Partnering with NOAA's National Severe Storms Lab to Study Deadly Tornadoes

For the first time the focus of a major study, funded by NOAA's NSSL, is being conducted to gather more severe weather research in Dixie Alley and Mississippi State researchers are playing a significant role.

Dixie Alley is the name of a seven state area in the Southeast that is vulnerable to strong tornadoes and monster storms. A study by Purdue and Mississippi State University indicate that there is a weather shift that is producing more tornadoes in portions of East Texas, Louisiana, Arkansas, Tennessee, Mississippi, Alabama, and Georgia than in the Great Plains' "Tornado Alley." The data also shows the tornadoes are apt to move faster and last longer. Those factors have caused more deaths in Dixie Alley even when compared to Tornado Alley or any other part of the country.

With the hope ultimately to save more lives during an extreme weather event in the Southeast, NOAA's National Severe Storm Laboratory launched the VORTEX-SE project. The Verification of Origins of Rotation in Tornadoes EXperiment, Southeast is a multifaceted study to help scientists understand how the environmental factors in the southeast region affect tornado development and how the public responds to forecast information.

Researchers, like Michael Brown, the state of Mississippi's climatologist and a Mississippi State professor of meteorology, believe that tornado formation in Dixie Alley is very different from the Great Plains, and that is part of what makes predicting tornado formation in the south so challenging. Brown is part of the project team that is partnering with scientists from Purdue, Texas Tech, the University of Colorado and the University of Alabama at Huntsville to grasp what triggers these monster storms und makes them so deadly.

Brown's team of MSU researchers is wrapping up a two-year VORTEX-SE field campaign of launching weather balloons in SE severe storm environments. The NGI and GRI researcher explained that the prime time for tornadoes in the southeast during three of the four seasons—fall winter and spring unlike the Midwest and Great Plains' season which is mainly in the spring.

"We have three teams that go out and launch high-resolution balloons into the atmosphere ahead of the storm. We are looking for subtle changes in the planetary boundary layer or what we call the lower atmosphere of the lowest 1 to 2 kilometers to see if the wind speed, temperature, humidity, and barometric pressure measurements are unique to SE tornado environments," Brown said.

The teams launch the balloons over different vegetation boundaries like fields of short crops to forests with large Loblolly pine trees. As the weather balloons move across the bisected terrain, they transmit a GPS location signal used to indicate where the measurement was taken.

Research that Closes Knowledge Gaps and Improves the Ability to Respond When Oil Mixes with Water

Pat Fitzpatrick, an NGI researcher and GRI associate professor, is collaborating with scientific experts from eight institute members of the CONsortium for oil spill exposure pathways in COastal River Dominated Ecosystems (CONCORDE) to explore water movements and organism distributions in the northern Gulf of Mexico. This research will provide insight on how future oil spills and dispersant usage might impact marine and plant life ecology.

The partnership includes University of Southern Mississippi's Department of Marine Science and the Gulf Coast Research Laboratory, Mississippi State University, Rutgers University, Oregon State University, Dauphin Island Sea Lab, Old Dominion University, and the U.S. Naval Research Laboratory.

After the *Deepwater Horizon* oil spill, accurate observations were not available at sufficient density to understand oil movement, the spill's interaction with deep river plumes and coastal wetlands impact. As a result, scientists and responders couldn't predict oil impact in the nearshore environment and around river deltas of the north central Gulf.
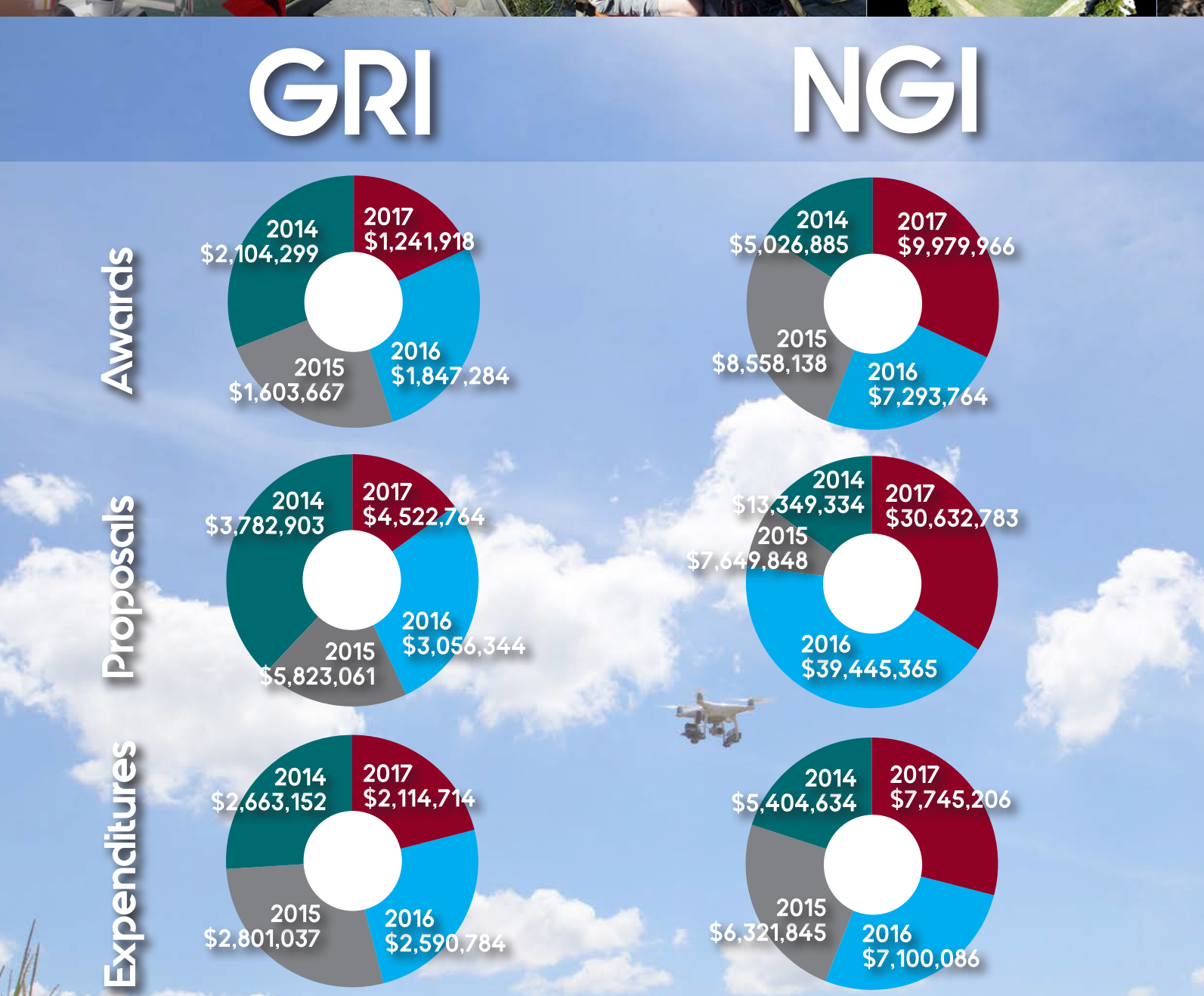
Fitzpatrick's research team specializes in meteorology research, and assists with the use of weather and ocean data in conjunction with CONCORDE field observations. A goal is to accurately predict how the Gulf of Mexico wind and major storm events influence spill movement, fresh water mixing with river discharges, and chemical and biological interactions that disturb the marine equilibrium.

"If we have the data, we can build high-resolution, computational models that give reliable wind and storm predictions of the northern Gulf of Mexico from the Mississippi River to Mobile Bay," Fitzpatrick said. "We need and rely on this data to build these four-dimensional models that detail in both time and space just how water cycles through the area, and how oil and dispersants can interact with marine life."

This research, Fitzpatrick explained, is not only important to advance the understanding of how coastal marine ecosystems respond to, and recover from, large-magnitude oiling events but also to anticipate economic after-effects. "Improving ocean current prediction can help us protect the fisheries from harmful algae blooms, which can be toxic or deprive oxygen to marine life, and also understand how other pollutants including oil spills."

This is the first time four-dimensional computational models at 3,000-feet resolution are being built to show the biology, meteorology, oceanography, and ecology at work across the northern Gulf. Scientists are learning the interactions—how the water moves in response to winds and tides, how various aquatic nutrients are carried by the different densities of fresh and salt water, and how plankton respond to these nutrients and the oil—over a variety of different time spans.

"We really need ocean environment observation, not just for this, but for hurricane research. We've reached a plateau of what we can do. To protect the marine environment, or to improve hurricane forecasts, we need more time to study the datasets which have been assembled, and acquire additional data to fill in knowledge gaps.

GRI NGI

Awards

GRI
2014 $2,104,299
2017 $1,241,918
2015 $1,603,667
2016 $1,847,284

NGI
2014 $5,026,885
2017 $9,979,966
2015 $8,558,138
2016 $7,293,764

Proposals

GRI
2014 $3,782,903
2017 $4,522,764
2015 $5,823,061
2016 $3,056,344

NGI
2014 $13,349,334
2017 $30,632,783
2015 $7,849,848
2016 $39,445,365

Expenditures

GRI
2014 $2,663,152
2017 $2,114,714
2015 $2,801,037
2016 $2,590,784

NGI
2014 $5,404,634
2017 $7,745,206
2015 $6,321,845
2016 $7,100,086

72 Projects
198 Publications

GEOSYSTEMS RESEARCH INSTITUTE
GRI develops and advances geospatial technologies to better understand and predict Earth and Mother Nature's systems that promote stewardship, sustainability and increases prosperity.

MISSISSIPPI STATE UNIVERSITY
GEOSYSTEMS RESEARCH INSTITUTE
NORTHERN GULF INSTITUTE

NORTHERN GULF INSTITUTE
NGI is a regional leader providing integrative research and education to improve the resiliency and conservation of the Northern Gulf of Mexico.

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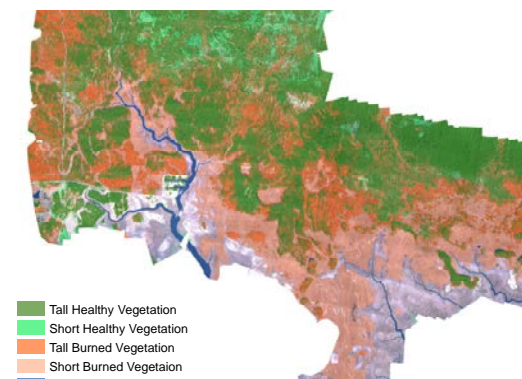www.ngi.msstate.edu

2017 GRI/NGI Annual Report

sUAS Program makes the Impossible Pursuit Possible

Researchers have developed an extensive small, unmanned aerial systems applied program that exploits sUASs to collect timely and high spatial resolution data that is difficult, if not impossible, to acquire any other way.
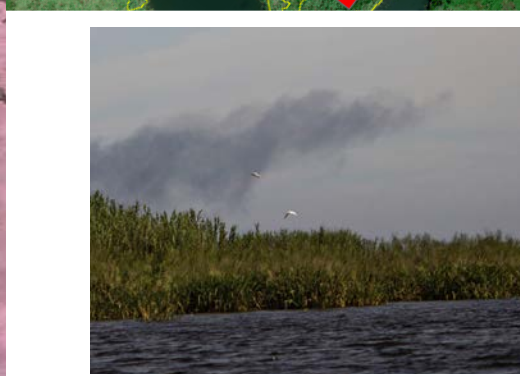
For instance the team is working to assess cellular coverage and bandwidth at various altitudes in the Mississippi Delta to prepare for the inevitable future demand that will come as more and more operations exploit sUASs for challenging and high-risk, real-time map applications like agriculture pest infestations, emerging flooding, search-and-rescue, wildfire analysis, traffic monitoring, and fugitive tracking.

Companies also seek the analysis of vegetative encroachment along transmission lines in challenging terrains, terrains for which access by even all-terrain vehicles is extremely difficult. The data collection is accomplished using both fixed-wing and vertical-take-off-and-landing (VTOL) sUASs. Computational experts, specializing in geospatial data analysis, are reseaslising the collection of individual images to create high-resolution maps and developing three-dimensional point clouds using photogrammetric techniques. Analysts are developing and refining techniques to utilize the multispectral imagery and point cloud for detecting hazardous environments where vegetation like trees and other plant foliage might damage the transmission lines or the structures holding the transmission lines. The proactive process of monitoring the area by comparing mosaics over time of the imposing hazards and degrading structures is cost-effective and maintains the integrity of the transmittal system.

Flying sUASs safely in national airspace is a top priority. Qualified, remote control pilots with the ability to operate sUASs safely in extended visible line-of-sight are essential to the industry. The dilemma is in determining a sUAS pilot's ability to fly at this level. Researchers are working to develop a system that accurately identifies sUAS pilots' capability. EVLOS is the space in which the pilot can detect larger aircraft such as manned aircraft, blimps, balloons, and parachutes with their eyes or ears, but unable to detect the small unmanned aerial vehicle that they are operating. The approach relies on information about the location, speed, and direction of all of the aircraft and the indication and presentation on the remote pilot's ground control station.

Tall Healthy Vegetation
Short Healthy Vegetation
Tall Burned Vegetation
Short Burned Vegetation

Customizing UAS Payloads and Technology to Identify Invasive Plant Species in the Gulf Coast

While using unmanned aerial systems to map gulf coastlines, a team of GRI researchers identified an invasive grass species.

The Mississippi State group initially was only collecting hydrologic data as part of a project funded by the National Oceanic and Atmospheric Administration. Titled SHOUT4Rivers, the project was to map Lower Pearl River delta regions using unmanned aircraft systems, so forecasters would know where water would move during periods of flooding. The official grant name is Sensing Hazards with Operational Unmanned Aircraft Systems Technology for Rivers.

As team members were reviewing collected images of the area near Louisiana's St. Tammany Parish, GRI invasive species expert Gray Turnage spotted pockets of something that should not be there—*Phragmites australis*, botanical designation for a perennial found throughout many temperate and tropical regions.

This strain of Phragmites outcompetes native plants for resources and space. Disrupting this vegetation harms the native wildlife that feeds on and lives within these marshes. Persistent disruption can lead to various species becoming endangered.

To best identify the plant species, the MSU team used UAS-mounted cameras to capture several multispectral images from various locations.

Sathish Samiappan, a GRI postdoctoral associate, was responsible for developing the computer software used for image analysis. Samiappan explained, UAS technologies are superior to satellites and manned flights in several ways. While satellite imaging may cover a very large area at once, those images are much less precise. Manned-flight images may be taken closer to the ground while covering a large area, but significant costs are incurred when hiring a pilot and airplane for an overall process that can be very time-consuming.

With a UAS vehicle, "the image area may be much smaller but the images are more precise and the process costs less and requires much less time to complete," he said.

Even with advantages UAS technology provides, human skills still are required.

"We differentiate the objects in an image by their color, texture, shape and more; these are called features of an image," Samiappan said. "Computer software cannot, however, make these distinctions, so we have to write software that trains them to recognize an image in much the same way we do."

To solve this issue, Samiappan uses a process called supervised classification to "teach" the computer how to differentiate objects in the images. Accurately identifying the areas where Phragmites grow can help local resource managers from, but not limited to, the St. Tammany Parish, local United States Forestry and Wildlife Services offices (USFWS), and the State of Louisiana reclaim affected areas.

As the project nears completion, both MSU researchers agreed that their next goal is to seek out additional opportunities to apply their newly developed image-enhancing process.

NGI Researchers Partner with NOAA Biological Oceanographers to Unravel Mysteries of Biscayne Bay

Biscayne Bay, located south of Miami, Florida, is known for its clear, Caribbean-like aquamarine color and serves as one of the state's top tourism vacation destinations for water activities. But the Bay, with its low nutrient water quality, serves another important environmental ecosystem function; it provides nursery habitat for a variety of marine life. This beautiful body of water also is a primary economic driver that contributes to a great way-of-life for the commercial, charter and recreational fishing industries.

The Bay's ability to maintain a low level of nutrients and a high level of marine biodiversity is sort of an anomaly to Anna Linhoss, a biological engineering professor and NGI researcher. She is partnering with scientists from NOAA's Atlantic Ocean Meteorology and Laboratory to study why runoff from sources like fertilizers in the Miami metropolitan and nearby rural agricultural areas is not degrading the water quality.

"The fact that Biscayne Bay is surrounded by huge urban and agricultural areas and still maintains a fairly healthy marine ecosystem is pretty amazing," Linhoss said. "How does the Bay maintain this healthy level of water quality with all the storm runoff and water coming from the city? How vulnerable is the Bay in terms of how much can it handle? We want to be proactive and understand what we can do to keep it in the condition that it is in or make it better."

It seems like a relatively easy science dilemma to understand given the belief that there is a linear relationship between more nutrients in the runoff means the development of more algae blooms and phytoplankton and that equates to poorer water quality.

However, Linhoss explained the quandary becomes more complicated when considering that ocean currents and flowrates into and out of the Bay can act as a mixer that spreads and dilutes pollution. There's also the consideration of Biscayne Bay's jagged coastline, smaller islands, seasonal cycles, storm surge, and population growth that adds to the complexity of understanding how greenhouse effects spread.

NOAA, the project's funding agent, agrees with Linhoss. They believe existing ocean models don't reflect the complexity of how the Bay maintains its nearly taintless state. As a result, they are providing on-site office space and biological oceanographers to partner with Linhoss and her postdoctoral researcher, Nicole Millet, to gather additional data and analyze data already collected.

"NOAA's biological oceanographers, Chris Kelble and Lindsey Vesser, are working with us to study long-term spatial and temporal relationships. We are trying to create computer simulations of what we see and then attempt to build accurate models of causal relationships when looking at peculiar data that is perplexing." Linhoss added, "NOAA is a fantastic partner and we are fortunate to collaborate every day with their scientists to unravel the scientific mysteries of Biscayne Bay."

Saving Mississippi's Biodiversity

Gray Turnage, a research associate with Mississippi State University's GRI, works with state stakeholders to save Mississippi's aquatic and wetland ecosystems from invasive plant species.

Invasive plant infestations occur when non-native plant species outcompete native plant species for resources like nutrients and sunlight.

"Native species have developed very tight ecological relationships with the other organisms around them because of selective pressures in that area. If an invasive species arrives that's not as adapted to that local ecosystem, then it can disrupts things," Turnage said.

One example is the invasive aquatic plant species Hydrilla. This species has recently been found in Lake Okhissa in Franklin County, Mississippi. Hydrilla can grow very dense and thus shade out native plants.

"The native vegetation dies because it can't get sunlight. Once the native vegetation is gone, you may start to lose aquatic organisms like insects and bivalves, which may rely on the native vegetation as a food source or for habitat. Once those organisms are lost, the fish species that feed on them may start to decline as well," Turnage said.

Such harm to Mississippi's ecology also threatens the economy. Dense-growing plant species make it difficult to fish, boat, wade or ski through the affected areas. Without viable spots for these recreational events, the state can lose potential revenue from tourists.

Turnage and his team work with the Mississippi Aquatic Invasive Species Council headed by the Mississippi Department of Environmental Quality. Other organizations involved are Mississippi State University, Mississippi's Department of Agriculture and Commerce, Department of Marine Resources, Department of Wildlife Fisheries and Parks, and the Gulf States Marine Fisheries Commission. Together, these organizations are working on a multistage plan to combat the problem of aquatic invasive species.

The first stage surveys high-traffic water bodies such as state fishing lakes, camping lakes and rivers. Because boats and trailers commonly spread invasive species, these waterbodies have been implicated as probable sites of invasion due to the high level of boat traffic they receive. The next stage involves educating people in the affected areas and, if the situation allows, controlling the infestation through physical, biological, mechanical or chemical means.

"Fisherman don't always check their trailer for plant fragments, which for some species can survive for days out of water. For hydrilla, an 8 inch fragment is all that is needed to start a new infestation. For water hyacinth, it can be around 4 or 5 inches across," Turnage said.

Time constraints, consent involving private property, and logistics of managing equipment failures are all real obstacles that require attention for a project of this size. Lack of public knowledge concerning invasive plant species also contributes to what the teams must deal with but despite these challenges, the important work of saving Mississippi's biodiversity and economic interests continues.

Developing Practical Farming Applications for UAVs

Researchers with Mississippi State University's GRI are conducting several projects to increase Unmanned Aerial Vehicles' viability as practical scouting tools for producers.

UAVs possess vast remote-sensing capabilities but for producers of various crops, instructions concerning proper hardware usage and how to read the relevant data are scant. Several projects are underway to provide producers with what Joby Czarnecki, assistant research professor with GRI, calls a "cookbook" of relevant reference material concerning UAVs.

"We need to be able to tell producers specific information according to their situation. That's why we call what we're doing a cookbook because producers need a list of "ingredients" and a method for combining them. They should be able to look up what UAV they need, which sensor will look at the correct portions of the spectrums they need, what spatial resolution they should be looking for, and how to do all of that when their plant is at a specified growth stage. If they have that information, then they will possess the best possible data to evaluate specific problems and will be able to make informed decisions. That information just simply does not exist right now," Czarnecki said.

UAVs will not solve every problem that producers have but the projects GRI is conducting have shown promise.

One project involves sensing infestation of Palmer Amaranth, a troublesome weed in cotton crops. The weed rapidly overtakes cotton fields and is usually combated by early season sprays. UAV sensing would spot possible regrowth of the weed from a larger viewing perspective than producers walking large fields and doing spot checks. The challenge for this project is learning what sensors and methods collect the data necessary to distinguish the weed from cotton and other features present in the field, such as tire tracks.

Sensing when corn crops need further irrigation is another project. One common practice for irrigating crops is scheduling regular sessions on a calendar. This method is insufficient because it does not match crop need but rather, an arbitrary timetable. Soil moisture probes have been introduced, which allow more objective determination of irrigation need. Compared with these probes, UAVs would provide a larger-scale view of corn fields on a spectrum that would tell producers whether irrigation is necessary. The challenge involves determining the relationship between the sensor data and actual crop moisture status and need.

A third project would help soybean producers manage crop loss to deer. Currently, producers are only able to spot check areas on foot and determine how much damage has occurred. UAVs would provide whole-field views. Using this data, GRI also hopes to determine when damage occurred within the lifecycle of the crop, thereby giving producers more loss-management options.

GRI projects are helping producers become more efficient in growing and protecting their crops. As such, funding and approving these projects are matters of social investment because a successful agriculture sector ensures a safe and reliable domestic food supply.

GRI Researcher Integrates GIS Software into Multi-discipline Research

John Cartwright, research assistant with GRI, assists Mississippi State researchers, students, and faculty members, along with organizations throughout the United States, with integrating geographic information systems (GIS) into their research.

The three most popular software packages available to handle geospatial data are:
• ESRI ArcGIS (python) – allows for standard and advanced geospatial analysis with various data sets such as imagery sets and vector analysis.
• ERDAS Imagine – a geographic and imaging software used predominantly to process imagery but has other geospatial or GIS-like capabilities.
• ENVI – a similar software to ERDAS but has better performance with multi-spectral imagery.

The task determines which one is best. Cartwright's job is to issue licenses to students and faculty, explain how to handle collected data, and assist with any technical issues by communicating with the software's vendors.

The software is relevant to many ongoing projects throughout Mississippi State and the nation.

The Carnivore Ecology Laboratory gains detailed analyses from the spatial data gathered on brown bears in late Lake Clark National Park and Preserve, Alaska that would not be possible to get otherwise.

The Cobb Institute of Archaeology uses it for various applications including recording the locations and attributes of archaeological sites and training students into viable candidates for employment by organizations who expect them to be proficient in GIS as well as other geospatial software.

An upcoming project with the U.S. Fish and Wildlife Service would see the software used to create habitat maps for endangered beach populations in Florida and Alabama as well as spatially-explicit species distribution models for rare and at-risk wildlife species in the Southeast.

Demand for GIS software has increased dramatically during Cartwright's tenure and it has created several obstacles. Technical issues and demand for licenses have gone from a few requests per year to nearly continuous queries since demand for software has increased.

Licensing issues also affect where someone can access the software. State researchers abroad have to be issued individual product licenses if they are not linked to the Mississippi State server which would normally grant them access.

GIS is in high demand and Cartwright works to make it accessible for all:

"There's a lot of things that researchers and students, depending on their background, can miss at the fundamental levels of doing geospatial research. I help them because oftentimes they need the tricks of getting through those things very quickly. I try to speed up the process."
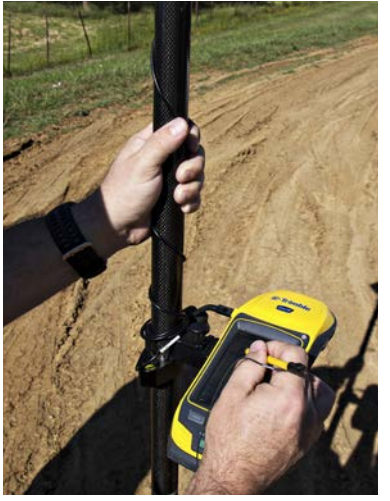
Combining Unmanned Aerial Systems Technology with GPS to Improve Conservation Efforts

GRI assistant professor Joby Czarnecki, is working with 22 other university departments and units, as well as several state and local agencies, to increase soil and water conservation activities in the Catalpa Creek watershed. A five-member team of faculty at MSU is working collaboratively to assess, monitor, and model the crucial areas of concern within the watershed, so that improvements resulting from increase conservation effort can be documented.

The team includes Czarnecki, along with John Ramirez-Avila, an assistant professor in civil and environmental engineering, Tim Schauwecker, an associate professor in landscape Architecture, Anna Linhoss, an assistant professor with Agricultural and Biological Engineering and a hydrology researcher with GRI, and Beth Baker, an assistant extension professor with the Forest Wildlife Research Center. GRI is conducting unmanned aerial vehicle missions within the watershed to collect imagery which is being used to create 3D models of the Creek channel. They are using this tool to help locate and measure the highly eroded areas which are creating issues with water quality within the watershed.

An interdisciplinary student research team is collecting additional data which will be used by all researchers. Students are currently using a GPS unit to catalogue channel cross-sections that will be used to validate GRI's UAS models. These cross sections will also serve as the basis for a hydraulic model being developed by Ramirez, who is also a researcher with GRI. The hydraulic model will determine which areas of erosion should be a priority for restoration, and which areas are apt to erode in the near future.

The GRI research team also is training and including future conservation and environmental experts. The students members include Diana Linder, civil and environmental Engineering; Garrett Prater, Gage Creel, Kristin Haynes and Wesley Brandon, agricultural and biological Engineering; and Lucas Whittenton with agricultural economics.

Mississippi State University Provides Benthic Maps for NOAA

Ryan Dodd, a research assistant with Mississippi State's GRI, uses multibeam sonar data to develop benthic habitat maps for the National Oceanic and Atmospheric Administration's National Marine Fisheries Service.

NOAA Fisheries is responsible for the stewardship of ocean natural resources and habitat. They use benthic habitat maps to assess marine resources for coastal management and ecological analysis. These maps provide information about ecosystem dynamics and the relationships between the biota and habitats that equip resource managers to make important decisions regarding coastal activities and their effects on marine life.

One current project involves using benthic maps to chart a variety of ocean and seafloor areas using multibeam sonar to accurately find and survey fish habitats. Working with NOAA scientists, Dodd creates the maps from a variety of methods including underwater photos and acoustic surveys. Basically the maps provide economic and time-saving advantages that ultimately allow researchers and policymakers to make informed decisions on how to monitor and protect various marine and plant life forms that could be in danger.

"Expeditions and research crews are really expensive and so it's a really good method to help resource managers find, study, protect and maintain the biodiversity along our coasts. Having these maps allows them to easily discern what areas the fish prefer, which enables researchers to anticipate future environmental effects on schools of fish and to pick and choose the best areas to evaluate rather than wasting time finding the underwater habitats," Dodd said.

Creating the habitat maps is a relatively new process that involves Dodd taking the data that NOAA collects, converting it to the generic sensor format, or GSF, running it through specialized software to clean it up, and using the results to create maps of area, depth and fish habitats.

"This is a long-term project about helping them with their efficiency. As a result, they have better records of their old maps, which helps them know what type of areas they are in, what types of fish species are in the habitat, and whether there are trends for surveying," Dodd said.

Expanding the Mississippi Geospatial Database

The Regional Geospatial Modeling Grant provides the opportunity to expand Mississippi's geospatial database and train its citizens on the use and applications of the data. Without the access to funding from a variety of federal sources, the geospatial database would not be complete if left to local and state financial resources.

Over the past decade, the program has acquired high-resolution imagery for 76 of the 82 Mississippi counties. The ortho-corrected imagery is used to update road maps, improve the identification of the location of residential units for E-911 databases, and provides a base for mapping features observed on the imagery (e.g., timber stands and housing developments).

Concurrent with the acquisition of aerial imagery, LIDAR data have been collected to develop high-resolution elevation datasets (+/- 6-inches over much of the state) and improve the delineation of surface drainage patterns to better understand the movement of water during heavy rainfall or flooding events.

The geospatial database collections are made available, at no cost, to the citizens of Mississippi through various state and federal repositories. The primary source in Mississippi for the geospatial data is the Mississippi Automated Resource Information System at www.maris.state.ms.us.

The Geospatial Education and Outreach Project was instituted over 10 years ago to provide training and technical support in the use and applications of geographic information systems. Two-day workshops range from introductory concepts in GIS to multiuser, geospatial database management systems, using commercial and "open source" software.

Paul Barnes, Harrison County Board of Supervisors' director of GIS said, "I manage a system accessed by GIS users from a variety of departments. After training, they use the applications of the data without always asking for help."

Initially, training was directed toward state and local government employees, now the workshops include federal government and private sector members. Since 2006, 3,650 people have participated in 367 workshops.

Reinforcing Levees across the Globe

An international partnership featuring researchers from Mississippi State University, Ole Miss, and the Colorado School of Mines, along with the University of Delft and Twente University in the Netherlands, is examining earthen dams and levees (EDLs)–critical infrastructure that provides flood protection, fresh water storage and renewable energy to society.

For five years, Jim Aanstoos, GRI associate professor emeritus, has been leading a team of researchers collaborating on multiscale monitoring science to enable a sustainable future for the vast worldwide array of EDLs. EDLs are prone to a costly cause of failure in the form of internal erosion of soils within the structure. This progressive failure occurs at areas of weakness in EDLs such as poor construction and/or aging.

Currently, the dam and levee inspections are performed infrequently and some of the problem areas are invisible to current methods of inspection. There is a critical need to advance the science of levee and dam monitoring to enable the implementation of a cost effective multiscale system that can identify internal weakness at an early stage, which can prevent catastrophic damage. Sensing the condition of levees remotely can help EDL managers focus and prioritize their inspection and maintenance activities.

The MSU team has been focusing on the use of synthetic aperture radar (SAR) from aircraft and satellites to remotely detect indicators of EDL instability such as slump slides. Sophisticated machine learning software has been trained to detect these features, and has been tested on sections of the earthen levees along the Mississippi River. The tests have shown a high accuracy rate in slide detection. Measurements of surface and sub-surface soil properties have been analyzed in connection with the radar data and found to have interesting correlations, which could lead to broader applications of this technology.