite called aflatoxin. It is a known carcinogen associated with liver and lung cancers in humans.

“Aflatoxin is a lethal toxin produced by a fungus called Aspergillus. Many external stresses cause the fungi to react, but hot and humid weather conditions increase its production of aflatoxin that invades corn, and other type of commodities,” explained Yao. “The aflatoxin detection process currently in place is expensive, has lower than desired accuracy rates and is time consuming. Our goal is to help improve detection and accuracy.”

Currently, Yao’s research is lab based and has an 80 percent detection rate. He hopes to increase that figure and one day transfer the research and technical knowledge into helping a commercial entity develop portable and affordable optical devices that farmers can use to screen corn samples in the field.

“In addition to the USDA, our research has captured the interest of the Gates Foundation and USAID’s Feed the Future initiative,” said Yao. “Thanks to the additional funds from these groups our research now has a world-wide impact.”

One of the many initiatives of USAID and the Gates Foundation is to use Science and Technology innovations, such as Yao’s research, to help fight world hunger and poverty by improving nutrition through early detection and elimination of aflatoxin from staple commodities. The GRI research also has an economic impact here in the U.S., as well as abroad, by increasing agricultural productivity and reducing health and medical costs related to diseases connected with aflatoxin.

“In addition to the USDA, our research has captured the interest of the Gates Foundation and USAID’s Feed the Future initiative,” said Yao. “Thanks to the additional funds from these groups our research now has a world-wide impact.”

Photos by Russell Kincaid
Global Research that Provides Enhanced Flood Protection, Clean Water and Hydropower

Research in using remote sensing to improve earth dam and levee sustainability has the potential to affect tens of millions of people who live or work behind levee-protected areas. A case-in-point is the 2011 floods along the Mississippi River where the U.S. Army Corps of Engineers estimated that the federal levee system prevented $62-billion in losses.

The levee systems sustained a good amount of damage and that is where the work of a multi-institution, four-year project funded by the National Science Foundation under their Partnerships for International Research and Education (PIRE) program becomes so important. An international partnership is conducting research on multi-scale monitoring science to enable a sustainable future for the vast worldwide array of earth dams and levees (EDLs). Researchers from Mississippi State University, the Colorado School of Mines, University of Delft and Twente University, both out of the Netherlands, are examining EDL critical infrastructure that provides flood protection, fresh water storage and renewable energy to developed and underdeveloped nations. The project is currently in year two and uses polarimetric and interferometric synthetic aperture radar (SAR) to examine earth deformations at a very small scale.

“We’re looking at the internal conditions of EDLs, their interaction with the natural environment, and how they will perform with climate change,” explained Jim Aanstoos, GRI associate professor and co-principal investigator on the project.

The Remote Sensing in Support of Advancing Earth Dam and Levee Sustainability through Monitoring Science and Condition Assessment team has recently undertaken a new research task that supports a project goal of assessing levee-landscape harmony.

“We’re using data provided by German space agency DLR from their TerraSAR-X satellite to look at slump slides and sand boils on levees and correlate how they change over time from the effects of precipitation, river channel sinuosity, river channel width, and distance to water,” said Aanstoos.

A remote-sensing based approach will allow levee managers to focus and prioritize their inspection and maintenance activities. Other benefits of the research are broad-based. EDL sustainability is a global issue that affects practically everyone through flood protection, clean water supply and hydropower.
GEO is the Largest Outreach Project of its Kind in the United States

The Geospatial and Education Outreach Project is training Mississippi’s workforce to become more organized and efficient. GEO’s value is realized in various applications by different business entities and government organizations. For instance, logistic employees use geographical information systems to plan optimal delivery routes; insurance assessors use GIS to measure risk and vulnerability; emergency personal use it to share street name/location and building floor plans with first responders; farmers use it to improve their yield per bushel of grain; and the business industry uses it to offer consumers optimal service. Since 2006 more than 3,000 Mississippians have participated in over 300 workshops across the state.

“We’re teaching a skill set to the residents of our state that once was exclusive to only government personnel and scientist,” explained Scott Samson, GRI professor, who developed the Mississippi State Extension Service project based at the Geosystems Research Institute. “Public awareness and accessibility of this technology has improved our state’s communities in the building and execution of successful disaster management plans.”

Providing citizens access to geospatial technologies not only restores the importance of understanding people and place interactions in disaster situations, but in an array of activities. And that helps build the state’s economic base. The Boston Consultant group conducted a study that shows the global geo services industry is valued at up to $270 billion per year and pays out $90 billion in wages. In the U.S., it employs more than 500,000 people and is worth $73 billion.

Samson added there is another economic added benefit, “Having in-state training saves Mississippi about $5.5 million compared to the cost if workshop participants had to go out of state to take the same training.”

ESRI Inc., the largest GIS software vendor in the world, has identified GEO Project as the largest outreach effort of its kind in the United States.

“More than 3,000 Mississippians have participated in over 300 workshops across the state.”

Photo by Beth Newman Wynn
GRI by the Numbers

2011 ($6,431,657)
2012 ($3,164,937)
2013 ($1,546,973)
2014 ($2,104,299)

24 PROJECTS

AWARDS

EXPENDITURES

2012 ($5,465,940)
2013 ($3,847,263)
2014 ($2,663,152)

Publications

Book or Book Chapter


Peer-Reviewed Journals


**Patents and Licenses**

