FOREST & WILDLIFE RESEARCH CENTER 2016 ANNUAL REPORT

MISSISSIPPI STATE UNIVERSITY™
FOREST AND WILDLIFE RESEARCH CENTER

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The Forest and Wildlife Research Center is a unit in the Division of Agriculture, Forestry and Veterinary Medicine at Mississippi State University.

The mission of the Forest and Wildlife Research Center is to promote, support and enable the management, conservation, and utilization of forest and other natural resources to benefit the stakeholders of Mississippi, the nation, and the world.

MISSISSIPPI STATE UNIVERSITY™
FOREST AND WILDLIFE RESEARCH CENTER

IN THIS ISSUE

from the

DIRECTOR

THE **FOREST AND WILDLIFE RESEARCH CENTER (FWRC)** at Mississippi State University is one of the premier research centers in the country, dedicated to conserving, managing, and utilizing the forest, forest products, wildlife and fisheries resources of Mississippi for the betterment of our citizens.

As the research arm of the College of Forest Resources, the FWRC works to promote, support, and enable the management, conservation, and utilization of natural resources in the state, region, and world.

This work is not possible without the generous help of our friends and supporters, appropriations through the state legislature, and private research sponsors. For example, Jimmy Bryan, a generous supporter of our college and the FWRC, endowed a bobwhite quail habitat restoration program for faculty and student development on his property near West Point, Mississippi. This program is but one of the many established by friends and alumni who entrust their gifts to us for the benefit of future generations. There are many others who have made land gifts through the MSU Foundation to the Bulldog Forest. The College of Forest Resources manages these working forests for research, education, and demonstration purposes.

We are truly making a difference in the state. The economic importance of the forest and forest products industries in our state are significant. These industries contribute $12.8 billion to the state's economy each year. An additional $2.7 billion is generated annually from hunting, fishing and wildlife viewing activities. This contribution correlates with the outstanding research conducted by FWRC scientists. For each dollar the FWRC receives in state funds, another $1.28 is received in grant support. We are proud of the return on investment we provide to the taxpayers of Mississippi.

We are also pleased to announce the USDA APHIS Wildlife Services National Training Academy, or NTA is now housed in the FWRC. The NTA is the country's first academy dedicated to training, instruction, and safely resolving human-wildlife conflicts and safety-related risks.

In this annual report, you will find a glimpse of the projects scientists in the FWRC are tackling to improve habitats and natural resources while finding new ways to utilize our forest resources. From developing new uses for wood and byproducts to determining new management techniques to promote forest growth, scientists in the FWRC work tirelessly to sustain and enhance our natural resources.

As you read this annual report, you will see the passion that our faculty, staff and students have for understanding, conserving and appreciating our natural resources. We will continue in these endeavors and encourage your participation. Thank you for your generous support.

George M. Hopper
Director

FORESTRY

The Department of Forestry's research is centered on sustainably managing and utilizing forest resources. The department has been developing practices to expand the growth of timber resources, demonstrate alternative plantings, and increase awareness of the economic importance of natural resources since 1954. The department actively works with the Mississippi Forestry Commission, U.S. Forest Service, forest industry, and other universities to reduce risk of insect, disease, and natural disasters . The department also studies the effect of timberlands on carbon sequestration, water quality, and wildlife habitat.

A LOOK AHEAD

Forecasting the value of forests

A forestry student uses binoculars to look into the forest. Photo by Megan Bean

Ever wondered how much the lumber in a forest will be worth in five years, ten years or more? An accurate estimation of expected forest volume growth and yield is critical for the 125,000 forest landowners in the state of Mississippi. That's why researchers in the MSU Department of Forestry have spent nearly four decades creating and refining growth and yield models.

Published models by forestry scientists in the Forest and Wildlife Research Center have been implemented in Windows and web software to allow forestry professionals to make growth and yield predictions based on age, species, site quality, and a variety of stand management options.

"What is unique about our growth and yield models is the software created to deliver the information to the end user," said Dr. Emily Schultz, forestry professor. "Published growth and yield models are generally long, tedious equations and software implementations are usually not available. We develop the models based on data collected over years and then develop computer programs to make the data work for anyone who wants to download it."

Development of growth and yield models at Mississippi State began in the late 1970s when Dr. Thomas Matney, forestry professor and biometrician, created a loblolly pine model. In 1982, a long term study was established for developing a red-oak sweetgum bottomland hardwood growth and yield system.

Schultz and Matney, with others, have developed computerized models for cutover, site-prepared loblolly pine plantations; old field loblolly pine plantations; natural longleaf; cutover, site-prepared slash pine; and bottomland hardwoods. The models take years to develop as trees are measured and re-measured over a long time period to create a database for modeling.

"We measure the individual tree diameter, basal area, and age as well as the number of trees per acre, the volume by species group, volume of board feet, and cubic feet by log grade," Schultz said. "We re-measure trees over time to refine the equations that are used to predict future growth of the stand and individual trees."

One of the most distinguishing features of their bottomland hardwood growth and yield model is the ability to assign grades to expected lumber yield. Hardwood is graded based on a number of characteristics of the finished lumber. By having a prediction tool that accurately distributes volumes into grade categories, landowners and managers can make informed decisions on the quality and health of hardwood forests.

Schultz and Matney continue to refine their models and are now providing software for other models published in the literature. They are also developing a web interface for each model, making it easier for users by avoiding the download and installation of a software package.

"By quantifying how a forest changes over time, forest managers gain a better understanding of forest stand dynamics and are better able to make good financial and environmental decisions," Matney said. "We have spent our careers developing these datasets and computer software programs to help better manage forest resources."

Several different growth and yield software products are available for downloading on the Forest and Wildlife Research Center website. Visit http://fwrc.msstate.edu/software.asp to download the software. ❖

BURN, GROW, REPEAT

MSU researchers study Russian wildfires, impact on climate change

RAGING WILDFIRES THAT SPAN AN AREA TEN TIMES larger than the state of Mississippi often flare up during Siberia's dry summer months. The burning trees and understory release carbon dioxide into the atmosphere, which may impact global climate change. Dr. Heather Alexander, an assistant forestry professor in the Forest and Wildlife Research Center, is working to understand the full impacts of this cycle.

To determine carbon amounts lost during the fires—and hopefully gained back during the forest regrowth process—Alexander has been traveling since 2014 to the legendary Russian province that covers most of Northern Asia.

Fires usually begin when lightning strikes dried moss during the summer months. From there, they spread to trees and the forest understory, all of which contain carbon. However, the biggest stores of carbon exist in the permafrost in the soil. The fire causes topsoil layers to subside, melting the permafrost and releasing even further amounts of carbon into the atmosphere.

This cycle is caused in part by changes that have already taken place in the global climate; as Siberian summers become drier and hotter, it's easier for fires to grip the landscape.

However, there is the chance that severe fires stimulate growth to a greater extent—meaning that more carbon may be captured in the denser stands that result after a fire. According to Alexander, the project's ultimate goal is to determine how much carbon is lost as compared to how much is taken in as the forest begins to regrow. Once they have established that ratio, they will have a better idea of the impact these forest fires might have on the global climate.

This year Alexander returned to Siberia to gather data on how stand density and other factors such as aspect, which is the direction a slope faces, and stream and river areas impact carbon storage. ❖

MSU assistant professor Heather Alexander and forestry graduate student Homero Pena take organic soil samples in a Siberian forest. Photo by Aaron Walker

CLIMATE CHANGE MITIGATION

MSU takes part in regional research

Pine trees in the John W. Starr Memorial Forest. Photo by Russ Houston

A FORESTRY PROFESSOR IN THE Forest and Wildlife Research Center is helping find ways to mitigate climate change. For several years, Dr. Don Grebner has worked as part of the PINEMAP project, a large regional project that looks at how managing pine trees can help mitigate climate change across the southeastern United States.

The work done by participating institutions has focused on looking at the biology of pine as well as developing software and tools to know more about the growth of pines. There are also researchers looking at economic impacts and landowner attitudes toward climate change.

"Most of the work that we've done here at MSU was done by my former doctoral student, Puskar Khanal," Grebner said. "He was largely involved with doing a regional assessment of nonindustrial private landowners, looking at their attitudes and behaviors about climate change."

Khanal performed an assessment of what the landowners think and know about climate change and began to anticipate how they would respond if certain programs, like incentives for delaying the harvest of pine trees, were in place.

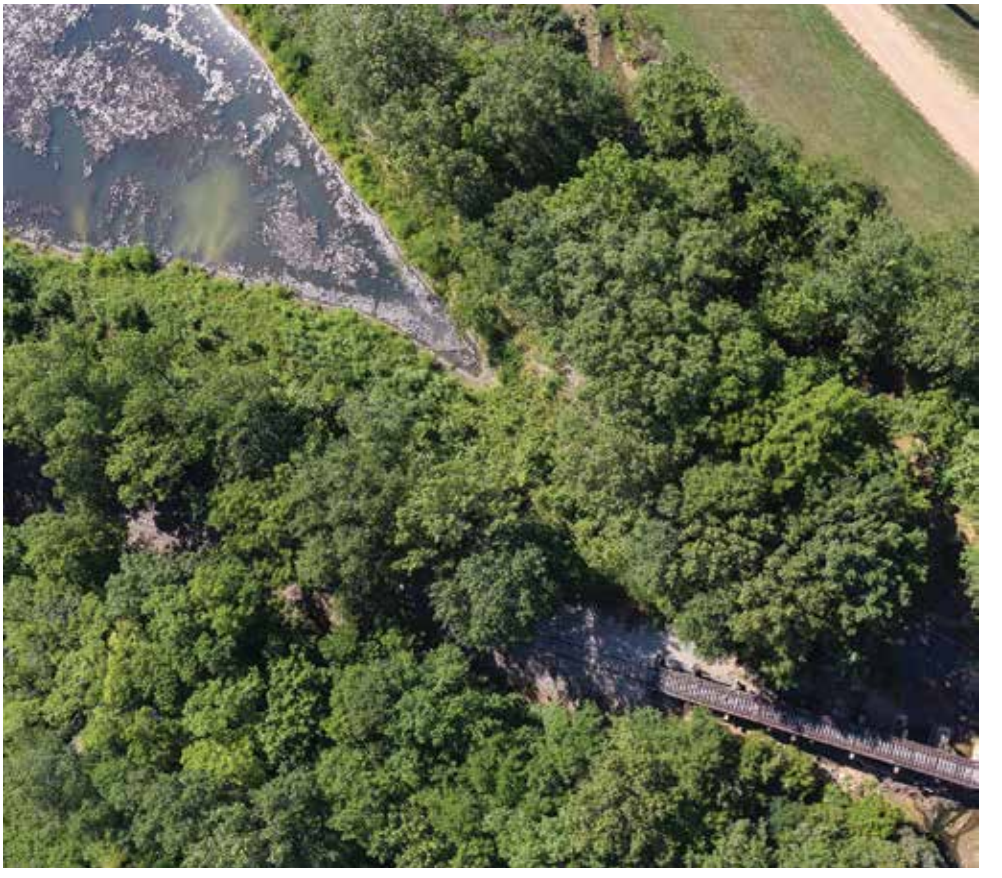
The research found that most individuals who own land for more than just timber management purposes—ones with recreational or wildlife objectives—were often willing to consider participating in programs that would mitigate climate change.

"Delaying harvest is a common way of mitigation," Grebner explained. "You're not transforming the forest into a product as soon. The longer the tree grows, the more carbon it can sequester. There is a tradeoff, and in a lot of cases, people are willing to do that given the right price."

Two papers based off of Khanal's research have been accepted and will be published soon. The overall PINEMAP project is winding down; Grebner said the lead university, University of Florida, will now begin to disseminate the information and develop tools that landowners can use. For example, one online tool that is in the works will allow people to assess the effect of climate change on their properties and find things that they can do (or not do) to help with mitigation. ❖

A VIEW FROM THE TOP

Forestry researchers use unmanned aerial vehicles



A view of tree tops from an unmanned aerial vehicle. Photo by MSU GeoSystems Research Institute

FORESTRY RESEARCHERS are using unmanned aerial vehicles (UAVs) to collect various data from field trials. Dr. Randall Rousseau, research and extension forestry professor in the Forest and Wildlife Research Center, hopes the technology will provide insight into several existing research projects.

Rousseau is studying loblolly pine, black willow, hybrid poplar, and eastern cottonwood at various sites across Mississippi. The plots are located in Lowndes, Marshall, Newton, Oktibbeha, and Washington counties. Rousseau said UAVs will help his team assess various crown characteristics, something he said can be difficult to determine from the ground.

Currently, ground measurements are taken to determine crown health. Now, UAVs will help verify those estimates from the air.

"It can be difficult to measure the overall crown shape and size from the ground. You run a straight line where you think the branch on the tree stops and then you measure two different ordinances, but it is still only an estimate. With the UAV, the camera is situated directly above the tree and you can get a better feel for what the true shape is and then correlate this back to light intercept and growth," he said.

Valerie West is a doctoral candidate under Rousseau's direction. As part of her dissertation, West is studying top dieback in loblolly pine and poplar. Top dieback simply refers to the crown of a tree dying, due to pathogen, nutrition deficiency or some other factor. West hopes UAVs will assist in this particular part of her research.

"Any time you lose the top of a tree, you've lost growth potential for a year or longer. The damage we are observing usually starts at the very top and during the growing season other pine trees and smaller trees block your view of the damage. When this happens, it is hard to determine the initial effect of the damage and it may become even worse before it is noticed. You have to use a piece of heavy equipment such as a boom lift to gain access to the top of the tree. The idea of being able to fly a UAV and spot the damage immediately will streamline the process tremendously."

Rousseau's team will also be using it for their eastern cottonwood and hybrid poplar research where the ability of a clone to retain its leaves late into the year provides more nutrient storage in the root system and superior growth during the spring of the next year. The UAV will be used to photograph various clones in their tests to determine the longest leaf retention.

"The photography can be taken quickly moving from plot to plot across the state and then later examined in the office to rate each clone for leaf retention. The UAV will expedite field work and provide access to plots that are difficult to reach in specific conditions," Rousseau said.

Rousseau's team initially worked with the Geosystems Research Institute. He has since purchased a Phantom 3 and one of the team's research associates is in the process of earning the proper pilot certifications.

While the research is preliminary, UAVs are new tools that may help provide clarity and precision in the field of forestry, providing another view from the top. ❖

COMPETITION BETWEEN CLONES

Researchers develop models for varietal pine production

A cloned forest site is part of this ArboGen study near Ravenel, South Carolina. Photo submitted

Mississippi State assistant forestry professor, Charles Sabatia, is developing models to more accurately predict production yield of varietal pines, or cloned trees. Unlike most crops, which cycle through their entire lifetime within a few months, trees grow over the span of decades. In that time, factors such as storms, pests, varying microclimates, and inter-tree competition all affect their success. Because of the multitude of variables and long growing period prior to harvest, models are needed to predict yield.

Sabatia, a scientist in the Forest and Wildlife Research Center, is developing models that will help forest managers decide the best way to manage stand density in varietal loblolly pine plantations. This research was generated by trends in southern pine plantation forestry in which use of varietals is on the rise.

"Varietal trees are exact copies of each other. Because of this, inter-tree interaction in stands of varietal trees will be different compared to the interaction among trees in a non-varietal stands," Sabatia explained.

Varietal pines create higher quality wood products as the individual cloned can be selected for straightness, uniformity of color, and other desirable attributes. However, this development calls for new models.

"In a normal forest, every tree is different. They interact with their microclimate to their own strengths—not every tree exploits resources in the same way, and so a balance is formed. However, in a clonal forest, each tree exploits resources in the same way. The genetic sameness results in more inter-tree competition," Sabatia explained.

In the long run, the fierce competition between trees may create a more uniform tree size distribution at harvest time, without the exceptionally large trees created in a non-varietal stands.

"Ultimately, we hope to answer the questions of whether different loblolly pine varietals exhibit the same type of competitive interactions among trees of the same varietal. We also hope to develop ways to adapt empirical forest growth and yield competition models to different loblolly pine varietals," Sabatia stated.

This research was funded by the Forest Modeling Research Cooperative, associated with the Virginia Tech Foundation. ❖

Graduate Student Profile:

Casey Johnston

HOMETOWN: Ruston, LA

SEEING THE FOREST THROUGH THE TREES

BEING ABLE TO IDENTIFY longleaf pine trees from other species is important because of the tree's very diverse ecosystem. About 900 plant species are associated with the longleaf pine ecosystem, as well as several endangered wildlife species—all of which can be cared for more easily if their exact stand locations are known.

Forestry graduate student, Casey Johnston, is working with Dr. David Evans using spatial technology to identify longleaf pine trees from other species in south Mississippi. Evans is a forestry professor in the Forest and Wildlife Research Center. The research, which is part of Johnston's master's degree program, uses remote sensing and spatial technologies to identify the lowest resolution of images needed to confidently differentiate between species.

A previous graduate student, Mary Frances Nieminen, found that longleaf pine could be identified from loblolly pine using geospatial software. However, the images use half-meter-sized pixels, which, according to Johnston, are expensive to obtain, have large storage requirements, and can be difficult to process. Johnston's project should make it more logistically feasible to identify longleaf pine across a large region.

"Longleaf pine has a lot of positive economical and environmental properties," Johnston said. "It has different structural properties than loblolly pine. It is slower to develop significant aboveground growth and is better adapted to withstand hurricane winds and forest fires frequently associated with its native coastal plains habitat. Longleaf pine also has the potential for efficient carbon sequestration, which assists in controlling climate change by providing long-term carbon dioxide storage."

To conduct the research, Johnston found aerially visible, mature, canopy-level examples of longleaf and loblolly pines within parts of south Mississippi. Their coordinates were obtained using a GPS and laser rangefinder. He then randomly halved the collected tree location points into control samples and test samples. Using the geospatial software, ERDAS Imagine, the samples were loaded on top of WorldView-2 satellite imagery. The 8-band imagery was subset into three spectral bands (Red-Edge, Near-Infrared 1, and Near-Infrared 2). The overall spectral value of each test sample canopy was collected across the imagery. These spectral signatures were used to classify the imagery.

An acceptable classification accuracy of the control samples at a half of a meter led to the next step of the project, pixel resampling. The classification was run with pixel sizes scaled to one, two, four, eight, and 16 meters. Discovering the lowest spatial resolution needed to acceptably classify longleaf pine from loblolly pine will conclude Johnston's project. Once the spatial resolution requirement question is answered, Johnston hopes that this information will be helpful in the future for locating longleaf pine on a larger area, perhaps within its entire range across the southeastern United States. ❖

FACULTY

Andrew Ezell
Professor and Head

Heather Alexander
Assistant Professor

Stephen Dicke
Extension Professor

David Evans
Professor

Joseph (Zhaofei) Fan
Assistant Professor

Brent Frey
Assistant Professor

Jason Gordon
Assistant Extension Professor

Laura Grace
Professor

Stephen Grado
Professor

Robert Grala
Associate Professor

Donald Grebner
Professor

James Henderson
Associate Extension Professor

Glenn Hughes
Extension Professor

John Kushla
Extension/Research Professor

Tom Matney
Professor

Ian Munn
Professor, CFR Associate Dean

Heidi Renninger
Assistant Professor

Scott Roberts
Professor

Randall Rousseau
Extension/Research Professor

Charles Sabatia
Assistant Professor

Emily Schultz
Professor

Brady Self
Assistant Extension Professor

Courtney Siegert
Assistant Professor

Changyou "Edwin" Sun
Professor

John Willis
Assistant Professor

EMERITUS FACULTY

Tom Monaghan
Professor Emeritus

WILDLIFE, FISHERIES & AQUACULTURE

The Department of Wildlife, Fisheries and Aquaculture develops and conducts a diversity of research projects that include studies of game and nongame species; ecology; wildlife diseases; endangered species conservation; ecological restoration; invasive species management; habitat reclamation, restoration, and management; conservation education; human dimensions; geospatial technologies in wildlife and fisheries sciences; landscape ecology; and wildlife and fish recreation.

NOXUBEE'S ANCIENT OCCUPANTS

Prehistoric fish discovered in the depths of Bluff Lake

Graduate students assist with tagging of a paddlefish in the Sam D. Hamilton Noxubee Wildlife Refuge's Bluff Lake. Photo Submitted

Assistant wildlife, fisheries and Aquaculture professor, Dr. Mike Colvin, along with biologists at the Sam D. Hamilton Noxubee Wildlife Refuge, recently documented high abundance of paddlefish in the refuge's Bluff Lake. Paddlefish are ancient fish that can grow up to six feet long, and are traditionally found in much larger waterways. They also are highly migratory, traveling hundreds of miles northward each year to spawn in the upper reaches of their range.

These factors make the Bluff Lake population especially interesting. So far, these paddlefish appear to be year-round residents of the lake.

The researchers suspect that they were drawn off course from their usual migration by the specific conditions created by the Noxubee spillage area.

While it might be exciting for a small waterway like Noxubee to have giant, prehistoric fish lurking in the depths, it isn't optimal for the species, especially if this population isn't able to spawn successfully.

"Paddlefish are endangered in parts of the United States due to overfishing for caviar. And because they're migratory, they travel through various states whose protection guidelines for them may not be as stringent. They may be protected in one part of their range, only to be caught in the next," Colvin explained.

To determine whether the paddlefish in the spillway are successfully spawning (and therefore contributing to the propagation of their species), Colvin and colleagues have set up sensors within the spillway to monitor conditions and draw correlations between fish behavior and factors like flow, temperature, and water levels.

They also tag the fish with acoustic tags, which register with sensors set up along the Noxubee and Tennessee-Tombigbee Waterway. With these sensors in place, they will be able to track each fish's movements and see whether they are migratory or resident.

Once they have determined what exactly is going on with this unique group of fish, their results will help inform the refuge management's decision about how to proceed. If the paddlefish are successfully spawning, Noxubee's management may do habitat improvement within the spillway. If not, they will work to change the conditions of the spillway so that paddlefish are no longer attracted to it.

This project is funded by the U.S. Fish and Wildlife Service's Inventory and Monitoring and the U.S. Geological Survey's Quick Response Program. ❖

THE HISTORY OF DEER

MSU researchers map genetic deer structure in Southeastern U.S.

DR. STEVE DEMARAIS, WILDLIFE, FISHERIES, AND aquaculture professor in MSU's Forest and Wildlife Research Center, and graduate student, Jordan Youngmann, are using genetics to map out the success of white-tailed deer restoration efforts that occurred in the 1900s throughout the Southeastern U.S.

Gaining a clearer picture of the genetic breakdown of the deer population will provide scientists with an idea of how earlier restoration efforts played out genetically in the population, and will also confirm many of the wives tales common in the Southeast that larger deer have northern lineages.

"A landowner recently mentioned to me that in a certain area of Mississippi there are markedly larger deer than the average regional body and antler size. He stated that the area had initially been stocked with northern deer, and as they tend to be larger, those genetics still influence modern herds. This project could help validate that," Demarais said.

Jordan Youngmann of Hoosick Falls, NY prepares DNA samples of white-tailed deer. Photo by Sarah Buckleitner

It will also help other restoration projects by providing insight into why the original restoration efforts were so successful.

"This is heralded as one of the best restoration stories out there: there were almost no deer in the early 1900s, and clearly there is a bounty of deer now. These deer are genetically robust and have not suffered any of the consequences that tend to be problems in restoration efforts," Youngmann stated.

The researchers are particularly interested in seeing how deer taken from northern states fared in the radically different climate of the Southeast.

To answer this question, they gathered genetic samples from throughout Alabama, Mississippi, and Louisiana, and then also collected samples from known stock sources, like Michigan, New York, and Texas. Afterwards, they analyze the DNA and compare it to see if they can find unique microsatellite markers that geographically distinguish deer. They hope to be able to find genetic traces of the original deer used for restoration of deer herds still living in the Southeast.

This research was jointly funded by Louisiana Department of Wildlife and Fisheries; Mississippi Department of Wildlife, Fisheries, and Parks; and the Alabama Department of Conservation and Natural Resources. ❖

HABITAT FOR WILD TURKEY

MSU scientists determining how much land is enough to restore wild turkey populations

Wild turkey were once abundant in Mississippi forests but there numbers are declining. Photo submitted

Landscapes are changing throughout the country and as wild places often disappear, so, too, do their inhabitants. These changes are placing a greater demand on the habitats that are preferred by wildlife, including game species.

Wildife, Fisheries and Aquaculture associate professor Dr. Guiming Wang, recently led a FWRC project to determine the habitat suitability for wild turkeys across the state. Wild turkey abundance has been declining across the Southeast since the 1990s. Understanding the habitat where turkey populations thrive is essential to reversing this downward trend.

Eastern wild turkey is an area-sensitive forest species, requiring large, contiguous tracts of suitable habitat for survival. While hardwood forests are their preferred space, they also like variety in their home ranges which include open fields for brooding, dense shrub for nesting, and large adjoining patches of land.

"While we do not yet know how much space is needed to sustain a viable turkey population, we do know they need a variety of habitats during the year," Wang said. "Our study found that the number of turkeys peaked when about one-third of their habitat is hardwood forest."

Funded by the Mississippi Department of Wildlife, Fisheries and Parks, information used in this study included trapping data and brood surveys collected from the state agency. Location data from hunters who harvested turkeys and random sightings from across the state were added to the dataset to create 664 non-duplicated locations for mapping.

Scientists found that wild turkey are more likely to occur in forested areas bordering other land cover types. Turkeys prefer diverse land covers in proximity to each other and tend to avoid water bodies and agricultural lands. Turkey numbers were lower where forests were less than 25 percent hardwood and adjoining habitat was less than 494 acres.

"On a large spatial scale, 29 percent of the landscape should be hardwood for optimum wild turkey abundance," Wang said. "At the home range scale, 39 percent should be hardwood. "

While this portion of the study is complete, scientists are continuing their work on turkeys to determine exactly how big of an area they need. The Mississippi Department of Wildlife, Fisheries and Parks has divided the state into five management regions. This fall, researchers will apply GPS transmitters to ten turkeys in each of the five regions. Ten turkeys have been tagged with GPS transmitters in a hunting club near Holly Spring, MS this spring.

Location and thermal data will be collected every 30 minutes for 14 hours. Scientists are hopeful this data will answer the question of how big of an area is needed for turkey populations to thrive.

"We know the habitat turkeys predominately use, we also know that generally they stay within about a 16-mile radius," Wang said. "Knowing how big of an area is needed to sustain viable turkey population is the next key to managing habitats favored by turkey and helping the population rebound." ❖

MANAGED LAND AS HABITAT HAVEN

MSU researchers study wildlife in tracts of pine

Prescribed fire in the Andrews Forestry and Wildlife Laboratory in Oktibbeha County, Mississippi. Photo by David Ammon

MANAGED PINE FORESTS ACCOUNT FOR 19 PERCENT of all forests in the Southeastern United States. At certain times, loblolly pine stands can be high in biodiversity. These stands can be home to many of the same species that are found in historically fire-maintained open pine savanna and woodlands. Oftentimes, these populations include species of conservation concern.

Scientists in the Forest and Wildlife Research Center studied how loblolly pine stands can help conservation efforts. Wildlife, Fisheries and Aquaculture research associates, Rachel Greene and Dr. Ray Iglay, evaluated different land management techniques in pine. The researchers determined what management techniques resulted in the most biodiversity.

The project was established by the late MSU Professor Dr. Sam Riffell in 2013. It was funded by the Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative. Research findings were published in Forest Ecology and Management in January 2016. Dr. Kristine Evans, Dr. Darren A. Miller, Dr. T. Bently Wigley, and Riffell were cited as co-authors on the study.

The literature review and meta-analysis focused on managed loblolly pine forests. Scientists compared the impact of site preparation on biodiversity. When chemical (herbicide) preparation was used instead of mechanical preparation, the number of birds increased. However, as herbicide application intensity increased such as using two applications instead of one or spaying the whole stand versus only tree rows, bird diversity decreased. Researchers also assessed the impact of mid-rotation management practices on different species. These practices included prescribed fire, selective herbicide, fire and herbicide combination, and thinning. The number of small mammals, reptiles, and amphibians in the stand increased after thinning. The number of birds increased after a prescribed burn and an herbicide application. However, combining fire and herbicide decreased the number of reptiles and amphibians. Yet, at the landscape scale, combining fire and herbicide promoted the greatest number of species due to high use of mid-rotation stands by birds.

The effects on biodiversity were short-term, lasting three to four years after stand establishment and four years after thinning. When a prescribed burn was initiated after thinning, thinning effects lasted an additional two to four years.

"Managed pine landscapes are a patchwork of different successional stages with stands constantly moving into and out of open pine," Greene said.

Scientists also assessed the economic feasibility of management efforts that were most likely to improve biodiversity. The analysis determined all management practices were economically feasible on an operational scale, meaning that a minimum of ten hectares were treated at a time. Researchers cautioned against viewing one management practice as a catchall approach, citing that practices combined produced different results at different stages. ❖

CONSERVATION WITHIN AN EVER-CHANGING LANDSCAPE

MSU serves as anchor to 20-member cooperative to protect future of 180-million acres

Assistant research professor Kristine Evans takes measurements in the Sam D. Hamilton Noxubee National Wildlife Refuge. Photo by Russ Houston

Atlanta currently covers an area larger than Massachusetts, with scientists expecting urban sprawl to increase exponentially in the coming years.

These predictions show urban development merging to create a corridor from Tuscaloosa, Alabama to Roanoke, Virginia, and from Chattanooga, Tennessee to Charlotte, North Carolina by 2060. Elsewhere, the same pattern is happening from Baton Rouge to Pensacola; Dallas to Shreveport and Springfield, Missouri to Fort Smith, Arkansas.

To offset the impact of this urban development, land-use changes, climate change, and sea-level rise in the coming decades, scientists from 20 state, federal, and non-profit organizations have come together to form the Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative (GCPO LCC).

Through a partnership with the U.S. Fish and Wildlife Service, Mississippi State University is co-host of the cooperative, which supports long-term conservation planning and design across 180 million acres in 12 states.

Dr. Wes Burger, professor and associate director of the Forest and Wildlife Research Center, is co-principal investigator for the cooperative alongside Dr. Kristine Evans, assistant research professor in the Geosystems Research Institute at Mississippi State.

The cooperate evaluates the habitat of 75 indicator species throughout the partnership's area, which spans the East Gulf Coastal Plain, Ozark Highlands, Mississippi Alluvial Valley, West Gulf Coastal Plain, and Gulf Coast. Bisected by the Mississippi River, these sub-regions are located in Mississippi, Alabama, Arkansas, Florida, Georgia, Illinois, Kentucky, Louisiana, Missouri, Oklahoma, Tennessee, and Texas.

The cooperative works to define, design, and deliver conservation that helps fish and wildlife species, communities, and ecosystems adapt to climate change and other stressors at the landscape level.

Mississippi State University is providing geospatial data and expertise to the Southeastern conservation blueprint—a network of lands and waters that sustains natural and cultural resources into the future—through the GCPO LCC's Conservation Planning Atlas, a tool that helps land resource managers make scientifically supported conservation decisions. In addition to the scientific support, Mississippi State also provides administrative support to the GCPO LCC. One MSU project funded by the GCPO LCC is studying land management in the context of conservation.

Dr. Robert Grala, an associate professor of forestry, is working to identify conservation, cultural, and economic benefits and perceptions of land management and how it matters to landowners in bottomland hardwoods, open pine stands, and grassland habitats across several Southeastern states.

The study includes Dr. William Cooke, professor and head of the Mississippi State geosciences department; Dr. Kevin Hunt, professor in wildlife, fisheries and aquaculture; and Dr. Jason Gordon, an assistant extension professor in the forestry department. It aims to determine how conservation benefits and perceptions affect land management objectives and landowner actions. The team will also work to quantify the monetary value of conservation activities and ecosystem services to determine if and how landowners can be encouraged to change their actions.

Maps that illustrate landowner conservation practice and preference at the landscape scale will be published to help inform and support future conservation practices. Researchers from the Duke University Nicholas Institute for Environmental Policy Solutions are collaborating on the project.❖

Graduate Student Profile:

Joe Lancaster

HOMETOWN: Hastings, MI

FINDING THE PREFERRED HABITAT

UNDERSTANDING HOW THE mallard selects different types of wetland habitats is critical for their long-term survival. By knowing their preferred habitats, wildlife managers can ensure the resources are available when birds come to winter in the South.

Joe Lancaster, a wildlife, fisheries and aquaculture graduate student in the James C. Kennedy Endowed Chair in Waterfowl and Wetlands Conservation program, has been researching mallards' use of wetland areas for six years. His project started as a master's research project in 2010 and morphed into a doctoral study in 2014. He works under the direction of Wildlife, Fisheries and Aquaculture associate professor Dr. Brian Davis.

In the beginning, Lancaster studied how mallards reacted to different levels of hunting in state-operated wildlife management areas. The Mississippi Department of Wildlife, Fisheries and Parks was interested in waterfowl use of wetland areas to determine how hunting pressure affected wintering waterfowl. The project expanded from there to evaluate what habitats the ducks use and how to best protect those areas.

"It is important that we identify the types of habitats that are important and increase survival of mallards during the wintertime," Lancaster said. "We can then manage habitats to increase the winter survival rate and send more birds back to the breeding grounds."

Previous research has shown that mallards choose landscapes comprised of 50 percent flooded agriculture, 20 percent moist soil wetlands, 20 percent forested wetlands, and 10 percent permanent wetlands for their winter homes. However, this project revealed the habitats best suited for mallards based on their winter survival rate.

Research was conducted by tagging wild mallards in the Mississippi Delta during the winter months of 2010, 2011, 2013, and 2014. A very high frequency transmitter was attached to female ducks, which emits a signal to truck-mounted antennas. The transmitter allows the researchers to triangulate the signal and through geographic information software, overlay map data to see what type of habitats are being used. The transmitter also detects if a mallard has died and allows researchers to recover the carcass and identify the cause of death—whether by avian or mammalian predator.

Preliminary results—based on the first two years of research—found that mallards with high winter survival rates are using more forested and moist soil wetlands than those with low winter survival. The project's final results are forthcoming. ❖

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SUSTAINABLE BIOPRODUCTS

The Sustainable Bioproducts Department seeks to advance manufacturing practices and improve and develop novel products through sustainable utilization and stewardship of forests and other natural resources by providing students with a world-class education, conducting meaningful, timely and innovative research, and cultivating long-lasting relationships with those who support and promote sustainability, both nationally and internationally.

ONE PIECE AT A TIME

MSU researchers set sights on improving the value of southern forests

Scientists in sustainable bioproducts are working to determine the value of southern lumber. Photo by David Ammon

MSU scientists want to improve southern lumber's value one piece at a time. Forest and Wildlife Research Center scientists Dr. Rubin Shmulsky and Dr. Dan Seale tested more than 2,000 boards of lumber. They hope their efforts will increase the value of southern forests.

The research encompassed ten states. Select boards were cut and collected from sawmills from Texas to Virginia. Researchers are trying to develop better nondestructive technologies. These technologies can potentially better determine the value of lumber.

Nondestructive testing tries to determine how stiff and strong each piece of lumber is without breaking it. For example, nondestructive testing takes place at sawmills and then that lumber is sold. With more accurate technology, sawmills can do a better job of separating out high value pieces from lower value pieces. This improvement helps increase profits for mills and tree farmers alike.

Rubin Shmulsky is professor and head of the Department of Sustainable Bioproducts. He explained that the value of southern forests increases when nondestructive testing improves.

"Southern pine is a multi-billion dollar industry. We hope to find better ways to determine the value of each piece of lumber," Shmulsky explained. "Stiffer and stronger pieces have more utility value. They can hold up greater loads and span longer distances. We can increase the potential economic value of every piece through more accurate testing."

Shmulsky explained that when the true strength of the wood can't be determined, sawmills must err on the side of caution.

"If we don't know how strong or stiff a board is, we have to value the piece conservatively at a lower value. With better testing, we can tease more value out. While two pieces might look alike, one piece might be twice as strong," he said.

The five-year study is in its third year. More than a dozen graduate students have participated in the research. One student is working on an app for carpenters to use in the field.

"The app should let carpenters select the stiffest, strongest piece of lumber. The quality of thousands of homes and structures could improve each year," said Seale, who is a professor in the Department of Sustainable Bioproducts.

Seale and Shmulsky are both excited that the research is a learning opportunity for so many students.

"Not only will our work inform future industry standards, we are also training the leaders of tomorrow," Seale said.

Researchers are now conducting small property tests on short samples that are 24-inches long. They are evaluating perpendicular and parallel compression, clear bending, tension, and sheer.

The research is funded by the U.S. Department of Agriculture's Agricultural Research Service. Participating collaborators also include the USDA Forest Products Laboratory, the Southern Pine Inspection Bureau, the Timber Products Inspection Agency, the Southern Forest Products Association, the Southeastern Lumber Manufacturers Association, the Mississippi Lumber Manufacturers Association, and the Mississippi Forestry Association. ❖

TERMITES, WHITE-ROT AND BROWN-ROT, OH MY!

MSU researcher finds new uses for nanoparticles

Termites and other pests cost Americans roughly $5 billion dollars in property damage each year. With the addition of fungi, like white-rot and brown-rot, the cost is astronomical.

Dr. Dragica Jeremic, assistant professor in the Department of Sustainable Bioproducts, is helping to address this issue with the help of a recent grant from the USDA, which will allow her to research whether the nanoparticle chitosan can serve as an effective protectant against pests and rot.

Chitosan is derived from chitin, a substance found in the exoskeletons of marine crustaceans. The researchers are hoping that this modified form of chitin will serve as an alternative to the copper-based wood protectants currently on the market.

"Most protectants used today are copper-based, but copper accumulates in the environment over time, and at high levels is toxic to aquatic organisms. Also, certain types of decay organisms are tolerant of copper. Through time, this issue is becoming increasingly important. We are trying to address this issue by developing an alternative protectant now," Jeremic explained.

The researchers also believe that chitosan may do more than protect against pests and rot. It is believed that, when combined with a substance called tripolyphosphate, chitosan may also improve fire retardant properties. This property, in combination with its antimicrobial properties makes it ideal as a wood protectant.

However, the chitosan requires some modification before it is ready for use. As it stands, the molecule is hydrophilic—meaning it absorbs water. Without modification, it could lead to soggy treated wood. Jeremic is attempting to modify the molecule so that it no longer is hydrophilic, but that it also retains its charge, which is one of the factors that makes it antimicrobial in the first place.

Once they have successfully modified the compound, they will begin testing to determine just how effective it is against rot. If those trials go well, it just may be the key to helping save Americans millions of dollars in property damage, as well as providing an environmentally- friendly option that can be used for years to come. ❖

Assistant sustainable bioproducts professor Dragica Jeremic examines chitosan. Photo by David Ammon

Assistant sustainable bioproducts professor Beth Stokes prepares materials for composite boards. Photo by David Ammon

FROM CROPS TO BOARDS

MSU scientists engineer wood from leftover plant materials

SCIENTISTS IN THE DEPARTMENT OF SUSTAINABLE BIOPRODUCTS are working in collaboration with the USDA to create a new, environmentally-benign engineered wood product from leftover plant-based materials.

The new wood composite will be composed of a cottonseed protein adhesive, guayule plant fibers, and wood chips. The guayule plant fibers are a plant-based termiticide that will increase the durability and longevity of the manufactured wood product.

The USDA agriculture research office in New Orleans developed the beginnings of the cottonseed protein adhesive by extracting a protein from seeds left after cotton has been ginned. Another USDA entity is working on a synthetic rubber made from the guayule plant. The engineered wood being developed at MSU will use waste products from both of these research projects.

The guayule plant is a flowering shrub that is native to the southwestern United States and northern Mexico. It is used as an alternate source of latex for rubber that is hypoallergenic.

USDA program leader, Gene Lester, first recognized the potential for a new product to be developed in 2014. He discussed the idea and worked closely with faculty in the Department of Sustainable Bioproducts to bring the project to fruition. Assistant professor, Dr. Beth Stokes, and graduate students are currently working on the project.

"The process begins by creating a six-inch square piece of particle board using wood chips, cottonseed adhesive, and the guayule plant resin," Stokes said. "If the product forms a tight bond, we will begin creating bigger boards from the product."

The engineered product will go through a series of durability tests—exposure to termites, water, and invasive fungi—as well as tests to ensure it can hold fasteners.

The possible uses for the engineered product are vast, serving as a green alternative to particle board that is currently on the market. Stokes said the goal is to create a wood product that is safe for families and uses no hazardous chemicals. ❖

NEW PRODUCT EMERGES FROM RENEWABLE RESOURCES

MSU scientists develop graphene from lignin

GRAPHENE HAS MANY EXTRAORDINARY PROPERTIES. It is about 100 times stronger than steel and conducts heat and electricity efficiently. It has been shown to enhance batteries, solar cells, electronic transistors, displays, and potentially hundreds of other products.

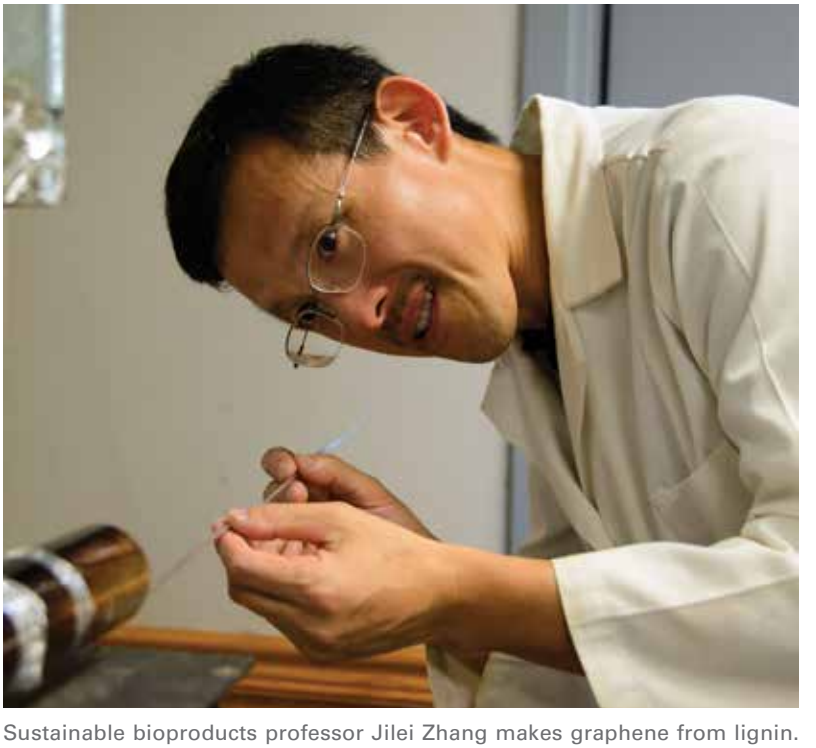
And while this amazing substance is useful in a variety of products, its cost can be astronomical. A one inch by one inch wafer of graphene cost about $115.00.

Sustainable bioproducts scientists, Dr. Jilei Zhang and Dr. Qiangu Yan, along with graduate student, Xuefeng Zhang, have developed a method to manufacture multi-layer graphene from a wood byproduct, lignin.

Lignin is a polymer that helps form cell walls in wood and bark. When wood is turned into pulp, the process breaks wood down into lignin, hemicellulose, and cellulose. Cellulose is primarily used to make paper. Hemicellulose is used to make chemicals and adhesives. Lignin is a byproduct of the process, with about 70 million tons available each year worldwide. Currently, most of the lignin is burnt onsite to power paper mills.

The process of turning lignin into multi-layer graphene requires heat and iron, the latter of which serves as a catalyst. Two patents are pending on the process which is supported by the U.S. Department of Agriculture's Forest Products Laboratory and National Institute of Food and Agriculture. Industry partner, Domtar, also supports the project.

"One of the great things about this project is the involvement of academia, government, and industry to develop a product that will provide an economic value to forest landowners and the forest product industry," Zhang said. "We are hopeful that trees damaged from wind, lightning, beetles, and other environmental conditions can be used by this process."



Sustainable bioproducts professor Jilei Zhang makes graphene from lignin. Photo by David Ammon

The discovery produces multi-layer graphene and multi-layer graphene shelled metal nanoparticles. Other known systems to produce graphene materials are expensive and less environmentally-friendly.

"One of the unique features of our invention is the ability to easily produce multi-layer graphene," Zhang said. "We also have the ability to produce another product, multi-layer graphene shelled metal nanoparticles through adjusting our process parameters."

While the process continues to be refined, scientists have already found the graphene shelled metal nanoparticles will remove lead from water. They are currently trying to determine if the particles will remove lead and heavy metals from soils.

"There are tons of uses for the graphene-based materials in energy storage systems and renewable production processes such as creating biofuels," Zhang said. "We are just beginning to uncover some of the great uses for this product made from renewable resources." ❖

Scientists in sustainable bioproducts are developing fuel from woody by-products. Photo by Megan Bean

DRIVING FORWARD WITH BIO-OIL

MSU researchers develop sustainable fuel for motor vehicles

DR. JASON STREET, PROFESSOR IN THE DEPARTMENT OF Sustainable Bioproducts, is working to develop biofuel out of sawdust and other organic expendables, like pinecones and compost. This fuel could eventually be used as an additive to ease dependence on fossil fuels.

"Petroleum product prices have the potential to be very volatile due to the amount of petroleum that we import, and we can't know when a country will have issues or decide to raise their prices or attempt to hurt our economy by using an embargo—the oil crises of 1973 and 1979 come to mind," Street explained.

To create the fuel, Street heats the organic material in a low-oxygen atmosphere, which converts them to hydrocarbons, an organic compound that consists of hydrogen and oxygen atoms. However, the hydrocarbons are not initially useful—they have too much oxygen, and must be altered to have a higher combustion rate, which is where catalyst technology comes into play.

"Catalyst technology can be approached from many different angles, but overall it consists of trying to increase the rate of a chemical reaction by changing reactants to produce a particular product without the catalyst itself undergoing a permanent change," Street explained.

Street and a chemistry graduate student, Griffin Burk, are also working on altering the process so that more usable liquid is produced, and so that the final product is more stable. As it stands, the fuel is too thick to work in an engine.

"In my opinion, the coolest thing about this project is that we're taking items most people would throw away—pine cones, peanut shells, and compost, for example—and converting them into hydrocarbons, which we could then use to power our cars," Burk said.

While maybe one day the United States could rely solely on biofuels, in the short term the researchers are hopeful that the hydrocarbons will be a valuable resource in taking a step away from dependence on fossil fuels. ❖

Graduate Student Profile:

Bhawna Soni

HOMETOWN: Madhya Pradesh, India

DEVELOPING BIO-BASED, ENVIRONMENTALLY-FRIENDLY PACKAGING

As consumer concern for the earth's limited natural resources grows, scientists and technologists have searched for bio-based materials that are environmentally-friendly, biodegradable, renewable, and abundant in nature. Bhawna Soni is part of that research, developing antimicrobial packaging films from agricultural harvesting waste and shrimp shells. Soni is pursuing a doctorate in forest resources, with a concentration in sustainable bioproducts.

Dr. El Barbary Hassan, associate professor in the Department of Sustainable Bioproducts, said that packaging is the largest single market for plastics and its disposal continues to contribute to filling landfills and enhanced greenhouse effects when burned. Soni's research attempts to replace petrochemicals in packaging with renewable biopolymers such as cellulose.

"Cellulose and its composites can produce biodegradable packaging that can maintain product quality and reduce waste disposal problems," Hassan said.

Soni's research focuses on packaging materials that can be used safely with seafood products, which are highly susceptible to quality deterioration.

The bio-based packaging is made from cellulose nanofibers from cotton stalks and chitosan from shrimp shells. Packaging films of different compositions of the cellulose nanofibers and chitosan were developed, and then tested for oxygen permeability, tensile strength, water vapor permeability, thermal stability, and antimicrobial activity.

Soni's work on this project began in January 2014 and is expected to be completed by May 2017. In April 2016, she began looking at other industrial applications for the cellulose nanofibers from cotton stalks and began development of low-cost natural absorbents for the removal of heavy metals from fresh water ponds. ❖

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Professor

Hamid Borazjani
Professor

Susan Diehl
Professor

El Barbary Hassan
Associate Professor

Dragica Jeremic
Assistant Professor

Mojgan Nejad
Assistant Professor

Darrel Nicholas
Professor

Dan Seale
Professor

Beth Stokes
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Jason Street
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CENTER FOR RESOLVING HUMAN-WILDLIFE CONFLICTS

The Center's mission is to advance research and applied management of natural-human systems, provide leadership and training for resolving human-wildlife conflicts, and expand educational opportunities for students interested in human dimensions of wildlife and fisheries conservation.

WIPING OUT WILD HOGS

MSU researchers take on one of natural resources' biggest pests

Wild hogs root up the ground, causing damage for agricultural producers and landowners. Photo submitted

IT IS ESTIMATED THAT WILD HOGS CAUSE $1.5 BILLION dollars in damage in the U.S. annually. Researchers in the Forest and Wildlife Research Center hope to shed light on the wild hog problem in Mississippi. Dr. Jessica Tegt, Dr. Bronson Strickland, and Dr. Marina Denny are trying to find ways to get rid of wild hogs for good.

The scientists hope they can determine exactly how much hog damage and control currently cost Mississippi producers. They also hope to learn about the public's knowledge and attitudes toward wild hogs.

Researchers sent surveys to 4,900 agricultural producers and timberland owners across the state with 500 responding to the survey. Of those, 305 people agreed to participate with follow up phone calls or onsite surveys. The survey included questions about the presence and frequency of wild hog sightings. It also asked about damage tolerance and control methods. Seventy-five of those landowners were randomly selected for site visits.

"We evaluated landscape characteristics with GPS data and verified the damage. The wild hog damage experienced by those landowners alone totaled one million dollars," Tegt said.

Researchers also sent surveys to 5,000 randomly-selected homeowners across Mississippi to determine public attitudes and knowledge of wild hogs. More than 800 homeowners responded. Only 39 percent of participants said they were somewhat familiar of wild hogs, while 50 percent said they had a negative attitude toward the species. More than half of the respondents thought wild hogs should be hunted to reduce damage.

"This survey showed us that there is an opportunity for education and outreach. Hunting isn't necessarily the answer. Hunters tend to keep a small source population. Understanding the proper techniques for trapping, discouraging hog hunting on your land, and shooting pigs as you see them are some of the best ways to get rid of them," Tegt said.

Tegt said that while the data are still being analyzed, the initial results have taught them a lot.

"We have a lot more hogs in Mississippi than previous data suggest. We're at a tipping point in the state. If we don't take action soon, we may never eradicate the wild hog population from Mississippi."

Tegt said the next steps include developing recommendations to minimize the negative effects of wild hog damage on agricultural and forestry productivity. Part of that plan includes an outreach program to educate law enforcement officers about wild hogs.

"This year we are focused on educating law enforcement so they can be our first line of defense when hogs are being illegally transported," she said.

Researchers also plan to replicate the surveys nationally.

"Forty-seven states have reported a presence of wild hogs," Tegt said. "This issue reaches well beyond our region."

This research is funded by the Mississippi Department of Agriculture and Commerce Land, Water and Timber Resources Board and the USDA APHIS Wildlife Services Feral Swine Mitigation Program. The work is conducted through the MSU Center for Resolving Human-Wildlife Conflicts, a partnership of the MSU Forest and Wildlife Research Center, MSU Extension Service, and the USDA Animal Plant Health Inspection Service. ❖

THE CORMORANT'S CATCH

MSU researchers take on catfish-eating cormorants

Cormorants cost Mississippi producers millions each year. Photo submitted

DR. BRONSON STRICKLAND, ASSOCIATE extension professor in the Department of Wildlife, Fisheries, and Aquaculture, is working to develop strategies that will prevent double-crested cormorants from eating catfish farmers out of house and home.

Cormorants are large waterbirds that migrate south each winter to roost. While they have been making the long journey from the northeastern United States to Mississippi for eons, the birds recently developed a taste for farm-raised catfish. The shallow ponds and plentiful fish provide a much easier meal than most natural waterways, and the cormorants flock to catfish aquaculture in the thousands—at any given time, 50,000 to 60,000 cormorants will be gulping fish out of ponds in the Delta. This creates a huge economic impact; for the Delta region alone, between $5 and $12 million worth of damage are caused each year.

The catfish industry is the largest aquaculture industry in the United States, with an annual production value of $450 million. Over half of those fish are raised in Mississippi, mostly in the Delta. Aside from being an important source of revenue, catfish also provide an eco-friendly option for consumers—they consume plant-based feed instead of meat-based feed and are native to the area.

The larger economic climate has also exacerbated the issue. The recession of 2008 halved the acreage of catfish ponds in the Delta, yet, according to producers, the same number of cormorants is feeding on a much smaller population. Strickland hopes to verify this scientifically, as well as to identify what attracts cormorants to particular ponds, and to examine the efficacy of past and present tactics for reducing predation.

Some strategies for reducing predation have been used by producers for ages, such as putting up scarecrows, or decoys, to scare the birds away. More recent developments, such as the tactic of using split pond production, which concentrates the fish in one small portion of the pond, may prove to be successful. The researchers suspect that this method metaphorically kills two birds with one stone: it makes production more efficient, and is easier to protect fish from cormorants.

This project was funded by and conducted in collaboration with the United States Department of Agriculture Animal and Plant Health Inspection Service, and the United State Department of Agriculture's National Wildlife Research Center. ❖

Graduate Student Profile:

Andrew Smith

HOMETOWN: Greenville, MS

CONTROLLING THE INVASION

Master's student Andrew Smith didn't go a traditional route when choosing a research project for his natural resources degree. Taking inspiration from his affiliations with the Boone & Crockett Club, Smith decided the way he could best impact natural resources would be from the side of policy and legislation.

Smith's project is investigating the effectiveness of wild hog legislation and policy in the United States. The project is a national investigation on the legislative treatment of invasive species, including research design, literature review, survey protocol, statistical analysis, model construction, and result/recommendations. The final chapter of his project will consist of invasive species policy recommendations to different sportsman caucuses across the country. He explained that each state's caucus goes to Congress each year with recommendations for game laws and legislation.

Early in his research, Smith found that wild hog policies and invasive species policy in general, vary tremendously across the country. On the federal and state level, Smith feels like the current legislation is ineffective.

"Everything that we do for the treatment of invasive species is done in a reactive manner," Smith said.

Currently, treatment of invasive species in the U.S. looks like this: a biological invasion will occur and while its presence is known, no resources are allocated to control it. Once the invader begins to reproduce and become established, it then begins to precipitate enough detrimental impacts for the government to take notice, so an environmental study on how to address the issue begins—a process that can take 1-2 years to complete. When that is complete, legislation is suggested, formulated, and potentially passed in order to complement existing management efforts—such as making it illegal to transport or handle the invasive species. From first notice, it may take up to a few years to make any progress on a recent invading species, giving it time to become reproductively established and naturalized, which subsequently leads to continuous expansion and precipitation of damage to agriculture and natural resources, Smith said.

Invasive species are the second greatest threat to world biodiversity, second only to habitat destruction. "As far as threats and destruction to commercial agriculture and natural resources go, invasive species are far underestimated," Smith said.

Smith's project focuses on wild hogs because in Mississippi—and the Southeast in general—the species is a huge threat to agriculture, native wildlife, human safety and thus national and state economies. While there is no official accurate estimate of population size, it is believed that the state of Mississippi has an estimated 150,000 to 300,000 wild hogs, which take shelter in forested lands such as wildlife refuges and other large expanses of wilderness. During night hours, wild hogs leave the protection of the forest and devastate crops in agricultural areas, returning to the protection of cover by morning.

The ultimate goal for Smith is to reduce hog numbers and detrimental impacts across the country by formulating effective, proactive policy with legislatures that would implement laws that affect how the animals can be treated recreationally, transported, and killed objectively.

"Kansas and Tennessee, as well as a few other states, have adopted a model for outlawing the recreational pursuit or sport-hunting of wild hogs, as this practice only complicates federal and state control efforts," Smith explained. "I don't know that this research will find this approach to be the best model for Mississippi—due to the fact that hog populations and land usage vary across states—just as social, political, and cultural atmosphere differs. But it is one that has already shown great success; both of these states have their wild hog population down to manageable numbers. However, legislation that is successful in one state may be completely ineffective in another. The key is being proactive when formulating natural resources policy, as well as having the involvement and support of the public."

Smith is employed as an extension agent and his graduate research is funded through the MSU Extension Service.❖

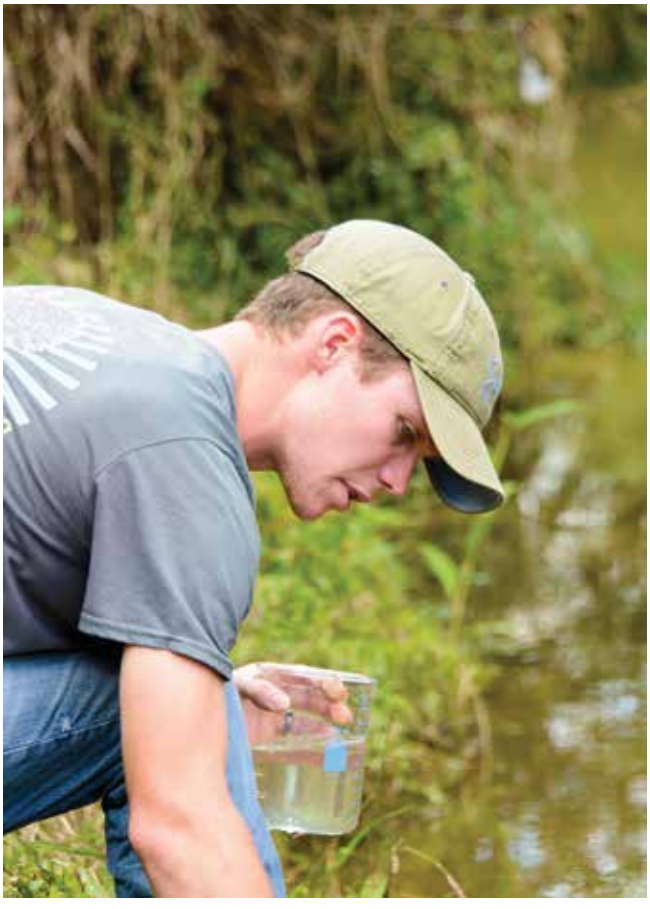
UNDERGRADUATE RESEARCH

Undergraduate students in the College of Forest Resources step outside of the classroom to engage in hands-on research with scientists in the Forest and Wildlife Research Center. The opportunity is made possible by the Undergraduate Research Scholars Program, now in its third year.

JOSHUA BYERS

HOMETOWN: *Olive Branch, MS*

Joshua Byers is a senior majoring in natural resources and environmental conservation. He is studying upland oak forests. Typically, oak forests have dominated the eastern United States. Recent fire suppression in the area has created the emergence of more fire-sensitive, shade-tolerant trees. Through a positive feedback cycle called mesophication, researchers hypothesize that the fire-sensitive trees are suppressing the oaks by promoting conditions not conducive to fire. Byers will systematically quantify potential pathways by which these trees facilitate their continued dominance at the expense of the upland oaks. Dr. Heather Alexander, assistant professor in the Department of Forestry, is directing the research.



RICKS BURTON

HOMETOWN: *Hernando, MS*

Ricks Burton is a junior majoring in forestry. He is studying water quality in the Catalpa Creek Watershed. The headwaters of the creek begin on the main campus of Mississippi State University. The research will help inform the effectiveness of recent best management practices set in place by MSU and the Mississippi Department of Environmental Quality. The best practices are intended to mitigate the contributions by MSU to identified water quality issues within the watershed. The data collected will be included in a watershed management plan, presented at professional meetings, and used in the preparation of peer-reviewed publications. Burton is mentored by Dr. Courtney Siegert, assistant professor in the Department of Forestry.

ISABELLE DURHAM

HOMETOWN: *Prattville, AL*

Isabelle Durham is a sophomore majoring in wildlife, fisheries and aquaculture. She is studying how foraging animals select for perceived or actual habitat selection. Durham will design and conduct experimental trials wherein fruit flies select breeding and foraging habitat from equally available resources of variable actual and perceived quality. Her research may inform use of habitat selection for wildlife management and conservation. Mentors include Dr. Garrett Street and Dr. Marcus Lashley, who are both assistant professors in Department of Wildlife, Fisheries, and Aquaculture and Dr. Natraj Krishnan, an assistant professor in the Department of Biochemistry, Molecular Biology, Entomology, and Plant Pathology in the College of Agriculture and Life Sciences.

KELLY MAGEE

HOMETOWN: *Lake Charles, LA*

Kelly Magee is a freshman majoring in sustainable bioproducts. Magee is helping develop test methods for evaluating two wood-based products: cross-laminated timber and particleboard created with a novel cottonseed protein adhesive and a plant-based termiticide. Cross-laminated timber panels are used in construction for modular buildings in Europe and Canada, but are not common in the U.S. Particleboard is widely used in the U.S. and abroad. The industry is currently developing bonding materials and insecticides that are non-hazardous to humans. Magee will determine if changes made in the standard protocols are effective in testing these novel products. Magee is under the direction of Dr. C. Elizabeth Stokes, assistant professor in the Department of Sustainable Bioproducts.

JACOB JONES

HOMETOWN: *Humnoke, AR*

Jacob Jones is a junior majoring in wildlife, fisheries and aquaculture. He is studying the Gulf killifish, a hardy baitfish which moves easily between fresh and saltwater. For the killifish to be produced commercially, researchers have to address specific issues that are preventing the commercial culture of the species. These issues include developing protocols to establish enough spawning females to produce and care for the young, and establishing egg collection and incubation methods that can be implemented in commercial hatcheries. In addition to measuring individual female egg output, Jones will test different spawning substrate materials. Jones is under the direction of Dr. Peter Allen, associate professor in the Department of Wildlife, Fisheries, and Aquaculture.

AMBER OWEN

HOMETOWN: *Jackson, MS*

Amber Owen is a senior majoring in wildlife, fisheries and aquaculture. Owen is collecting a single season of plot-level avian species and vegetative data for the Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative, or GCPO LCC. The cooperative manages conservation efforts across 180 million acres. Owen's research will help fill information gaps identified in the Noxubee NWR conservation and management plans, as well as inform future revisions in the cooperative's science agenda. Owen is under the direction of Dr. Kristine Evans, assistant professor in the Geosystems Research Institute, or GRI; Toby Gray, GRI research associate; and Steve Reagan, refuge manager of the Sam D. Hamilton Noxubee National Wildlife Refuge.

SAMANTHA RUSHING

HOMETOWN: *Southhaven, MS*

Samantha Rushing is a senior majoring in wildlife, fisheries and aquaculture. Rushing is evaluating bat roost characteristics and senescence (process of deterioration with age) and bat use on the Sam D. Hamilton Noxubee National Wildlife Refuge. She is working with refuge employees and university scientists to learn how to identify bats in roosts and track bats that are tagged with radio-telemetry transmitters. She will gain the skills to manage and curate datasets and generate and evaluate hypotheses using that data. Rushing is under the direction of Dr. Scott Rush, assistant professor in the Department of Wildlife, Fisheries, and Aquaculture. Drs. Michael Colvin, assistant professor, and Christopher Ayers, instructor, in the Department of Wildlife, Fisheries, and Aquaculture, assist on the project as well.

RESEARCH PUBLICATIONS

Adams, H.P., **L.W. Burger**, S.K. Riffell. 2015. Edge effects on avian diversity and density of native grass conservation buffers. Open Ornithology Journal 8:1-9.

Abbott, B, **H.D. Alexander.** 2016. Biomass offsets little or none of permafrost carbon release from soils, streams, and wildfire: an expert assessment. Environmental Research Letters 11(3).

Akhtari, M., **A. Borazjani**, M. Arefkhani. 2015. Efficacy of lignocellulosics materials, zeolite and perlite for removal of cation and anions from sea and waste water. Wood Research 60(2):273-280.

Alexander, H.D., J. Moczygemba, K. Dick. 2015. Growth and survival of thornscrub forest seedlings in response to restoration strategies aimed at alleviating abiotic and biotic stressors. Journal of Arid Environments 124: 180-188.

Alexander, H.D., M.C. Mack. 2016. A canopy shift in interior Alaskan boreal forests: Consequences for above and belowground carbon and nitrogen pools during post-fire succession. Ecosystems 19(1): 98 -114.

Allen, P.J. 2015. Using physiology for fish conservation: Examples from primitive fishes. Journal of Fisheries Science and Technology 118-124.

Allen, P.J., D. Wise, M. Griffin, T. Greenway, L. Khoo, M. Jablonsky. 2015. Using 1-D and 2-D J-resolved 1H-NMR metabolomics to understand the effects of anemia in channel catfish (*Ictalurus punctatus*). Metabolomics 11:1131-1143.

Arthur, M., B. Blankenship, A. Schorgendorger, G. Carmean, **H.D. Alexander**. 2015. Stand structure and tree health following repeated prescribed fire in an Appalachian hardwood forest. Forest Ecology and Management 340: 46-61.

Avgar, T., J.A. Baker, G.S. Brown, J.S. Hagens, A.M. Kittle, E.E. Mallon, M.T. Mcgreer, A. Mosser, S.G. Newmaster, B.R. Patterson, D.E.B. Reid, A.R. Rodgers, J. Shuter, **G.M. Street**, I. Thompson, M.J. Turetsky, P.A. Wiebe, J.M. Fryxell. 2015. Space-use behavior of woodland caribou based on a cognitive movement model. Journal of Animal Ecology 84:1059-1070.

Baker, B.H., R. Kroger, J.P. Brooks, R.K. Smith, J.M. Prince Czarnecki. 2015. Investigation of denitrifying microbial communities within an agricultural drainage system fitted with low-grade weirs. Water Research 87:193-201.

Berner, L., **H.D. Alexander**, M. Loranty, P. Ganzlin, M.C. Mack, S. Goetz. 2015. Biomass allometry for alder, dwarf birch, and willow in boreal forest and tundra ecosystems of northeastern Siberia and northern Alaska. Forest Ecology and Management 337: 110-118.

Broderick, D., K. Frey, J. Rogan, **H.D. Alexander**, N.S. Zimov. 2015. Estimating upper soil horizon carbon stocks in a permafrost watershed of Northeast Siberia by integrating field measurements with Landsat-5 TM and Worldview-2 satellite data. GIScience and Remote Sensing 52(2): 131-157.

Chitwood, M.C., M.N. Peterson, H.D. Bondell, **M.A. Lashley**, R.D. Brown, C.S. DePerno. 2015. Perspectives of wildlife conservation professionals on intensive deer management. Wildlife Society Bulletin 39(4):751-756.

Chitwood, M.C., M. B. Swingen, **M.A. Lashley**, J.R. Flowers, M.B. Palamar, C.s. Apperson, C. Olfenbuttel, C.E. Moorman, C.S. DePerno. 2015. Parasitology and serology of free-ranging coyotes (*canis latrans*) in North Carolina, USA. Journal of Wildlife Diseases 51(3):664-669.

Chitwood, M.C., **M.A. Lashley**, J.C. Kilgo, C.E. Moorman, C.S. Deperno. 2015. White-tailed deer population dynamics and adult female survival in the presence of a novel predator. The Journal of Wildlife Management 79(2):211-219.

Christian, A., K. Knott, C.K. Vance, J.F. Falcone, G. Fahey, S.T. Willard, **A.J. Kouba**. 2015. Nutrient and mineral composition during shoot growth in seven species of bamboo consumed by giant panda. Journal Animal Physiology and Animal Nutrition 99(6):1172-1183.

Dahal, R.P., **J.E. Henderson**, **I.A. Munn**. 2015. Forest products industry size and economic multipliers in the US South. Forest Products Journal 65(7-8):372-380.

FWRC authors in bold

Davis, J., J. Straub, R.M. Kaminski, **G. Wang**. 2015. Simulations of wood duck recruitment from nest boxes in Mississippi. Journal of Wildlife Management 79: 907-916.

Deng, Y., **I.A. Munn**, K.H. Coble, H. Yao. 2015. Willingness-to-pay for potential standing timber insurance. Journal of Agriculture and Applied Economics 47(4):510-538.

Dick, K., **H.D. Alexander**, J. Moczygemba. 2016. Use of shelter tubes, grass-specific herbicide, and herbivore exclosures to reduce stressors and improve restoration of semi-arid thornscrub forests. Restoration Ecology.

Dolan, B., K. Fisher, **M. Colvin**, S. Benda, C. Danley, J.T. Peterson, M. Kent, C.B. Schreck. 2015. Diminished innate, but not adaptive, immune responses in migrating adult Chinook salmon, *Oncorhynchus tshawytscha*. The Journal of Immunology 194 (1 Supplement): 146.15.

Dolan, B., K. Fisher, **M. Colvin**, S. Benda, J.T. Peterson, M. Kent, C.B. Schreck. 2016. Innate and adaptive immune responses in migrating spring-run adult chinook salmon, *Oncorhynchus tshawytscha*. Fish & Shellfish Immunology 48:136-144.

Eseyin, A., **P.H. Steele**. 2015. An overview of the applications of furfural and its derivatives. International Journal of Advanced Chemistry 3(2):42-47.

Eseyin, A., **P.H. Steele**, C. Pittman. 2015. Current trends in the production and applications of torrefied wood/biomass - a review. BioResources 10(4):8812-8858.

Eseyin, A.E., **E.M. Hassan**, M.E. Emad. 2015. Comparative analyses of Nigerian and US corn stalks, using PY-GC/MS. International Journal of Advanced Chemistry 3:18-24.

Falster, D.S., R.A. Duursma, M.I. Ishihara, D.R. Barneche, R.G. FitzJohn, A. Varhammar, M. Aiba, M. Ando, N. Anten, M.J. Aspinwall, J.L. Baltzer, C. Baraloto, M. Battaglia, J.J. Battles, B. Bond-Lamberty, M. van Breugel, J. Camac, Y. Claveau, L. Coll, M. Dannoura, S. DelagrangeJ.-C. Domec, F. Fatemi, W. Feng, V. Gargaglione, Y. Goto, A. Hagihara, J.S. Hall, S. Hamilton, D. Harja, T. Hiura, R. Holdaway, L.S. Hutley, T. Ichie, E.J. Jokela, A. Kantola, J.W.G. Kelly, T. Kenzo, D. King, B.D. Kloeppel, T. Kohyama, A. Komiyama, J.-P. Laclau, C.H. Lusk, D.A. Maguire, G. le Maire, A. Mäkelä, L. Markesteijn, J. Marshall, K. McCulloh, I. Miyata, K. Mokany, S. Mori, R.W. Myster, M. Nagano, S.L. Naidu, Y. Nouvellon, A.P. O'Grady, K.L. O'Hara, T. Ohtsuka, N. Osada, O.O. Osunkoya, P.L. Peri, A.M. Petritan, L. Poorter, A. Portsmuth, C. Potvin, J. Ransijn, D. Reid, S.C. Ribeiro, **S.D. Roberts**, R. Rodríguez, A. Saldaña-Acosta, I. Santa-Regina, K. Sasa, N.G. Selaya, S.C. Sillett, F. Sterck, K. Takagi, T. Tange, H. Tanouchi, D. Tissue, T. Umehara, H. Utsugi, M.A. Vadeboncoeur, F. Valladares, P. Vanninen, J.R. Wang, E. Wenk, R. Williams, F. de Aquino Ximenes, A. Yamaba, T. Yamada, T. Yamakura, R.D. Yanai, R.A. York. 2015. BAAD: a Biomass And Allometry Database for woody plants. Ecology 96:1445.

Feaga, J.S., **F.J. Vilella**, R.M. Kaminski, **J. Davis**. 2015. Waterbird use of catfish ponds and Migratory Bird Habitat Initiative wetlands after the Deepwater Horizon oil spill. Waterbirds 38:269-281.

Fleming, J., **E.D. Dibble**. 2015. Ecological mechanisms of invasion success in aquatic macrophytes. Hydrobiologia 746:23-27.

Fleming, J., **E.D. Dibble**, J.K. Madsen, R. Wersal. 2015. Investigation of Darwin's naturalization hypothesis in invaded macrophyte communities. Biological Invasions 17:1519-1531.

Flinn, J.J., **S. Demarais**, **B.K. Strickland**, S.L. Webb, K. Gee, P.D. Jones. 2015. Estimating age and antler traits of photographed white-tailed deer. Journal of the Sourtheastern Association of Fish and Wildlife Agencies 2:135-143.

Gordon, J.S., A. Barton. 2015. Stakeholder attitudes towards reforestation and management of bottomland hardwood forests in the Mississippi Delta. Journal of Forestry 113(3):308-214.

Grala, R.K, **S.C. Grado**, **I.A. Munn**. 2016. Family forest owners' familiarity with conservation programs in Mississippi, USA. Small-scale Forestry 15(3):303-319.

Grebner, D.L., **R.K. Grala**, O. Joshi, G. Perez-Verdin. 2015. Physical and economic aspects to assessing woody biomass availability for bioenergy production and related supply constraints. In: Handbook of Bioenergy (pp. 299-321). Eds. Eskogilu, S. Rebennack, S., and P.M. Pardalos. Springer International Publishing, Switzerland 343 p.

Greene, R.E., **R.B. Iglay**, K.O. Evans, D. Miller, T. Wigley, S.K. Riffell. 2015. A meta-analysis of biodiversity responses to management of southeastern pine forests – opportunities for open pine conservation. Forest Ecology and Management 360:30-39.

Grodsky, S.M., **R.B. Iglay**, C.E. Sorenson, C.E. Moorman. 2015. Should invertebrates receive greater inclusion in wildlife research journals? Journal of Wildlife Management 79(4):529-536.

Gutzwiller, K.J., **E.D. Dibble**, J. Franklin. 2015. In memoriam: Samuel K. Riffell (1970-2014). Landscape Ecology 30:959-962.

Hassan, E.M., A. Hussein, **P.H. Steele**, E. El-Giar. 2016. Characterization of bio-oils from the fast pyrolysis of white oak and sweetgum. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects 38(1):43-50.

Hassan, E.M., E.M. El-Giar, **P.H. Steele**. 2016. Evaluation of the antioxidant activities of different bio-oils and their phenolic distilled fractions for wood preservation. International Biodeterioration & Biodegradation 110:121-128

Hassan, E.M., I. Elsayed, A. Eseyin. 2016. Production high yields of aromatic hydrocarbons through catalytic fast pyrolysis of torrefied wood and polystyrene. Fuel 174:317-324.

Henderson, J.E., **I.A. Munn**. 2016. Mississippi furniture industry and its importance to the state economy. Forest and Wildlife Research Center, Research Bulletin FO461, 24 pp.

Howell, P.P., **M. Colvin**, P. Sankovich, A. Hemmingsen. 2016. Life histories, demography, and distribution of bull trout from Mill Creek, a tributary of the Walla Walla River. Transactions of the American Fisheries Society 145 (1):173-194.

Hu, L., R.E. Tackett, O. Tor, **J. Zhang**. 2015. Analysis of sitting forces on stationary chairs for daily activities. Ergonomics 59(4):556-67.

Hussain, A., **I.A. Munn**, **R.K. Grala**. 2016. Economic impacts of productivity improvements in US forest products industries: A general equilibrium analysis. Forest Products Journal 66:66-76.

Iglay, R.B., D. Miller, **B.D. Leopold**, **L.W. Burger**. 2015. Soil N and C response to mid-rotation vegetation management in intensively managed pine stands. Soil Science 180:33-38.

Jiang, G., J. Qi, **G. Wang**, Q. Shi, Y. Darman, M. Hebblewhite, D.G. Miquelle, Z. Li, X. Zhang, J. Gu, Y. Chang, M. Zhang. 2015. New hope for the survival of the Amur leopard in China. Scientific Reports 5:15475.

Jones, B.M., M.V. Cove, **M.A. Lashley**, V.L. Jackson. 2016. Do coyotes influence occupancy of prey in urban forest fragments. Current Zoology 62(1): 1-6.

Jones, W. 2015. Natural Resource Enterprises: Enhancing landowner incomes and conservation in forests in the USA. Symposium Proceedings of Small-Scale and Community Forestry and the Changing Nature of Forest Landscapes – International Union of Forest Research Organizations.

Joshi, O., **D.L. Grebner**, **I.A. Munn**, **R.K. Grala**. 2015. Issues concerning landowner management plan adoption decisions: A recursive bivariate probit approach. International Journal of Forestry Research vol. 2015, Article ID 926303, 8 pages.

Joshi, O., **D.L. Grebner**, **J.E. Henderson**, S.R. Gruchy. 2015. Landowners, bioenergy, and extension strategies. Journal of Extension 53(2).

Joshi, O., **D.L. Grebner**, P. Khanal. 2015. Status of urban wood waste and their potential use for bioenergy in Mississippi. Resources, Conservation & Recycling 102(2015):20-26.

Karwan, D.F., **C. Siegert**, D.F. Levia, J. Pizzuto, J. Marquard, R. Aalto, A.K. Aufdenkampe. 2016. Beryllium-7 wet deposition variation with storm height, synoptic classification, and tree canopy state in the mid-Atlantic USA. Hydrological Processes 30:75-89.

Kittle, A.M., M. Anderson, T. Avgar, J.A. Baker, G.S. Brown, J. Hagens, E. Iwachewski, S. Moffatt, A. Mosser, B.R. Patterson, D.E.B. Reid, A.R. Rodgers, J. Shuter, **G.M. Street**, I.D. Thompson, L.M. Vander Vennen, J.M. Fryxell. 2015. Wolves adapt territory size, not pack size to local habitat quality. Journal of Animal Ecology 84:1177-1186.

Kushla, J.D., A.J. Londo. 2015. Chapter 3: Mississippi Soils. In Adam T. Rohnke and James L. Cummins (eds). Fish and Wildlife Management: A Handbook for Mississippi Landowners. University Press of Mississippi, Jackson. pp.34-47.

Kushla, J.D., **D.L. Grebner**. 2015. Chapter 2: Forest Management. In J.E. Henderson and R.C. Parker (eds.), Study guide for the Mississippi Board of Registration for Foresters Examination. Forest and Wildlife Research Center, Research Bulletin FO448, Mississippi State University, pp 19-32.

Kushla, J.D., **J.S. Gordon**, A.J. Londo. 2015. Whats in a name: Updating extension programs as part of a marketing strategy. Journal of the National Association of County Agriculture Agents 8(1).

Lancaster, J.D., **J. Davis**, R.M. Kaminski, A.D. Afton, E.J. Penny. 2015. Mallard use of managed public hunting area in Mississippi. Journal of the Sourtheastern Association of Fish and Wildlife Agencies 2:281-287.

Lashley, M.A., M.C. Chitwood, C. Harper, C.S. DePerno, C.E. Moorman. 2015. Variability if fire prescriptions to promote wildlife foods in the longleaf pine ecosystem. Fire Ecology 11(3):62-79.

Lashley, M.A., M.C. Chitwood, C.A. Harper, C.E. Moorman, C.S. DePerno. 2015. Poor soils and density-mediated body weight in deer: Forage quality or quantity? Wildlife Biology 21(4):213-219.

Lashley, M.A., M.C. Chitwood, R. Kays, C.A. Harper, C.S. DePerno, C.E. Moorman. 2015. Prescribed fire affects female white-tailed deer habitat use during summer lactation. Forest Ecology and Management 348:220-225.

Lei, J., B. Wylie, D. Nossov, B. Peterson, **H.D. Alexander**, M.C. Mack, J. Rover, M. Waldrop, J. McFarland, X. Chen, N. Pastick. 2015. Spatially explicit estimation of aboveground boreal forest biomass in the Yukon River Basin, Alaska. International Journal of Remote Sensing 35(4):939-953.

Li, G., B. Yin, X. Wan, W. Wei, **G. Wang**, C.J. Krebs, Z. Zhang. 2016. Successive sheep grazing reduces population density of Brandt's voles in steppe grassland by altering food resources: a large manipulative experiment. Oecologia 180(1): 149-159.

Lloyd, M.C., **J. Neal**. 2015. Young-of-year fish sampling gears in a tropical reservoir. Journal of the Sourtheastern Association of Fish and Wildlife Agencies 2:35-41.

Lochmann, S., C.M. Adelsberger, **J. Neal**. 2015. Movement of bigmouth sleeper, *Gobiomorus dormitor*, in the Río Cañas, Puerto Rico, revealed by radio telemetry, and a discussion of the species' amphidromous characterization. Gulf and Caribbean Research 26:1-8.

Luo, Y., V.K. Guda, **E.M. Hassan**, **P.H. Steele**, B. Mitchell, F. Yu. 2016. Hydrodeoxygenation of oxidized distilled bio-oil for the production of gasoline fuel type. Energy Conversion and Management 112:319-327.

Marty, J., **J. Davis**, **R.M. Kaminski**, M.G. Brasher, **G. Wang**. 2015. Waste rice and natural seed abundances in rice fields in Louisiana and Texas coastal prairies. Journal of the Sourtheastern Association of Fish and Wildlife Agencies 2:121-126.

McGreer, M., E.E. Mallon, L.M. Vander Vennen, P.A. Wiebe, J.A. Baker, G.S. Brown, T. Avgar, J. Hagens, A.M. Kittle, A. Mosser, **G.M. Street**, D.E.B. Reid, A.R. Rodgers, J. Shuter, I.D. Thompson, M.J. Turetsky, S.G. Newmaster, B.R. Patterson, J. M. Fryxell. 2015. Selection for forage and avoidance of risk by woodland caribou (*Rangifer tarandus caribou*) at coarse and local scales. Ecosphere 6(12):288.

Michel, E., **S. Demarais**, **B.K. Strickland**, **J.L. Belant**. 2015. Contrasting the effects of maternal and behavioral characteristics on fawn birth mass in white-tailed deer. PLoS ONE 10(8): e0136034.

Michel, E., **S. Demarais**, **B.K. Strickland**, **J.L. Belant**, J.J. Millspaugh. 2015. Quantifying dominance of adult female white-tailed deer in the presence of abundant food. Behaviour 153(1):49-68.

Moore, J.R., D.J. Cown, R.B. McKinley, **C.O. Sabatia**. 2015. Effect of stand density and seedlot on three wood properties of young radiata pine grown at a dry-land site in New Zealand. New Zealand Journal of Forestry Science 45:4.

Mun, S.P., Z. Cai, **J. Zhang**. 2015. Preparation of Fe-cored carbon nanomaterials from mountain pine beetle-killed pine wood. Materials Letters 142:45-48.

Neal, J. 2016. A case study on cooperative fisheries management and research: 25 years of university and agency collaboration in Puerto Rico. Journal of Fisheries Science and Technology. Special Issue: 36-42.

Neal, J., M. Prchalova. 2015. Threadfin shad Dorosoma petenense density and biomass of four Puerto Rico reservoirs – seasonal differences and comparison among temperate and tropical reservoirs. Acta Societatis Zoologicae Bohemicae 78:229-240.

Ohno, K., C. Clausen, F. Green, III, **S.V. Diehl**. 2015. Insights into the mechanism of copper-tolerance in Fibroporia radiculosa: The biosynthesis of oxalate. International Biodeterioration and Biodegradation 105:90-96.

Omar-Ali, A., C. Hohn, **P.J. Allen**, J.R. Rodriguez, L. Petrie-Hanson. 2015. Tissue PAH, blood cell and tissue changes following exposureto water accomated fractions of crude oil in alligator gar, *Atractosteus spatula*. Marine Environmental Research 108:33-44.

Omer, A.R., J.M. Prince Czarnecki, **B.H. Baker**, J.A. Hogue. 2016. Characterizing nitrogen outflow from pre-harvest rice field drain events. Agricultural Water Management 165:44-49.

Ouyang, Y., **J. Zhang**, T. Leininger, **B.R. Frey.** 2015. A STELLA model to estimate water and nitrogen dynamics in a short-rotation woody crop plantation. Journal of Environmental Quality 44:200-209.

Parapati, D., V. Guda, K. Penmetsa, S.K. Tanneru, B.K. Mitchell, **P.H. Steele**. 2015. Comparison of reduced and sulfided CoMo/γ-Al2O3 catalyst on hydroprocessing of pretreated bio-oil in a continuous packed-bed reactor. Journal of Environmental Progress & Sustainable Energy 34(4):1174-1179.

Pont, D., D.J. Cown, R.K. Brownlie, **C.O. Sabatia**, M.S. Watt. 2015. Calibrated tree counting on remotely sensed images of planted forests. International Journal of Remote Sensing 36:15, 3819-3836.

Poudel, J., **J.E. Henderson**, **I.A. Munn**. 2016. Economic contribution of hunting expenditures to the southern United States of America. International Journal of Environmental Studies 73(2):236-254.

Prince, A., M.C. Chitwood, **M.A. Lashley**, C.S. DePerno, C.E. Moorman. 2016. Resource selection by southeastern fox squirrels in a fire-maintained forest system. Journal of Mammalogy 97(2):631-638.

Ramee, S.W., C. Green, **P.J. Allen**. 2016. Effects of low salinities on osmoregulation, growth and survival of juvenile Gulf Killifish *Fundulus grandis*. North American Journal of Aquaculture 78(1):8-19.

Renninger, H.J., N. Carlo, K.L. Clark, K.V. Schafer. 2015. Resource use and efficiency, and stomatal responses to environmental drivers of oak and pine species in an Atlantic Coastal Plain forest. Frontiers in Plant Science 6:297.

Riffell, S.K., A.P. Monroe, J.A. Martin, K.O. Evans, **L.W. Burger**, M.D. Smith. 2015. Response of non-grassland avian guilds to adjacent herbaceous field buffers: Testing the configuration of targeted conservation practices in agricultural landscapes. Journal of Applied Ecology 52:303-309.

Sabatia, C.O., H.E. Burkhart. 2015. On the use of upper stem diameters to localize a segemented taper equation to new trees. Forest Science 61(3):411-423.

Shipes, J.C., **J. Davis**, E.P. Wiggers, E. Mills, R.M. Kaminski, M.R. Kneece. 2015. Annual habitat selection by mottled ducks in coastal South Carolina. Journal of the Sourtheastern Association of Fish and Wildlife Agencies 2:268-273.

Siegert, C., D.F. Levia, S.A. Hudson, A.L. Dowtin, F. Zhang, M.J. Mitchell. 2016. Small-scale topographic variability influences tree species distribution and canopy throughfall partitioning in a temperate deciduous forest. Forest Ecology and Management 359:109-117.

Skidmore, J.P., **T.G. Matney**, **E.B. Schultz**, Z. Fan. 2015. Initial estimation of forest inventory sizes for timber sales from easily observed stand attributes. Forest Science 61(1):123-127.

Soni, B., **E.M. Hassan**, B.S. Mahmoud. 2015. Chemical isolation and characterization of different cellulose nanofibers from cotton stalks. Carbohydrate Polymers 134:581-589.

Stevenson, K.T., **M.A. Lashley**, M.C. Chitwood, M.N. Peterson, C.E. Moorman. 2015. How emotion trumps logic in climate change risk perception: Exploring the affective heuristic among wildlife science students. Human Dimensions of Wildlife 20(6):501-513.

Stewart, H., B. Bosworth, L. Petrie-Hanson, J.A. Martin, **P.J. Allen**. 2015. Effects of chronic upper temperature regimes on growth of two geographic strains of channel and hybrid catfish. Aquaculture Research 46:1229-1236.

Street, G.M., J. Fieberg, A.R. Rodgers, M. Carstensen, R. Moen, S.A. Moore, S. Windels, J.D. Forester. 2016. Habitat functional response mitigates reduced foraging opportunity: implications for animal fitness and space use. Landscape Ecology.

Street, G.M., A.R. Rodgers, J.M. Fryxell. 2015. Mid-day temperature variation influences seasonal habitat selection by moose. Journal of Wildlife Management 79:505-512.

Street, G.M., J.M. Fryxell, A.R. Rodgers, T. Avgar. 2015. Characterizing demographic parameters across environmental gradients: a case study with Ontario moose (Alces alces). Ecosphere 6:138.

Street, G.M., L.M. Vander Vennen, T. Avgar, A. Mosser, M.L. Anderson, A.R. Rodgers, J.M. Fryxell. 2015. Habitat selection by moose (*Alces alces*) following recent disturbance with implications for management and conservation. Canadian Journal of Zoology 96:813-821.

Struebig, M.J., A. Wilting, D. Gaveau, E. Meijaard, R.J. Smith, **Borneo Mammal Consortium**, M. Fischer, K. Metcalfe, S. Kramer-Schadt. 2015. Targeted conservation safeguards a biodiversity hotspot from climate and land-cover change. Current Biology 25:372-378.

Sumners, J.A., **S. Demarais**, R.W. DeYoung, R. Honeycutt, A.P. Rooney, R.A. Gonzales, K. Gee. 2015. Variable breeding dates among populations of white-tailed deer in the southern United States: The legacy of restocking? Journal of Wildlife Management 79:1213-1225.

Sun, C. 2015. Empirical Research in Economics: Growing up with R. Pine Square LLC. 580 pp.

Sun, C. 2015. An investigation of China's import demand for wood pulp and wastepaper. Forest Policy and Economics 61(1):113-121.

Sun, C., J.C. Mingie, D. Petrolia, **W. Jones**. 2015. Economic impacts of nonresidential wildlife watching in the United States. Forest Science 61(1):46-54.

Sun, D., J. She, J. Gower, **C.E. Stokes**, G. Windham, R.E. Baird, T.D. Mlsna. 2015. Multivariate analysis of microbial volatile organic. International Journal in Agricultural Research Science 2(4):186-197.

Tanneru, S.K., **P.H. Steele**. 2015. Liquefaction of dried distiller's grains with solubles (DDGS) followed by hydroprocessing to produce liquid hydrocarbons. Fuel 150:512-518.

Tor, O., X. Yu, **J. Zhang**. 2015. Characteristics of torques for driving screws into wood-based composites. Wood and Fiber Science 47(1):2-16.

Ul Islam, Z., Z. Yu, **E.M. Hassan**, C. Dongdong, Z. Hongxun. 2015. Microbial conversion of pyrolytic products to biofuels: a novel and sustainable approach toward second-generation biofuels. Journal Industrial Microbiology and Biotechnology 42:1557–1579.

Wan, X., L. Liu, **G. Wang**, Y. Guo. 2016. Litter sizes of Daurian ground squirrels peak at intermediate body sizes. Mammalian Biology 81:61-65.

Wang, G. 2015. Effects of weather and landscape on horse West Nile Virus infection risks in Mississippi, USA. Geospatial Health 10(2):357.

Wang, X., O. Hagman, B. Sundqvist, S. Ormarsson, **H. Wan**, P. Niemz. 2015. Impact of cold temperatures on the shear strength of Norwayspruce joints glued with different adhesives. European Journal of Wood and Wood Products 73(2):225-233.

Webb, K.M., R. Schultz, **E.D. Dibble**. 2016. The influence of invasive aquatic plant removal on diets of bluegill in Minnesota lakes. Journal of Aquatic Plant Management 54: 37-45.

Williams, C.L., K.A. Dill-McFarland, M.W. Vandewege, D.L. Sparks, S.T. Willard, **A.J. Kouba**, G. Suen, A.E. Brown. 2016. Dietary shifts may trigger dysbiosis and mucous stools in giant pandas (*Ailuropoda melanoleuca*). Frontiers in Microbiology 7:661.

Willis, J.L., M.B. Walters, K.W. Gottschalk. 2015. Scarification and harvest gap size have interacting effects on young seedling establishment. Forest Ecology and Management 347, 237-246.

Winandy, J.E., **H.M. Barnes**, J.M. Hill. 2016. Effect of specimen width when evaluating laboratory-manufactured, fire retardant-treated strandboard. Wood and Fiber Science 48(1):2-12.

Xu, W., Z. Wu, **J. Zhang**. 2015. Compressive creep and recovery behaviors of seat cushions in upholstery furniture. Wood and Fiber Science 47(4):431-444.

Xu, W., Z. Wu, **J. Zhang**, W. Mao, Q. Huang. 2015. Preliminary study of effects of tip geometry and material type of circular saws on cutting surface quality of medium density fiberboard. Forest Products Journal 65(3/4):100-105.

Yan, L, **E.M. Hassan**, V. Guda, R. Wijayapala, **P.H. Steele**. 2016. Upgrading of syngas hydrotreated fractionated oxidized bio-oil to transportation grade hydrocarbons. Energy Conversion and Management 115:159-166.

Yan, Q., **J.T. Street**, F. Yu. 2015. Synthesis of carbon-encapsulated iron nanoparticles from wood derived sugars by hydrothermal carbonization (HTC) and their application to convert bio-syngas into liquid hydrocarbons. Biomass and Bioenergy 83:85-95.

Yan, Q., R. Li, H. Toghiani, Z. Cai, **J. Zhang**. 2015. Synthesis and characterization of carbon nanospheres obtained by hydrothermal carbonization of wood-derived and other saccharides. Trends in Renewable Energy 1(2): 119-128.

Yang, B.Z., **R. Shmulsky**, **R.D. Seale**. 2015. Development of laminated planks from southern pine lumber. European Journal of Wood and Wood Products 73(4):547-549.

Yang, B.Z., **R.D. Seale**, **R. Shmulsky**, J. Dahlen, X. Wang. 2015. Comparison of nondestructive testing methods for evlauating No. 2 southernyellow pine lumber: Part A, modulus of elasticity. Wood and Fiber Science 47(4):375-384.

Yu, X., O. Tor, F. Quin Jr., **R.D. Seale**, **J. Zhang**. 2015. Screwdriving torque in particleboards. Wood and Fiber Science 47(1): 17-30.

Yu, Y., C.Y. Ni, T. Yu, **H. Wan**. 2015. Optimization of mechanical properties of bamboo plywood. Wood and Fiber Science 47(1):109-119.

THESES & DISSERTATIONS

DISSERTATIONS

Conkling, T.J. 2015. Ecological determinants of avian productivity and aviation risk in semi-natural grasslands. Dissertation, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Faust, D.R. 2016. Optimizing carbon to nitrogen ratios to improve nitrogen removal in agricultural drainage ditches. Dissertation, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Hodges, B.N. 2016. Evaluation of soil and forage nutrient levels in habitats of gopher tortoises (Gopherus polyphemus) in south Mississippi. Dissertation, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Khanal, P.N. 2015. Carbon sequestration on nonindustrial private forest lands for climate change mitigation in the southern United States. Dissertation, Department of Forestry, Mississippi State University.

Luo, Y. 2015. Upgrading distilled bio-oil with syngas to liquid hydrocarbons. Dissertation, Department of Sustainable Bioproducts, Mississippi State University.

McConnell, M.D. 2015. Investigation the influence of density-dependent and density-independent factors on Northern Bobwhite population processes. Dissertation, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Mutandwa, E. 2015. Willingness of Mississippi's nonindustrial private forest landowners to manage forests for ecosystem services. Dissertation, Department of Forestry, Mississippi State University.

Ning, Z. 2015. Forest management under the uncertainties of carbon life cycle. Dissertation, Department of Forestry, Mississippi State University.

Sherif, R.S. 2015. Modeling susceptibility of forests to hurricane damage based on forest ownership, age, and type. Dissertation, Department of Forestry, Mississippi State University.

Skrobot III, F. 2016. Mycotoxin production on water damaged building materials. Dissertation, Department of Sustainable Bioproducts, Mississippi State University.

THESES

Alatawi, A.S. 2016. An inventory of terrestrial vertebrates in Aldesa Valley and estimating factors that affect avian species richness and occurrence. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Alexander, T. 2016. Investigation of a stress class system for no.2 2 by 8 southern yellow pine. Thesis, Department of Sustainable Bioproducts, Mississippi State University.

Bily, D.S. 2015. Recovery of Phytophthora ramorum and other Phytophthora spp. in a forest adjacent to a Mississippi ornamental plant nursery. Thesis, Department of Sustainable Bioproducts, Mississippi State University.

Bridges, L.E. 2016. The value of canopy cover: a hedonic pricing study in Lakeland, Tennessee. Thesis, Department of Forestry, Mississippi State University.

Catchot, T.R. 2015. Relationships between non-destructive tests, breaking strength, and stiffness of wood crossarms. Thesis, Department of Sustainable Bioproducts, Mississippi State University.

Culpepper III, C.M. 2015. Development of white crappie Pomoxis annularis reproduction methods in closed aquaculture systems. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

D'Errico, H.K. 2016. Tall, cross-laminated and massive timber buildings: a United States perspective. Thesis, Department of Sustainable Bioproducts, Mississippi State University.

Davis, P.B. 2015. Economic tradeoffs of managing pine plantations for timber production or wildlife habitat. Thesis, Department of Forestry, Mississippi State University.

Foggia, J.R. 2015. Implications of stand adjacency and edge for birds in a managed forest ecosystem. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Greene, E.J. 2015. Plant community and white-tailed deer nutritional carrying capacity response to intercropping switchgrass in loblolly pine plantations. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Kamps, J.T. 2015. Effects of prescribed fire management on northern bobwhite Colinus virginianus. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Katzenmeyer, J.B. 2016. Use of highway culverts, box bridges, and caves by winter-roosting bats in Mississippi. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Kneece, M.R. 2015. Breeding and brood rearing ecology of Mottled Ducks in the Ashepoo, Combahee, and Edisto Rivers Basin, South Carolina. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Marshall, C.D. 2016. Assessment of early successional arthropod and breeding bird response to intercropping switchgrass within an intensively managed loblolly pine forest. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Peterson, N.R. 2015. Subspecies composition, genetic variation and structure of Largemouth Bass in Puerto Rico reservoirs. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Reeves, J. 2016. Early growth and survival of Shumard oak and Nuttall oak planting stocks. Thesis, Department of Forestry, Mississippi State University.

Schnake, D.K. 2016. Underplanted shortleaf pine seedling survival and growth in the North Carolina Piedmont. Thesis, Department of Forestry, Mississippi State University.

Taylor, R.G. 2016. A comparison of mixed integer programming and a heuristic approach for harvest blocking in Australia. Thesis, Department of Forestry, Mississippi State University.

Tomlinson, W.E. 2016. Comparison of stands designated as old growth and those in managed hardwood areas at Tara Wildlife properties. Thesis, Department of Forestry, Mississippi State University.

Wheat, B.R. 2015. Effects of intercropping switchgrass in managed pine stands on plant communities and white-tailed deer forage production. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

BY THE NUMBERS

PEOPLE

94
Masters students

47
Doctoral students

67
Faculty

RESEARCH PROJECTS

211
Projects Active During FY16

137
Research Sponsors

157
Refereed Publications

$7.9M
Total Sponsored Research Funding

RESEARCH SPONSORS

Acoustigreen
Alabama Department of Conservation and Natural Resources
Alabama Division of Wildlife and Freshwater Fisheries
Albany Industires
American Bird Conservancy
American Furniture Manufacturing
Andersen Corporation
Anthony Hardwood Composites
Appalachian Regional Commission
ArborGen, LLC
Arch Wood Protection, Incorporated (a Lonza company)
Architectural Testing, Inc.
Audubon Mississippi/National Audubon Society
Axess Direct, Inc.
BASF Corporation
Bauhaus Furniture Group, LLC
Bayer Material Science, LLC
Colgate University
Cooperative Ecosystems Studies Units
Cox Industries
Cullman Cabinet and Supply Company
Delta F.A.R.M.
Dr. Wolman GmbH
Ducks Unlimited, Inc.
DuPont
Eco Thermal Control, LLC
EcoSynthetix, Inc.
EnSafe
Ethan Allen Global, Inc.
Flexsteel Industries
FP Innovations
Franklin Corporation
FuturaGene
Genics Incorporated
Georgia Research Institute
Gilman Speciality Products
Grain Processing Corporation

TOTAL FWRC FUNDING, FY16

$14.48M

44.57% STATE APPROPRIATIONS
05.93% FEDERAL APPROPRIATIONS
48.85% GRANTS AND CONTRACTS
00.65% SALES

Hauser Bears
Heritage Home Group, LLC
Hexion, Inc.
HHC USA Corporation
HM Richards Furniture
Homestretch Furniture
IKEA Industry
INEOS Melamines
Intertek Testing Services NA Ltd.
Inter-university Consortium of Political and Social Research
Iowa Department of Natural Resources
ISK Biosciences Corporation
Jasper Wood Products
Jeld-Wen Windows and Doors
Jernigan Copeland
Joint Fire Science Program
Kansas Department of Wildlife Parks & Tourism
Kentucky Department of Fish and Wildlife
KMG-Bernuth, Inc.
Kodi Group, LLC
Kop-Coat, Inc.
Koppers Holdings, Inc.
Koppers, Inc.
Lane Furniture
Lanxess Corporation
Leachco, Inc.
Lonza Wood Protection
Louisiana Department of Wildlife and Fisheries
Lybrand Consulting, LLC
Magna Exteriors and Interiors Corporation
Martco LLC
Michigan Department of Natural Resources
Mike Graves
Mississippi Department of Wildlife, Fisheries & Parks
Mississippi Institute for Forest Inventory
Mississippi Land, Water and Timber Resources Board
Mississippi Lignite Mining Company
Mississippi Wildlife, Fisheries and Parks Foundation
Missouri Department of Conservation
Monsanto Company
MSU Research and Technology Corporation
National Council for Air and Stream Improvement, Inc.
National Salvage & Service Corporation
Natural Resources Research Institute
North American Wholesale Lumber Association
Nemours Wildlife Foundation
New South Equipment Mats, LLC
Nisus Corporation
NTA, Inc.
Osmose Utilities Services, Inc.
Overseas Hardwoods Company
Penta Task Force
PFS Corporation
POET, LLC
PoleXpert LLC
Puerto Rico Department of Natural and Environmental Resource
Railway Tie Association
Renewalbe Sciences LLC
Rooms to Go
Roura Material Handling Supplier
Safari Club International Foundation
Sierra Pacific Industries
Sleepmade
South Dakota State University
Southern Ionics
Southern Motion
Specialty Bedding
Stairbuilders & Manufacturers Association
Stein Fibers, LTD
TACKL Technologies
Temple-Inland
Tennessee Valley Authority
Tennessee Wildlife Resources Foundation
Texas Parks & Wildlife Department
The Pennsylvania State University
Three Rivers Planning & Development District, Inc.
Tolko Industries
Trex Company
United Furniture Industries
United States Army Corps of Engineers
United States Economic Development Administration
United States Fish and Wildlife Service
United States Geological Survey
University of Florida
University of Houston - Institute for NanoEnergy
University of Southern Mississippi
University of Washington
USDA Agricultural Research Service
USDA Animal & Plant Health Inspection Service
USDA Forest Products Laboratory
USDA Forest Service
USDA National Institute of Food and Agriculture
USDA Natural Resources Conservation Service
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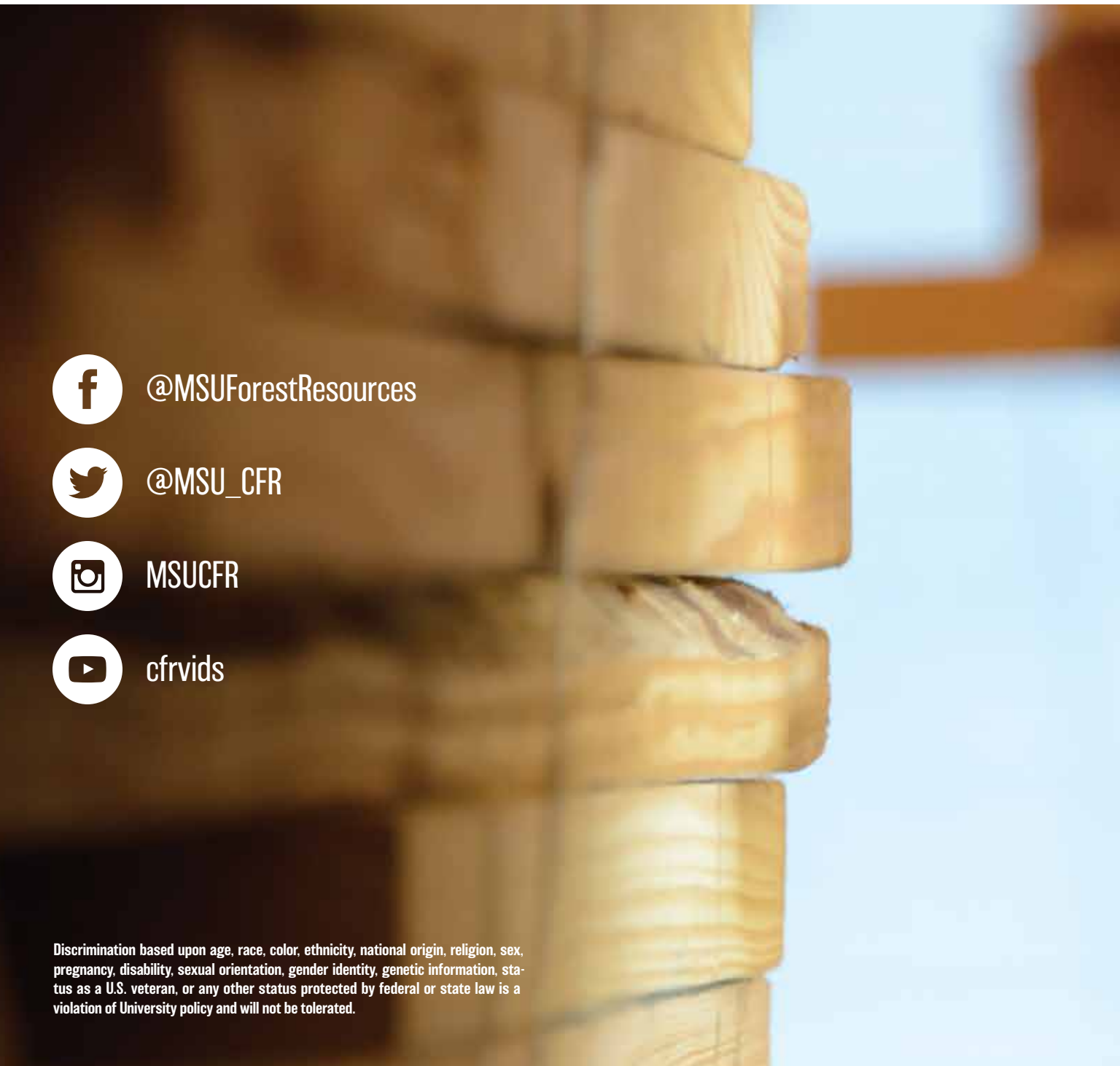

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