

**FOREST &
WILDLIFE
RESEARCH
CENTER
2018**
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.



ON THE COVER: Pine trees at the John W. Starr Memorial Forest. (Photo by Russ Houston)

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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, FWRC scientists and students work to promote, support, and enable the management, conservation, and utilization of natural resources in the state, region, and world.

Forestry and wildlife represent a significant sector of the state's economy. Natural resources support jobs, manufacturing, and funding for governmental agencies. FWRC research increases economic development and environmental protection for our state's natural resources. Our work is not possible without the generous help of our friends and supporters, appropriations through the state legislature, and private research sponsors. In fiscal year 2018, we had 69 sponsors provide support for 282 projects. Grants, contracts, and federal appropriations represented nearly 65 percent of our funding. That means that for every dollar we receive in state support, we generate \$1.47 in extramural support. We are proud of the return on investment we provide to the taxpayers of Mississippi. This level of funding would not be possible without the hard work, reputation, and relationships our scientists have built over the years with conservation partners in the U.S. and abroad.

Forestry and natural resources are an economic powerhouse for Mississippi. The forest and forest products 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 state's abundant resources and outstanding research conducted by FWRC scientists, along with our conservation partners.

And, our College of Forest Resources students, at both the undergraduate and graduate level, are fully immersed in the FWRC research program. We are training the next generation of leaders to think critically, work in teams, and solve problems related to natural resource management. We are dedicated to this mission and are excited about the future of natural resource management.

In this annual report, you will find a few of the projects that FWRC scientists are pursuing. From developing new uses for wood and byproducts to determining new management techniques to promote forest growth and ensure healthy wildlife habitat, scientists in the FWRC work tirelessly to sustain and enhance our natural resources.

As you read, 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 continued participation.

Thank you for your generous support!

A handwritten signature in black ink that reads "George Hopper". The signature is fluid and cursive, with a long horizontal stroke at the end.

George M. Hopper

Dean and Director

FORESTRY

The Department of Forestry conducts research to sustainably manage and utilize forest resources. This includes developing new practices to expand the growth of timber resources. As the second largest agricultural commodity in the state, the department works to increase awareness of the economic importance of natural resources. 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, alternative plantings, and wildlife habitat.

BEST OF BOTH WORLDS

Managing for timber production and wildlife habitat

FORESTRY IS A \$12.79 BILLION INDUSTRY IN MISSISSIPPI. Approximately 125,000 Mississippians own and manage more than 19.7 million acres of forestland across the state. Fishing, hunting, and wildlife watching also contribute to the economy of the Magnolia State, boasting a \$2.7 billion annual economic impact for Mississippi, with hunting alone contributing \$1.14 billion. That's why Forest and Wildlife Research Center researchers sought to learn more about how forest landowners manage for both timber production and wildlife habitat.

Dr. Ian Munn, associate dean and professor in the College of Forest Resources, and colleagues, Dr. James E. Henderson, Phillip Brock Davis, and Dr. Bronson K. Strickland, have done extensive research to answer the questions: What are the tradeoffs of managing for wildlife instead of timber? And can landowners manage for wildlife and still make a profit from their timber?

The team modeled different management scenarios in loblolly pine plantations. Some scenarios focused on wildlife habitat while others focused on timber production. The results indicated that landowners could manage for both timber production and wildlife habitat.

"The take home message for landowners is that timber management and wildlife management are not mutually exclusive. You can manage for timber and still provide good habitat for wildlife and make money," Munn said.

Munn, who is an avid hunter, was interested in landowners being able to manage land for both timber production as well as wildlife. The two and a half year study focused mainly on white-tailed deer and quail, but Munn believes the findings can apply to a variety of wildlife across the Southeast in similar forests under similar economic conditions.

In a course Munn teaches in the forestry department, his students



Pine timber creates good deer habitat while generating a good return for timber.

work with a broad spectrum of Mississippi landowners to develop timber management plans for their properties. As a result, Munn knows that the number of landowners who are strictly interested in just managing for timber is very small.

"Most landowners want a return for their timber, but they also want a place to go and hunt," he said. "You can maximize or certainly optimize a combination of both. You can generate good deer habitat while still making a good return on your timber."

Since the team knew that wildlife needed something different in their forest than the maximum production from a pine plantation, they set out to ask the questions: Can we provide what deer need in the forest? What quail need?

"The forest that is optimal for generating timber revenue is not the best habitat for various wildlife species," Munn said. "We're trying to maximize timber growth while the animals are looking for ideal habitat, which is an entirely different thing."

As an economist, Munn said that he is very well versed in what the economic returns are for timber, but he, as well as others in his field, did not have a good handle on the economic returns from managing timber for wildlife. By focusing more on wildlife, he found that land can be managed so that good deer and quail habitat is present throughout most of a pine plantation's lifetime.

"I think it was really encouraging to wildlife professionals to see that managing for wildlife and managing for timber were not mutually exclusive," Munn said. "Only a few people had begun looking at the big picture, and we were able to present the results in a simple way so that people could realize that it's very doable. It's still a good investment from a financial standpoint even though we're managing for wildlife in addition to timber." ❖

This research is funded by the Forest and Wildlife Research Center.

HARDWOODS ABLAZE

Research finds prescribed fire is good for upland oaks

WHEN WE THINK OF WILDFIRES, IMAGES OF acres of upland forests ablaze out West may come to mind, however, fires happen each year at home in Mississippi. In 2017, there were 2,318 wildfires which threatened 4,441 structures and burned 33,574 acres across the Magnolia State. But prescribed fires, which are intentionally set under relatively controlled conditions to achieve specific forest management objectives, also burned another 38,826 acres.

Dr. Heather Alexander, an assistant professor who studies forest and fire ecology, has researched how fire can either be used as a tool to manage forests or as a natural disturbance which alters forest ecosystems. She works across a variety of forest types from Mississippi all the way to Arctic Siberia. She began studying fires in the Daniel Boone National Forest in Kentucky as part of her dissertation.

Through that research, Alexander researched the effects of suppressing fires in the Appalachians.

“We suppressed fires for 80 plus years in this country and that has had a lot of ramifications,” she said. “It is one reason why we have horrible fires out West now because when systems don’t burn like they are supposed to, you can get large fuel loads accumulating to where all it takes is somebody throwing a cigarette out the window or abandoning a campfire under dry conditions to get big fires.”

Alexander said the ramifications aren’t as severe in the East

because these systems are wetter and decomposition rates are higher than those out West, leading to lower fuel loads.

“What we found was there wasn’t a huge impact on fuel loads when we burned in the East like people would expect,” she said. “That was probably the most interesting discovery is that the burns were such low intensity, and fuel loads were relatively low, so that the fires didn’t consume a lot of fuel. There are a lot of other good reasons to burn, but fuel reduction isn’t one of them in this case since the fires just don’t get that hot.”

What Alexander found in the Appalachian study applies to Mississippi forests.

“One thing that I’m doing here at MSU is looking at fire in hardwood forests in Mississippi,” she said. “For a long time people thought fire in a hardwood forest was a bad thing and that we should not burn our hardwood stands, but the ecology and research is teaching us that oak forests in the uplands depend on fire. They need fire to come through every eight to fifteen years to clear out the maples, winged elms, and birch, or the oak won’t be able to compete.”

“In terms of timber, oaks are a premier hardwood timber, so if you want an oak-dominated forest in the uplands, then you have to have periodic fire in the system or some level of harvesting to increase understory light, but generally speaking, it’s cheaper and easier to burn than to harvest, especially across large tracts of land,” she said.

“Fire is not bad. It is a very important disturbance in a forest system and not just with pine,” she added.

A few more reasons why prescribed fire is good for the ecosystem is that it manages composition from unwanted species, helps prepare the seedbed, gets rid of pests and pathogens, and in some instances, removes fuels such as dead wood and leaves from the forest floor.

Alexander’s work includes wildlife, fisheries and aquaculture assistant professor Dr. Marcus Lashley and forestry assistant professor Dr. Courtney Siegert. All the research in northern Mississippi is performed on one of the Bulldog forests named Spirit Hill Farm owned by Bob and Sheryl Bowen.

“It’s invaluable to have a Bulldog forest site available for research,” Alexander said. “We’ve been so lucky to have a university forest accessible to researchers and students which is what we have at Spirit Hill Farm.” ❖



Prescribed burn at Spirit Hill Farm. (Photo submitted)

This research is funded by the Forest and Wildlife Research Center.

BEETLE MANIA

Scientists eager to understand global pest

PINE BEETLES ARE A GLOBAL PROBLEM. WHILE Mississippi has experienced one of the worst southern pine beetle outbreaks in decades, areas such as Arizona and Honduras battle the pest as well. In the Western U.S., mountain pine beetles threaten the health of the forest and people alike, increasing the wildfire risk. In Honduras, where people depend on the forest for food, water, shelter, and their own livelihoods, a recent outbreak was so devastating the government mobilized the military and sent them into the forest with chainsaws to stop the spread of southern pine beetles. Researchers in the Forest and Wildlife Research Center (FWRC) and the Mississippi Agricultural and Forestry Experiment Station (MAFES), funded through a National Science Foundation EAGER grant, are digging deeper into the big picture impact of pine beetle outbreaks.

The team includes Dr. Courtney Siegert, assistant professor in forestry and FWRC researcher, and Dr. John Riggins, associate professor in entomology and MAFES scientist. They are studying the relationship between southern pine beetles, blue stain fungus, and subterranean termites. Riggins said the relationship is significant because pine beetles and termites are considered keystone species, which drive the structure and function of an ecosystem through their activities. The effects of these keystone species work in a linear fashion, with the actions of one species influencing the next and so on.

“Pine beetles are oftentimes the most important herbivore in a pine ecosystem. Their presence can change the structure and dynamic of a forest. Similarly, termites are the most important decomposer invertebrates that break down a system and by their presence and activity, they drive a forest’s carbon cycle dynamics,” Riggins said.

The team set up an initial test site of a simulated pine beetle attack on 37 forested acres of the John W. Starr Memorial Forest in Winston County, Mississippi in the summer of 2015 to investigate the pest’s impact on forest carbon storage and cycling. They determined that some termite species preferentially feed on wood from bark-beetle-killed trees. The scientists narrowed the preference down to the presence of certain fungi called bluestain that is carried by eight-legged mites that live on the pine beetles.

Researchers then sought to discover how widespread this relationship

was in climates outside of Mississippi. The study expanded to include sites at the MAFES McNeill Research Unit in Pearl River County, Mississippi; plus sites in Flagstaff, Arizona and Siguatepeque, Honduras.

Researchers collect data on felled trees that are naturally infested with pine beetles alongside felled healthy trees. They have caged individual wood sections in different ways so they can study the impact of above- and below-ground invertebrates, fungi, and microbes in isolated settings. At the end of year one, they measured woody decomposition, conducted DNA analysis on fungi, and visually inspected the presence of invertebrate on half of the felled logs. They also measured carbon and nitrogen in and around the tree, including the carbon that is being released into the atmosphere from the wood and the soils. They will repeat this with the other half of the logs at the end of year two.

Researchers hope the sites will show them the prevalence of the interspecies interaction across different climates between different subspecies of pine beetles and termites. They also hope to determine how each species contributes to the breakdown of wood.

Currently, models for forest decomposition don’t factor in the biological influences of invertebrates, fungi, or microbes.

“All of the current models use temperature and rainfall to predict the rate of turnover, which is critical in determining whether carbon is released back into the atmosphere or incorporated into the terrestrial carbon pool,” said Siegert, who is assessing how the biotic interactions influence the hydrology and biogeochemistry of each site. “We hope that by understanding the role decomposers play, we can improve our predictive

capability in determining how a forest stores and cycles carbon.”

Siegert said some of the findings have surprised the team.

“Fungi seem to break down the log faster when invertebrates like termites are excluded, which is something we didn’t expect,” Siegert said. “This raises new questions that will be important to investigate.”

Siegert also said nutrient exchanges are already happening.

“We see movement of carbon and nitrogen. For example, we see nitrogen increases in the bark and decreases in the soil. What that’s telling us is that decomposer communities are taking nitrogen reservoirs from the soil and putting it into the wood to help it decompose.” ❖



Scientists set up a simulated pine beetle attack on the John W. Starr Memorial Forest. (Photo submitted)

The project’s other co-investigators are Dr. Natalie Clay of Louisiana Tech University and Dr. Juliet Tang of the U.S. Forest Service Forest Products Lab. Collaborators include Dr. Oscar Leverón of Universidad Nacional de Ciencias Forestales and Dr. Richard Hofstetter of Northern Arizona University. Funding has been provided from the National Science Foundation with added financial support from a MAFES Special Research Initiative grant and both the College of Agriculture and Life Sciences’ and College of Forest Resources’ Undergraduate Research Scholars Programs. Additional funding is provided by the MSU Department of Biochemistry, Molecular Biology, Entomology, and Plant Pathology; the Institute for Genomics, Biocomputing and Biotechnology; the FWRC; and the Office of Research and Economic Development.

CHARTING A BETTER COURSE TO CONSERVATION

Understanding conservation preferences and interactions in the Southern U.S.

O PEN PINE STANDS, BOTTOMLAND HARDWOODS, and grasslands are iconic landscapes of the South. Which is why entities like the Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative exist. The GCPO LCC is one of the nation's 22 landscape conservation cooperatives focused on conserving and restoring the nation's ecological, historical, and culturally significant landscapes. Researchers in the Forest and Wildlife Research Center (FWRC) helped the cooperative further their mission by getting to the heart of what landowners think and feel about their own little stretch of these iconic spaces.

Dr. Robert Grala, FWRC researcher and forestry professor, partnered with colleagues from MSU, the Nicholas Institute for Environmental Policy Solutions at Duke University, and the Center for Environmental and Resource Economic Policy at North Carolina State University to better understand conservation preferences and interactions among landowners and land managers in the Southern U.S.

"The cooperative wanted to know the best way to connect with and encourage landowners to participate in conservation activities," Grala said. "They were also curious what tools landowners might need to effectively implement conservation efforts."

In the first study, researchers sent surveys to 6,000 landowners across three habitats: open pine stands, bottomland hardwoods, and grasslands.

"In this study, we sought to identify attitudes towards and value of landowner conservation activities," Grala said.

Of the 33 percent who responded, researchers determined that

landowners owned land for several reasons, some to make a profit and others to simply enjoy the space. Personal recreation, healthy soils, clean water, wildlife habitat, and appealing visual appearance were high priorities for landowners and oftentimes a contributing reason for ownership. It was also determined that, depending on habitat, landowners would be willing to participate in conservation efforts for incentives ranging from \$128 to \$166 per acre per year.

In the next study, researchers steered by the team at Duke University developed maps to determine possible demand for ecosystem services in the region. The team mapped nine ecosystem services: food provision, timber production, pollination, biodiversity, hunting, birding, carbon sequestration, water filtration, and infiltration capacity. The team evaluated demand for these ecosystem services, identified areas primed for restoration, and estimated where additional ecosystem services could be enhanced in the future.

In the third study, researchers used special software to identify communication trends between landowners and agencies focused on conservation. They found that landowners reached out to National Resources Conservation Service and university extension services the most. The programs most utilized with the highest level of satisfaction were the Conservation Reserve Program, Environmental Quality Incentives Program, and the Conservation Stewardship Program, all through NRCS.

The researchers identified a gap in perception between the agencies and the landowners. While agencies thought they were effective in reaching out to area landowners, 20 percent of landowners reported never reaching out to any agency for technical or financial assistance on implementing conservation efforts.

"We found a significant number of landowners weren't calling on those organizations frequently or almost at all. Based on that, we can tell there is a gap and that landowners aren't utilizing all available resources," Grala said.

The team built a social network map to illustrate how agencies can better help landowners and each other.

"We wanted to see where contacts did take place so we could determine the organizations most successful for the dissemination of information to landowners on the ground as well as among other organizations," Grala explained. "We determined that NRCS, university extension service, state wildlife agencies, and state forestry commissions were all well positioned to be boots-on-the-ground resources for helping landowners implement conservation efforts."

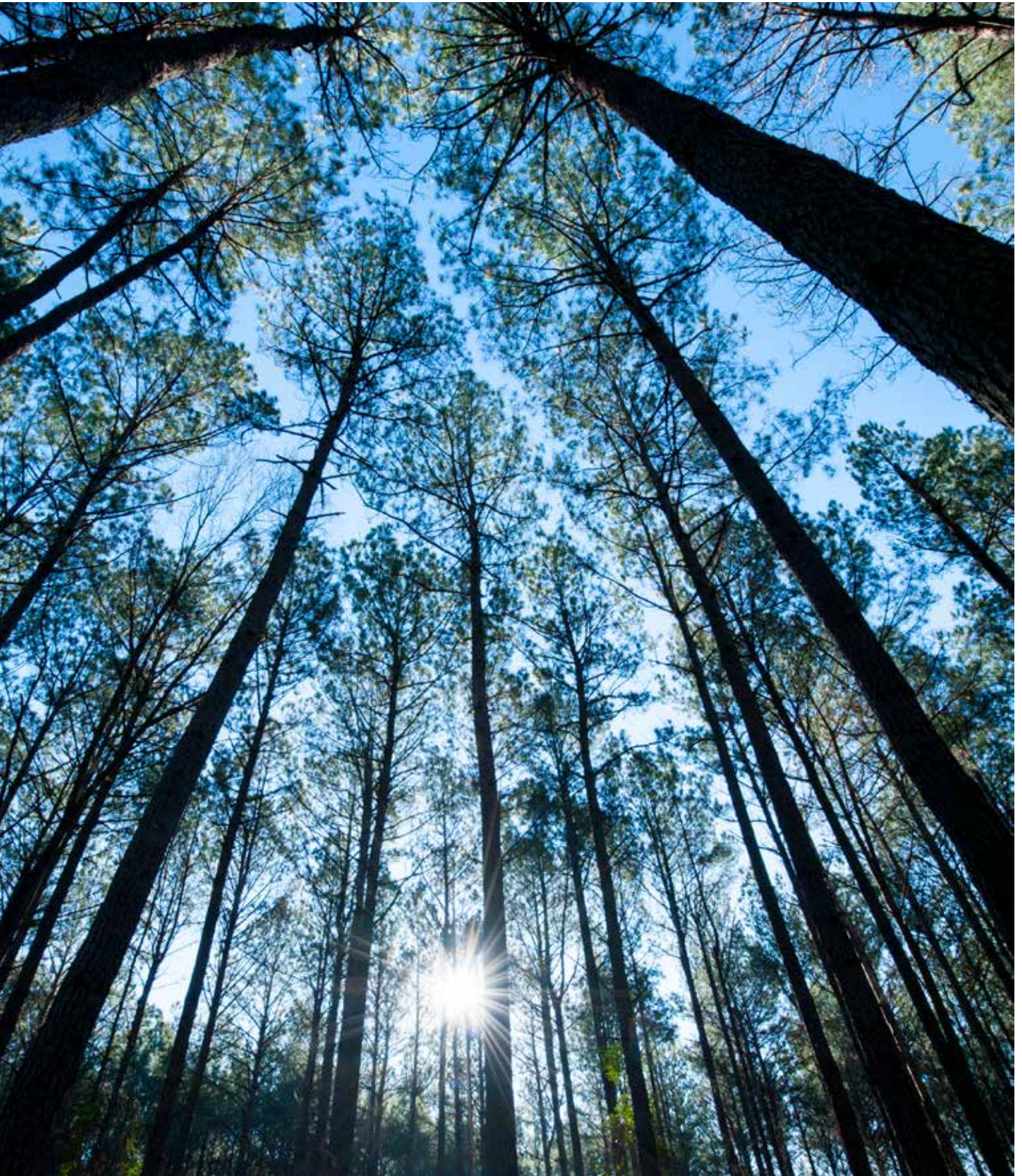
Grala said the most exciting aspect of the work is its practical component.

"The end game is practical application that will hopefully lead to increased participation in conservation programs while helping those programs become more effective," Grala said. "From my perspective that is very important because these programs face limited budgets so this information should help land managers better target landowners primed for conservation. We now know what these landowners need and can help them make the best management decisions." ❖

This research is funded by the U.S. Fish and Wildlife Service.



Personal recreation, healthy soils, clean water, wildlife habitat, and appealing visual appearance were high priorities for landowners and oftentimes a contributing reason for ownership. *(Photo by Russ Houston)*



Graduate Student Profile:

Anusha Shrestha

HOMETOWN: Kathmandu, Nepal

REDUCING THE LOAD

Understanding Mississippi forest landowners fuel reduction treatments

WHILE ANUSHA SHRESTHA GREW UP IN THE bustling city of Kathmandu, her father, who is a forester, inspired her to pursue a career in the great outdoors.

“My father had an amazing influence on me. Growing up seeing him in this industry and traveling all over the country got me interested,” the MSU doctoral student said. “You can visit so many places in this profession.”

After graduating with her bachelor’s in forestry from Tribhuvan University, Shrestha worked in Nepal as a field officer collecting data.

“As a field officer I had the opportunity to visit many places outside of the city. It was really beautiful,” she said.

While 44.5 percent of Nepal is covered in forests, Mississippi’s forests make up over 60 percent of the state’s landscape. After earning a master’s in forestry from the University of Arkansas at Monticello, Shrestha came to MSU to study wildfires in the Magnolia State, specifically assessing landowner perception on fuel reduction treatments such as prescribed burns.

Shrestha is in the process of analyzing survey data from 2,000 randomly selected non-industrial private forest landowners to determine if they use fuel reduction treatments and the type and frequency of treatments they employ. She also sought to determine their likelihood of fuel reduction treatment implementation within the next five years. Finally, she hopes to determine how much landowners are willing to pay for fuel reduction treatments.

“Thus far, I’ve found that more than half of the landowners surveyed haven’t implemented any fuel reduction treatment on their land. Of those that do implement some kind of treatment, most choose prescribed burns,” she said. “Another interesting result is if a landowner’s neighbor has implemented a fuel reduction



treatment, they are less likely to do the same on their own land.”

She said that perceived risk also influences a landowner’s decision of implementing a safeguard. She hopes to explore spatial variables to compare perceived risk with actual risk.

Dr. Robert Grala, forestry professor, serves as Shrestha’s major advisor.

“Anusha is a stellar student,” Grala said. “She’s committed, productive, reliable, and autonomous with excellent quantitative skills.”

Grala pointed out Anusha has given seven poster presentations and five oral presentations in her two years at MSU and she has received several awards.

“This year she won first place in the poster presentation at the International Society of Forest Resource Economics while last year she placed second in the same competition,” Grala said. “She also received the David M. Moehring Memorial Graduate Student Award in the College of Forest Resources.” ❖

The project was funded by Joint Fire Science Program.

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WILDLIFE, FISHERIES & AQUACULTURE

The Department of Wildlife, Fisheries and Aquaculture develops and conducts research on 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. The department is the research arm for the Mississippi Department of Wildlife, Fisheries and Parks and works with a variety of governmental and non-governmental agencies to manage wildlife populations and habitat.

LEGACY OF THE LAKES

How depth defines lakes in the Delta

THE HUNDREDS OF FLOODPLAIN LAKES THAT DOT the landscape of the Mississippi Alluvial Plain between Cairo, Illinois and Baton Rouge, Louisiana tell a story that spans the ages. These lakes were created by the meandering of prehistoric river systems, the Mississippi River, and other contemporary rivers that flow through the valley to join the Mississippi River. While rich in legacy, lakes also serve as a water source for Delta farmers. Forest and Wildlife Research Center scientists are helping to strike the delicate balance between industry and environment, providing insight that helps give farmers the water they need while still protecting the legacy of the lakes.

The Mississippi River Valley Alluvial Aquifer level loses more than 300,000 acre feet per year. Increasingly, Delta farmers turn to lakes as a source for irrigation. Those lakes have a tipping point, it seems, which occurs when water withdrawals negatively impact aquatic health. For several years, the Mississippi Department of Environmental Quality has sought to determine and refine best practices for using oxbow lakes as irrigation resources.

Ten years ago, Dr. Steve Miranda, assistant unit leader of the U.S. Geological Survey Cooperative Research Unit and FWRC adjunct professor, began studying biotic integrity of oxbow lakes across the Mississippi Alluvial Valley as part of a project with the U.S. Army Corps of Engineers.

“The agency does a lot of work in the Delta maintaining stream flow and channelization. Maintaining biotic integrity of the lakes is central to their work,” Miranda said.

Miranda’s team measured the biotic integrity of approximately 60 lakes in the Mississippi Alluvial Valley. In collecting that dataset, they were able to answer a question the Mississippi Department of Environmental Quality had been trying to answer on best practices in irrigation.

“In our study, we found one simple variable that dictates so much of what is going on in the lake—depth. If you tell me how deep an oxbow lake is, I can tell you the likely fish assemblage and physical and chemical characteristics of the body of water,” Miranda said.

“By better understanding the relationship between depths and environmental and biological conditions, we can identify how deep the lake needs to be to maintain the integrity of its biological and environmental characteristics.”

The team measured environmental factors in each lake including nitrogen, phosphorus, chlorophyll, turbidity, clarity, and sedimentation. They also measured biological factors such as the species richness which accounts for the number of species in any given lake, and the species diversity which accounts for the number of species as well as the allocation of individuals among species.

Miranda found lake conditions changed with depth, but both environmental and biological conditions changed much quicker in lakes shallower than two meters, or approximately six and a half feet.

“We evaluated all of the variables and expected things to gradually change including species composition, phytoplankton, and turbidity as the lakes went from deep to shallow. We were looking for a point where change accelerated. We have several graphs that indicate a fast shift in environmental and biological composition happens around two meters. That was the depth the Mississippi Department of Environmental Quality sought to determine,” Miranda said.

The team has hypothesized that in lakes shallower than two meters, sediment respiration, excessive turbidity, and seesaw daily temperatures and oxygen cause the observed tipping point.

“The next step is to test this hypothesis to figure out what exactly is causing this shift at two meters. If you know what causes it, you can come up with solutions to address it, which may allow you to draw more water. Now, however, we recommend that we don’t draw water from lakes shallower than two meters,” Miranda said. ❖

Dr. Austin Omer formerly with the Department of Wildlife, Fisheries, and Aquaculture and Dr. Jack Killgore with the U.S. Army Corps of Engineers were co-investigators on the research, which was published in the journal of Agriculture, Ecosystems and Environment. Additionally, several MSU graduate students contributed to the work. The project was funded by the Vicksburg District of the Army Corps of Engineers, the MSU Forest and Wildlife Research Center, and the U.S. Geological Survey.



Oxbow lakes are historically and biologically significant. (Photo courtesy of the USGS Mississippi Cooperative Research Unit)

PEST OR GUEST

Scientists study the relationship between songbirds and deer

THE EASTERN PHOEBE IS A SMALL, plump songbird with a big appetite for insects. Weighing in at less than one ounce, the bird has developed a relationship with white-tailed deer, using the game species as a buffet table of sorts.

Don Chance, a wildlife, fisheries and aquaculture graduate student, first noticed the connection between phoebe and deer while reviewing game camera video footage from the Andrews Forestry and Wildlife Laboratory in Oktibbeha County. A unit of the Bulldog Forest, the property is being used by Forest and Wildlife Research Center scientists to examine the effects of forest management practices on wildlife, among other studies.

Eighty-one cameras are set-up in the forest to survey wildlife interactions with each other and the environment. And while it is not uncommon for birds to flock around deer, the young scientist thought it unusual for the deer to allow the bird to perch on its back.

The question led to a research project to determine if the bird is a welcomed guest or an unsolicited visitor.

Drs. Garrett Street and Marcus Lashley; both wildlife, fisheries and aquaculture scientists; along with graduate students, used the camera surveys to observe interactions between the bird and deer. In particular, scientists hoped to determine if the interaction only benefitted the bird or if it provided mutual benefits for the two animals.

“In literature, scientists have defined the relationship as mutualistic, benefiting both the bird and deer,” Street said. “But this is based on the fact that deer may avoid grooming when the bird is present. What we want to know is if there is a benefit to the cleaning that would reduce stress on the deer from decreased parasite loads or disease transmission.”

The most frequent insects observed on deer are ticks, lice, biting flies and keds—also known as deer flies.

The video revealed deer-phoebe interactions at three camera locations. At one location, a phoebe followed a deer, catching insects stirred by the animal’s movement, and then perched on a shrub adjacent to the large game. Another clip showed a phoebe perched on the back of a deer. At a third location, a bird was hovering next



A phoebe rests on the back of a white-tailed deer. (Photo by San Malcolm)

to the deer, preening parasites directly from the shoulder of a deer.

“Phoebe were using deer to find food on the animal or by indirectly catching flying insects flushed by deer,” Street said. “We were not able to observe the deer grooming itself. It appeared that the deer was quite content allowing the bird to snack from the insects that had hitched a ride.”

However, the team suspects the relationship mostly benefits the birds, Street added.

The phenomenon gave birth to more questions.

Ticks are a problem for wildlife and humans because of their ability to transmit diseases. Lashley and students hope to determine the effects of forest management practices on tick populations.

“We know the relationship between the phoebe and deer is somewhat beneficial to both parties. The phoebe removing the ticks from the deer is decreasing risk of disease and subsequent transmission to humans,” Lashley said. “Understanding how forest management practices affects wildlife and tick populations could be beneficial to landowners who also have to deal with the flesh-burrowing insect.”

Ultimately, the research will help landowners understand the benefits of different forest management practices. It will also contribute to our understanding of wildlife interactions.

“It is interesting that we still find new, undocumented interactions amongst wildlife in nearby forests,” Lashley added. ❖

In addition to Chance, graduate students Carolina Baruzzi and Johanna McCollum contributed to the study. The study was funded by the MSU Forest and Wildlife Research Center.

MIGRATORY BIRDS FIND A TEMPORARY HOME

Waterbird communities and seed biomass in the Mississippi Alluvial Valley

ON THE HEELS OF AN ENVIRONMENTAL DISASTER, Dr. J. Brian Davis, associate professor and James C. Kennedy Endowed Chair in Waterfowl and Wetland Conservation, and colleagues found a bright spot amongst the devastation from the Deepwater Horizon oil spill in 2010.

In response to the oil spill, the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) created the Migratory Bird Habitat Initiative (MBHI) to provide inland wetlands for migratory and resident waterbirds. NRCS commissioned the MSU Forest and Wildlife Research Center to conduct a scientific evaluation of the initiative.

Davis, along with colleagues Dr. Richard Kaminski, Dr. Elizabeth Webb, and graduate students Jessica Tapp and Matthew Weegman, spearheaded the study of habitats enrolled in MBHI. Together they evaluated which waterbird species used the habitats provided and how much food was available for the birds.

“My predecessor, Dr. Richard Kaminski, and I and four other professors or agency colleagues had five graduate students between us

that worked on this, and one of our fellow colleagues in Missouri, Elizabeth Webb, had a couple of students,” Davis said. “So we had a mixture of students and four or five big studies besides this one which spanned over about four years.”

The area that this particular study covers was the Mississippi Alluvial Valley, which historically has been an important flyway for migratory birds, and includes Missouri, Arkansas, Mississippi, and Louisiana.

The project compares waterbird response to those areas that were aggressively managed and those that were not. Most of these were on private lands, but they also selected wildlife refuges and state conservation areas in Missouri.

“Our objective was to look at several types of waterbirds such as waterfowl, cormorants, egrets, herons, and other birds that use a little deeper water like grebes—a freshwater diving bird. The other ones that are really important and typically have habitat limitation in the fall are little shorebirds such as western sandpipers or yellowlegs. Those birds prefer mud-flat or really shallow water where they can feed on aquatic insects,” Davis said.

Landowners agreed to manage habitats for one to three years, providing critical feeding and shelter areas for waterbirds in shallow wetlands. The management involved mowing and disking vegetation, applying herbicides to control unwanted vegetation, and flooding certain areas to create shallow wetlands. Flooded rice fields, for instance, proved to be a haven for migrating and wintering birds during the initiative.

“Another key to this is the intensity of the vegetation and water management because there are obviously all sorts of vegetation out in the fields, but some of those are really beneficial to certain waterbirds while others aren’t.” Davis explained, “Typically the more intensive the management of wetlands with the proper use of water management, leads to greater seed production and more seed heads means more seed for the birds.”

After 17 surveys which identified 17,097 waterbirds, scientists found that there were nearly three times more dabbling ducks and waterbirds collectively on managed wetlands compared to reference wetlands, or those not aggressively managed. They also collected a sample of seeds, invertebrates, and bugs, which Davis said were fairly robust across sites despite not always being well managed. This showed the team the richness and resilience of the seedbanks.

Davis expressed that he is proud to be a part of a team tasked with evaluating an initiative that potentially affected so many birds.

“I’m just really grateful,” Davis said. “This project has probably been personally my most interesting and motivating projects just because of the scope of it and all of the people involved.” ❖

This research was funded by NRCS through the Forest and Wildlife Research Center at MSU and the Missouri Cooperative Fish and Wildlife Research Unit at the University of Missouri.



Shorebirds prefer mud-flat or really shallow water where they can feed. (Photo submitted)

A QUILL IN THE CAP FOR QUAIL MANAGEMENT

Supplemental feeding changes the quail population paradigm

A CENTURY AGO, THE BOBWHITE QUAIL, NAMED for its distinctive whistle, was common throughout the Southeast. In 1966, however, scientists began tracking a drastic population drop. Over the next fifty years, the species declined by 85 percent. Forest and Wildlife Research Center scientists are doing their part in restoration efforts of this granivore, whose storied legacy is steeped in tradition.

Not only was the bobwhite's song once ubiquitous across southern farmland and forests, large quail plantations, which intensively managed bobwhite quail as a game bird, began cropping up in the early 1900s. While large numbers of birds no longer grace working agricultural and forest landscapes, these historic plantations are the last strong hold of resilient populations in the Southeast and essential to restoration efforts today.

Dr. Wes Burger, FWRC associate director, partnered with Dr. Bill Palmer, director of research at Tall Timbers Research Station, in an effort to help land managers produce and maintain high populations on these conservation lands. The study, conducted in a pine and grass ecosystem known as the "Redhills" of northern Florida and southern Georgia, sought to determine how food availability influences the way quail move and forage.

"Throughout the South, quail populations declined because the plant communities they depend on are no longer part of working agricultural and forest landscapes," Burger said. "In the past, quail populations were an accidental byproduct of our agricultural and forest land management practices. In modern landscapes, quail populations can only be restored and maintained through intentional management that creates those communities."

He explained that bobwhite quail need three habitats to thrive: annual weed communities, which provide brood habitat and seeds the quail forage on; perennial native grasses for nesting habitat; and shrubby cover up to six feet to protect from weather and predators.

"If you think about the successional changes over 50 years from bare soil to mature forest, these plant communities thrive in a forest's first seven years or so, although these same components can occur in the ground cover of a mature forest if it has an open canopy," Burger said.

He explained that while the forests and agricultural landscapes of the early twentieth century offered these plant communities in abundance, the landscape is very different today.

"In fire-dependent forest systems of the Southeast, constant disturbance set back forest succession. Now, we exclude natural fire in an industrial forest model characterized by high stocking rates and dense canopies that shade out those plant communities," Burger said. "Similarly, agricultural landscapes were ideal for quail before native grasses like little bluestem and broomsedge were replaced with improved forages such as Bermudagrass and fescue and herbicides were broadly used to control weeds in row crops. Field expansion through elimination of non-crop natural communities such as fencerows and riparian areas further diminished habitat for bobwhite in farmlands."

However, populations persist and even thrive where land management practices create and maintain those essential habitats. Increasingly, land managers are adopting practices designed to give bobwhite every opportunity to thrive. One practice common on intensively managed properties is spreading of high energy supplemental feed. Supplemental feeding provides researchers an opportunity to not only evaluate the potential benefits of this practice, but to also ask fundamental ecological questions about how food availability affects resource selection, space use, movements, and individual fitness. That's why researchers sought to measure the persistence and availability of supplemental feed over time. They spread two rates of grain sorghum evenly along feeding trails across 10 percent of the landscape. Feed trails were distributed so that bobwhite in every portion of the landscape had access to an abundant and high energy food source. The first rate was equivalent to two bushels of sorghum per acre, per year while the second equaled a half a bushel per acre, per year. The team compared both levels against the control of natural background food available in the environment, evaluating food abundance every three days and replenishing feed every 15 days.

Bobwhite, and seemingly every other granivore in the landscape, readily consumed the high energy food. The two bushel treatment produced 100 seeds per meter square on day one declining to 20-25 seeds in the same area by day 14. The half bushel treatment started with 22 seeds over the same area and 15 days later declined to zero.

While food abundance didn't affect movement rate or home range size, it did



affect the amount of time birds spent foraging. In high density food situations, birds spent 10 percent of their time foraging compared to 20 percent when food was scarce. Resource availability also influenced the birds' space use within their home range, with birds in food-rich environments foraging in more concentrated locations than birds in low food density situations.

At high density, grain sorghum made up a high proportion of the birds' diet. At low density, sorghum was a minor component of the diet. Experimental manipulation of food availability allowed researchers to estimate the birds' "giving up density," which indicates when an animal will stop foraging for a given food no longer available in abundance.

Burger said the giving up density, which is about 24 seeds per meter square, when converted to a caloric value is also an indirect measure of food availability across the landscape.

"Foraging animals move from patch to patch sampling but when they find a food-rich patch they spend more time there. Theory predicts that they should forage in that patch until its availability

is lower than the average food availability in other patches," Burger explained. "The rationale is that if you left that patch to find another you'd have a 50/50 chance of finding a more food-rich patch."

Burger also pointed out the practical implication of the research. "We learned that supplemental feeding does affect quail behavior and foraging efficiency. In some situations supplemental feeding has also been shown to increase survival or reproductive success. In particular, supplemental feeding prior to the nesting season seems to bring birds into breeding condition earlier and result in greater recruitment," Burger said. "Land managers, if they intend to feed, just need to be strategic and feed at a density that approximates 100 seeds per square meter every 14 to 15 days because after that the residual food left in that environment will fall below the bird's giving up density." ❖

Ryan Miller, an MSU wildlife, fisheries, and aquaculture master's student who graduated in 2011, conducted the field research, which was funded by Tall Timbers Research Station and the Forest and Wildlife Research Center.



Bobwhite quail have declined by 85 percent over the last 50 years. FWRC and Tall Timbers scientists are working to reverse that trend. (Photo submitted)

Graduate Student Profile:

Bradley Richardson

HOMETOWN: Cobden, Illinois

THE CATCH OF THE DAY

Researchers study Delta catfish disease

WHAT IS BETTER THAN A CATFISH FRY with friends and family? Mississippi, being the number one state in catfish production, most likely provides the catfish on your plate.

“Mississippi accounts for 50 to 60 percent of all farm-raised catfish in the U.S. The four state region of Mississippi, Louisiana, Arkansas, and Alabama produce 95 percent of all farm-raised catfish. So, if you eat catfish, you most likely consume a Southern grown delicacy,” said Bradley Richardson, wildlife, fisheries and aquaculture doctoral student mentored by Drs. Michael Colvin and David Wise.

Richardson has been working with the catfish industry in the Mississippi Delta since the summer of 2016, concentrating on aquatic diseases. He and other researchers are working with farmers to try and combat these diseases, especially one particular bacterial disease that has sprung up in the last few years. The name of the bacterium is *Aeromonas hydrophila*, which is very common and exists in almost every water source in the world, but there are pathogenic forms of the disease that can be especially potent.

“The key thing we’re evaluating is what triggers these outbreaks,” he said. “The outbreaks appear to be pretty random, so we are trying to figure out what the drivers are and what is really happening in these ponds. On the front end, we want to try to reduce these occurrences by figuring out what’s causing this problem and how we can prevent it. On the back end, once these outbreaks do occur, how can we minimize loss without the use of antibiotics?”

The scientists are working at both ends of the spectrum, which can be challenging. In lieu of antibiotics, feed additives from plant extracts can be used to bolster the immune system of the fish. They are also working on a vaccine which could reduce the number of cases in general, but this is difficult as *Aeromonas* mutates easily.

Currently, they are working with two strains of the disease, while trying to determine how many strains exist. They are also developing support tools to help provide farmers with an early detection



Bradley Richardson stands in the Thompson Hall Courtyard at MSU. (Photo by David Ammon)

system to help them decide what ponds may have *Aeromonas* issues in a given production season.

Richardson’s research, which is funded through the Thad Cochran National Warmwater Aquaculture Center, is still in progress, but the research will impact Mississippi aquaculture farmers as well as those from surrounding states.

While the number of cases of *Aeromonas* has decreased in the last year, Richardson is continuing his research to assist farmers with future recurrences.

“We haven’t had an outbreak yet this year. There is an old adage that says if you have a disease problem just start researching the disease, and it will go away,” he said jokingly. “This summer, we are about half way through the production season, and we haven’t seen any catfish with *Aeromonas* at all.”

The team of researchers on this project consist of several individuals, but the core team is made up of Cynthia Ware and Drs. Michael Colvin, David Wise, Charles Mischke, Matt Griffin, and Terrence Greenway. ❖

Richardson is originally from southern Illinois. He graduated in 2013 from Murray State University in Kentucky with a bachelor’s in fisheries and aquatic biology and a chemistry minor, and then continued his education by receiving a master’s from Murray State in 2015. His ultimate goal is to become a professor at a university. He is also currently the MSU student sub-unit president of the American Fisheries Society, as well as the graduate student representative for the Department of Wildlife, Fisheries and Aquaculture.

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SUSTAINABLE BIOPRODUCTS

The Department of Sustainable Bioproducts conducts research to advance natural resource-based manufacturing practices. Through improvement of existing products and development of new ones, the department extends the sustainable utilization and stewardship of forests and other natural resources. The department also works to extend the use of natural resources through the development of wood preservation methods and new products made from underutilized forest resources.

WELL-AGED WOOD

Using wood tannins as a way to preserve wood

ONE OF THE MOST SYNONYMOUS products associated with tannins is red wine. One of the reasons certain wines are tannic is because they are aged in oak barrels. Wood tannins are used in a variety of ways from tanning leather to helping age fine wines. Another way researchers in the Forest and Wildlife Research Center are hoping to utilize wood tannins is to preserve the wood itself.

Dr. Darrel Nicholas, sustainable bioproducts professor, is a powerhouse when it comes to wood preservation. He's been researching ways to better preserve wood for most of his career, developing patents for wood preservation systems that have been the industry standard. Now as the industry shifts to more environmentally-friendly preservation methods, Nicholas is concentrating on elements within the wood itself as a way to innovate.

"Over the years, we've conducted research on wood extractives like tannins and antioxidants for wood preservative systems," Nicholas said.

In one recent study, he partnered with visiting scientist Dr. Sun Phil Mun to evaluate how tannins found in pine bark might protect wood against termites.

"We extracted tannins from the bark using different solutions like methanol and water," Nicholas explained. "Then we separated those components into different fractions and tested each fraction for termite activity."

The tannins extracted were rich in antioxidants, which helped deter both termite activity and wood decay.

Now Nicholas hopes to combine tannins with borates, a kind of salt, as the next step in finding a low toxic wood preservative.

"While borates are good wood preservatives, the method of fixing borates in the wood through water-soluble solutions has



FWRC scientists are studying tannins found in bark as a deterrent against termites and wood decay. (Photo by David Ammon)

been ineffective. The borates leach out to such a high degree that they are no longer effective," Nicholas explained. "Now we are exploring ways to use the tannins, which have preservation properties themselves, as a way to fix the borates into the wood to provide enhanced protection."

In addition to protecting against termites and wood decay, Nicholas hopes to improve the wood's dimensional stability.

"We are evaluating new compounds that control dimensional changes in wood," he said. "One of the big problems with wood is that it shrinks and swells, so being able to develop a wood preservation system that addresses this is something that hasn't been done."

Nicholas said the researchers must keep several goals in mind when developing these systems.

"We need to develop a low toxic wood preservation system that promotes the longevity of wood exposed to elements, while helping with dimensional stability, all at the lowest cost possible." ❖

This research was funded by the Forest and Wildlife Research Center.

A BETTER BUILDING MATERIAL

Scientists look for new ways to use bark

NATURAL RESOURCES ABOUND IN THE MAGNOLIA State but two resources not often utilized are bark, a byproduct of the state's thriving forest products industry, and Mississippi clay.

A scientist in the Forest and Wildlife Research Center is using novel approaches to turn these abundant raw materials into profit for industries and better bio-based products for consumers.

Sometimes in order to think big, you must start small. Dr. Yunsang Kim intends to do just that.

"If I had to sum up my research in one word, it would be nanocellulose," he said.

Nanocellulose is a wood-based fibrous material typically ten to 100 nanometers in width comprised of varying lengths. (To put it in perspective, one nanometer is 75,000 times smaller than a human hair.)

Kim hopes to combine nanocellulose with Mississippi clay to create clay-cellulose fiber sheets as non-toxic fire retardant for the oriented strand board that becomes what we know as wood paneling. The goal is to make wood paneling, which is used in the construction of a lot of buildings, less flammable.

"We will evaluate the thermal and flame shielding properties of clay-cellulose fiber based on sheets as nanostructured fire-resistant materials," Kim explained.

From there, Kim and his team will conduct fire performance testing on the panels.

In another proposed project aimed at improving the performance of building materials, Kim hopes to use wood-based products to help better insulate buildings.

"The U.S. forest products industry produces more than 20 million dry tons of bark each year. Due to its high ash content and low energy value, the conversion and utilization of bark into value-added products has been limited so far," he said.

Kim hopes to change that by evaluating three conversion processes for converting bark into hydroxyl-rich liquid polyols to bind with synthetic materials in an effort to create a rigid polyurethane foam.

This foam will be used as a thermal insulation core for building applications.

"We also plan to perform a lifecycle assessment of the energy and carbon flows to determine the overall added value compared to the traditional use of bark," Kim said.

He pointed out that both projects may eventually tie into broader applications, which he hopes will further reduce the carbon footprint of the forest products and agricultural industries and beyond.

"I started out as a polymer scientist and shifted my research focus to bio-based materials because I wanted to utilize bioproducts available in these industries in a way that provides value for growers, businesses, and consumers alike," Kim said. "We know that bio-based material is the future. We know where we have to go and it's exciting to help figure out how to get there." ❖

This research is funded by the Forest and Wildlife Research Center.



Dr. Yunsang Kim examines polyurethane made from bark. (Photo by David Ammon)

NEW APP MEASURES WOOD STIFFNESS

Apple app grades lumber

ARE ALL BOARDS CREATED equal? As commercial pine sawmills process logs, the evaluation of each piece of lumber is extensive. Mills use both visual and mechanical means to grade all types of dimensional lumber. Pieces are tested for strength and stiffness and the numbers crunched through an algorithm to determine the grade.

But lumber grading, just like in school, can create a range of values. For consumers to determine the actual performance of each piece, researchers in the Forest and Wildlife Research Center have developed an app which allows lumber buyers to conduct additional testing to determine where a piece of lumber sits within a determined grading scale.

After four years of development, a new app called Smart Thumper uses vibration or soundwaves to determine the stiffness of each piece. Available through the Apple App Store, weekend warriors can test individual pieces of dimension lumber at a local home improvement store to select the best pieces of lumber for their projects.

Dr. Dan Seale, Warren S. Thompson Professor of Wood Science and Technology and one of the lead developers, said the app is perfect for carpenters, contractors, architects, engineers, mill managers/supervisors, quality control personnel, and consumers. He pointed out that it can be particularly beneficial for the do-it-yourself market.

“Say a consumer has a pack of lumber which meets the specification for number two grade, but he needs a couple of pieces for a header, something that might span the opening for a window or door. He could use this app to help him pick out the stiffest pieces that are least likely to sag over time,” Seale explained.

Dr. Frederico França, co-developer of the app, has an undergraduate degree in wood industry engineering and a master’s in wood



The Smart Thumper app uses sound or vibration to evaluate lumber. (Photo by David Ammon)

science. He came to MSU to get his doctoral degree in sustainable bioproducts. Now he is an assistant research professor in the Forest and Wildlife Research Center. His love of physics fueled his ideas for a smartphone app that is able to collect lumber properties through the use of sound and vibration.

“With this app, I can show you which board is stronger and which is weaker,” França said. “This can’t always be done through visual inspection, you need vibration or you need sound.”

The idea for the app occurred when França discovered that a device designed for the same purposes that the Smart Thumper addresses costs around \$8,000.

“The goal was to make something cheaper, and more readily available, to give consumers and stakeholders broader access to nondestructive testing equipment,” França said. “Now anyone with a smartphone can download the app to help pick out the stiffest board for whatever they are building.”

França says this app can help further evaluate lumber within established grades, potentially optimizing the longevity and cost efficiency of wood structures by selecting stiffer pieces for situations that demand higher performance.

Find out more by visiting smarththumper.fwrc.msstate.edu. ❖

This research is funded by the Forest and Wildlife Research Center.

BEND, BREAK, EVALUATE

Scientists work to increase value of southern forests

TIMBER IS A MULTIBILLION DOLLAR INDUSTRY. Forestry is the number two leading commodity in the state of Mississippi generating \$1.2 billion in timber harvesting last year alone. Scientists in the Forest and Wildlife Research Center have completed a five year study to help increase the value of southern forests.

“Wood is the most important source of housing in the U.S. and the U.S. South is the most viable and sustainable, and largest wood basket in any developed nation. We have a responsibility to make sure we use this resource wisely and promote its ongoing use in perpetuity. We want wood structures to be engineered correctly and the materials therein to be properly and appropriately used. By developing better engineering valuation technology for lumber and building products, we help assure that just the right amount, or an optimal amount, of wood is used in construction,” said Dr. Rubin Shmulsky, professor and head of the Department of Sustainable Bioproducts.

The two part study, which involved several faculty and dozens of graduate students, included the evaluation of approximately 300 pieces and then expanded to another 2000 pieces of lumber acquired from 10 southern states from Virginia to Texas over the course of five years. The team conducted several methods of nondestructive testing to evaluate the accuracy and reliability of those methods, which are currently and widely used for grading and testing structural lumber.

Researchers evaluated the specimens nondestructively with

continuous proof bending, transverse vibration, and longitudinal stress wave methods in sequence. Specifically, the team was interested in the linear relationship of the modulus of elasticity, or MOE, and the modulus of rupture, or MOR, finding that MOE can be used to predict MOR. Once that data was collected, the team broke the boards, destructively evaluating them by four-point static bending tests to obtain static MOE and MOR values.

Shmulsky said the team statistically compared the results in an effort to find ways and means of increasing board performance and economic value.

“We consistently find that there are achievable ways to better evaluate the economic value of lumber. This in turn can be extended to forests. The more we know about the value of the lumber coming from the forest, the more value forest managers and timberland owners can achieve from their land. Also, they can make better informed decisions about their forest management and operations,” Shmulsky said.

Dr. Dan Seale, Warren S. Thompson Professor of Wood Science and Technology, served as co-principal investigator on the project. He said the team has wrapped up research on bending properties, which apply to the beams, girders, joists, rafters, and stringers in a building and



Researchers evaluated lumber nondestructively with continuous proof bending, transverse vibration, and longitudinal stress wave methods to determine the linear relationship of the modulus of elasticity and the modulus of rupture. (Photo submitted)



will get to work testing tension, which is important for wood trusses.

Seale said the research was like trying to solve a big puzzle and one of his favorite aspects of the work is watching graduate students figure out their individual roles in solving that big picture problem.

“I love to see a graduate student finally put all of the pieces together. Each of them works on their own little piece and when we are all working together, there’s inevitably a moment when each of them realizes their one piece is part of a really big pie and that all the pieces need to fit together,” Seale said.

He is also proud of Smart Thumper, an app that was released in 2018, born out of this research project. Seale said he’s also proud of the potential impact the research can have on the industry as a whole.

“We have millions of acres of forests that need to have the best value and economic opportunity possible. We know to keep land in forests instead of having it converted to agriculture or other uses, the forests need to have as much value as possible,” Seale said. “By better

evaluating how stiff and strong every single stick of wood is then ultimately those trees become worth more money and landowners will keep that land in forests and replant and grow it for the future.” ❖

The following partners have contributed to the research through funding or other support: USDA Agricultural Research Service, USDA Forest Products Laboratory, Mississippi Lumber Manufacturers Association, Southern Pine Inspection Bureau, Timber Products Inspection Agency, Southern Pressure Treaters’ Association, Mississippi Forestry Association, American Wood Protection Association, Southern Forest Products Association, Southeastern Lumber Manufacturers Association, Stairbuilders and Manufacturers Association, Southwestern Hardwood Manufacturers Club, and mills across the Southeastern U.S. Funding is also provided by the Forest and Wildlife Research Center.

Graduate Student Profile:

Kassandra Stout

HOMETOWN: Buffalo, New York

BUILDING BRIDGES BETWEEN GENERATIONS

Perceptions of the millennial generation surrounding wood products

HOW OFTEN, AS YOU WANDER ACROSS YOUR hardwood floor to set your mug down on the oak coffee table, do you stop to think about the wood products you use every day? Wood products exist all around us. We work at wooden desks, write notes on paper, and have homes made and furnished with wood.

Kassandra Stout, a sustainable bioproducts graduate student, explores these questions with her research project on “Attitudes and Perceptions of the Millennial Generation Surrounding Wood Products and the Wood Products Industry.” She focuses on the millennial generation between the ages of 18 to 38, and is concerned with what they think about the wood products industry.

“There has always been a running perception, for as long as I can remember, that leans towards the negative when you start talking about the wood products industry because people automatically go to, ‘Oh, you’re cutting down trees. You’re harming the environment,’” she said. “There is that perception out there that exists, and with this study, I’m hoping to shed some light on what the millennial generation is actually thinking when they think about the wood products industry.”

The project aims to help the wood products industry and academia better understand how the industry is perceived right now with this generation. Stout wants to help bridge the gap and provide more awareness about what the industry actually does to improve the overall persona of wood products. She points out that wood products have been around for years and will continue to be around. Thus, she seeks to foster a better outlook



that’s more positive and encouraging towards wood products.

Stout further explained the details of the project which involved a survey that was sent out to 1,500 millennial-aged individuals to gauge the thoughts and feelings they have towards wood products and the industry. The questions range from simple to more complex. One example is: Do you believe that hardwood floors improve the value of a home?

“We really set a magnifying glass on millennials to see exactly what they think about what we do and the products that we make because going forward in the future the millennials are the up and coming generation,” she said. “They are going to be the main consumers and the main workforce for many years to come, so gaining their insight and understanding how they value things and how they view them is very important. It is especially important for a business that relies upon products that consumers will buy and encourage others to buy.”

She is currently sifting through resultant data from 1,479 usable completed surveys.

“The big picture problem that I’m working on would be the fact

Kassandra Stout studies millineals to gauge their thoughts on wood products and the industry. (Photo by David Ammon)



that there has been a decline in interest and awareness in younger generations towards the industry and what we do,” she said. “My overall goal is to create a better understanding.”

Stout is originally from Buffalo, New York, and she went to Hood College in Frederick, Maryland, where she graduated in 2017 with a double major in marketing communications and English. She plans on graduating from her master’s program in sustainable bioproducts in May of 2019.

Stout’s major professor, Dr. Rubin Shmulsky, describes her as a very self-motivated individual.

“I am most proud of her helping to design and then jumping into a project which is entirely novel,” Shmulsky said. “This is an important research area for all aspects of wood products related business as that particular economic sector contains a large number of employees who are at or near retirement age. The younger millennials will be the people who come in and work for these companies and ultimately become groomed to run these respective businesses.” ❖

This research is funded by the Forest and Wildlife Research Center.

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CENTER FOR RESOLVING HUMAN-WILDLIFE CONFLICTS

The Center for Resolving Human-Wildlife Conflicts advances research and applied management of natural-human systems, provides leadership and training for resolving human-wildlife interactions, and expands educational opportunities for students interested in human dimensions of wildlife and fisheries conservation.

WORKING LANDSCAPES

Management practices to improve biodiversity



OPEN LONGLEAF PINE FORESTS ONCE COVERED much of the Southeastern U.S., including Mississippi. Now, while more than 60 percent of the Magnolia State's 30 million acres is covered in trees, the pine landscape has shifted from longleaf to loblolly. In 2017, the timber industry generated \$1.2 billion dollars making it the second largest commodity in Mississippi. While economic benefit is the top priority for landowners with trees in timber production, scientists in the Forest and Wildlife Research Center sought to find practical ways for these landowners to help increase biodiversity in working landscapes.

Dr. Ray Iglay, assistant research professor in the Forest and Wildlife Research Center, was part of a study that lasted approximately 10 years. From 1999 to 2008, researchers treated intensively managed pine stands in east-central Mississippi to determine if certain management practices could increase different species of wildlife and plants, also known as biodiversity, in the forest.

"We were trying to figure out what kind of mid-rotation management would improve biodiversity in these working landscapes," Iglay said.

Iglay explained that typically landowners will thin trees midway through the growth stage, around the twelve year mark, depending on tree growth and site location. From there, they may administer a fertilizer application, and then clear cut a dozen or so years after that.

"Our idea was to thin midstory trees while simultaneously using treatments like prescribed burn and herbicide application that would help wildlife, specifically species of concern like certain grassland birds," Iglay said. "We sought to increase biodiversity of birds, small mammals, reptiles, amphibians, ground beetles, and vegetation in general."

Four treatments were applied across six mid-rotation, thinned pine stands in 25-acre experimental units. The treatments included prescribed burn, herbicide application, herbicide application plus prescribed burn, and a control. The prescribed burns were repeated every three years across the life of the study while herbicide was applied only once at

the onset of the study. Using the Partners in the Flight avian conservation assessment database, the team scored all avian species observed on the land over a period of nine years.

"Combining prescribed fire and herbicide had the greatest positive impact among high-priority, open pine bird species and total avian conservation, but independent treatments also elicited positive responses," Iglay said.

He pointed out that the results offer a suite of solutions for landowners hoping to increase biodiversity, while concurrently meeting economic and sustainable forestry goals.

"Our results indicate that each treatment produced conditions benefiting a specific subset of birds including both high and low priority species, and no one treatment can be used to benefit all species observed in this study," Iglay explained. "Rather, these treatments offer multiple management options, and all treatments may be used at the landscape scale to create a matrix of forest conditions to support a diversity of birds and sustainable forestry."

Iglay is excited that the research has resulted in practical applications for timber producers.

"By evaluating different ecological questions and, in this case, looking at how we might affect niche space and provide more opportunities for nesting birds and other species to increase in diversity, we were able to make recommendations for landowners interested in increasing biodiversity in working landscapes," Iglay said. ❖

The research has been published in six peer-reviewed journals. Drs. Bruce Leopold and L. Wes Burger, Jr., and Rachel Greene, with Mississippi State contributed to the research. Darren Miller who was with Weyerhaeuser Company at the time of the research also worked on the project. Funding was provided by Weyerhaeuser, the National Council for Air and Stream Improvement, BASF, National Wild Turkey Federation, and the Forest and Wildlife Research Center.

MSU TRAINS WILDLIFE SERVICES PERSONNEL

National Training Academy housed at MSU

FROM BIRDS IMPACTING AVIATION TO BEAVERS building dams and destroying property, human-wildlife interactions affect our world in many ways.

Wildlife Services officers with the USDA Animal and Plant Health Inspection Service (APHIS) are the first line of defense in defusing these conflicts. Their work requires continuous training, which is where Mississippi State lends a hand.

In late 2016, the university became home to the Wildlife Services National Training Academy (NTA) through a cooperative agreement with the USDA-APHIS Wildlife Services. In early 2017, the NTA team began coordinating and delivering several courses in basic and advanced firearms, explosives, and immobilization and euthanasia drug delivery.

Chad Dacus, program director and training coordinator, earned a bachelor's in forestry and a master's in wildlife, fisheries and

aquaculture from MSU. He spent 14 years with the Mississippi Department of Wildlife, Fisheries and Parks before joining NTA.

"The feedback has been positive," Dacus said. "In one particular course, several attendees rated the course as excellent and indicated that the course increased their knowledge base of the subject 20 percent or greater across several metrics. One attendee remarked that in his 10 years in government service, this was the best course he had attended."

Dacus went on to explain the NTA's twofold mission.

"We provide ongoing, standardized training programs to current and incoming Wildlife Services personnel, and we record and maintain training records," Dacus continued.

NTA instructors also serve as subject matter experts for professional coursework reviews for Wildlife Services technicians applying for federal wildlife biology positions. They completed 139 coursework reviews and provided 85 coursework endorsements in 2017.

Dacus works with Janean Romines, a Wildlife Services employee and NTA program liaison with nearly 30 years of state and federal experience in wildlife biology. Her wealth of institutional knowledge contributes to NTA's success in meeting training needs. Romines said the academy will continue to expand the scope of its training based on agency needs as directed by the Wildlife Services management team and safety committees, as well as the NTA steering committee.

"In 2018, we expanded our training to include ATV safety handling, risk communications, tactical emergency medical care, contaminant response, and unmanned aerial systems basic training, as well as developing new employee orientation resources," she said.

She said a collaborative spirit has helped the team hit the ground running.

"This has been an amazing first year that exceeded my expectations," Romines said. "Our phenomenal staff has worked from day one as a team. Wildlife Services is excited about this part-

nership, and we are here as a result of Dr. Jessica Tegt and her vision for a training academy and also the support of Dr. George Hopper and Dr. Gary Jackson. Through their combined work and the effort of our staff, I think we are well on our way to creating an amazing program with MSU." ❖

The NTA is housed under the Department of Wildlife, Fisheries, and Aquaculture within the Center for Human-Wildlife Interactions as a unit of Extension and the FWRC.



Chad Dacus looks over a target with a training participant. (Photo courtesy of NTA)

Graduate Student Profile:

Isidro Barela

HOMETOWN: Belen, New Mexico

TRACKING BEAVERS

*Researchers study
American beavers for
wildlife management*



THE AMERICAN BEAVER, ONCE PRIZED FOR ITS PELT, is now frequently considered a nuisance for the extensive damage they can cause to crops, timber, and roadways. There is limited economic data on the damage caused by beavers, however, estimates for southern states reach millions of dollars.

Since beavers are a species of management concern across the U.S. and especially in the South, MSU researchers are investigating beaver ecology to help improve management practices of their populations for either their positive environmental effects as a keystone species or as agricultural and infrastructure pests.

Isidro Barela, a master's student in the Department of Wildlife, Fisheries and Aquaculture from Belen, New Mexico, is undertaking research to predict likely areas on the landscape where beaver may live. If land managers can identify where beavers may occur, they may be able to better manage damage that might arise from a nuisance situation.

"I am very interested in beavers as a species because of their capability to manipulate their environment on such a large scale and their impacts on riparian communities," Barela said. "I am also very interested in the geospatial field. This research allowed me to apply these two interests into a research project that may contribute to the overall body of scientific knowledge of beaver ecology as well as predictive modeling, which may improve management practices for the American beaver."

By also pursuing the geospatial and remote sensing minor in the Department of Geosciences, Barela can combine wildlife and geospatial science to evaluate two very different approaches used to predict habitat suitability for the American beaver. One modeling

technique is known as Maxent, a method that uses data about known beaver locations to predict habitat suitability. The other method, Expert Opinion Models, also predicts habitat suitability but uses environmental variables identified and ranked by beaver experts to make predictions.

The results from the research found that both modeling approaches performed well, but the Expert Opinion Models may have better performance at predicting greater areas of suitable habitat.

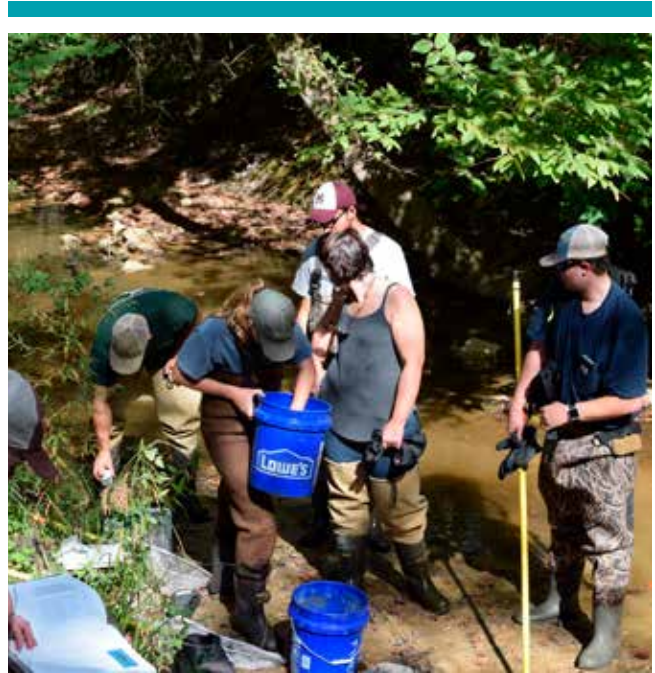
Dr. Leslie Burger, assistant extension professor in the Department of Wildlife, Fisheries and Aquaculture and Barela's graduate co-advisor, said, "Isidro explored ways in which managers can use habitat models, satellite imagery, and professional opinions to predict where beavers might occur on the landscape."

When asked about his personal experience as a MSU Bulldog, Barela said, "What I enjoyed the most about my time at MSU is the graduate student community. While I've been here, I have made friends and met colleagues from all over the world. The diversity of graduate students at MSU made my experience here very enjoyable. This diversity allows individuals to learn from different experiences, cultures, and ways of thought that allow communities to grow culturally and professionally." ❖

This research was funded by USDA APHIS Wildlife Services and the MSU College of Forest Resources.

UNDERGRADUATE RESEARCH

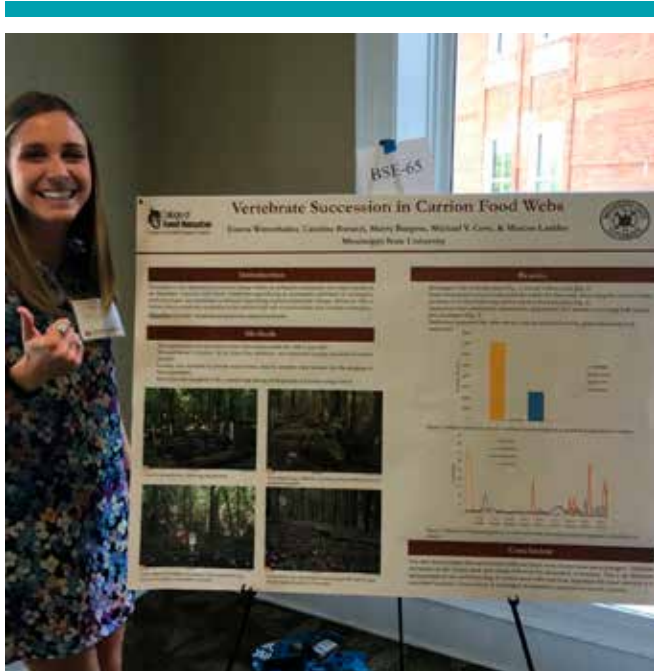
Undergraduate students in the College of Forest Resources step outside of the classroom to engage in hands-on research with scientists in the Forest and Wildlife Research Center. The opportunity is made possible by the Undergraduate Research Scholars Program, now in its fourth year.



ASHLEY SHANNON

HOMETOWN: *Nesbit, Mississippi*

Shannon, senior wildlife, fisheries and aquaculture major, examined angler catch-rates in comparison to the Farmer's Almanac "fishing calendar." The Farmer's Almanac predicts daily fishing conditions and, while the exact formula is unknown, the forecasts are widely accepted in popular culture. The study attempted to corroborate historic fishing conditions using creel data collected from Enid Lake, northcentral Mississippi. Catch-per-unit-effort (CPUE) as hourly catch-rates for boat anglers were calculated over three years. Those estimates were then compared to the Farmer's Almanac's predicted fishing conditions (poor, fair, good, best) using linear regression. The influence of year and fishing condition were evaluated by parameterizing models that included and excluded their effect on mean angler catch rates. Conclusions of the research suggest that local conditions and weather may influence fishing conditions, however, other abiotic factors, including water temperature, light intensity, and barometric pressure, may better predict fishing success. Shannon worked under the direction of Dr. Michael Colvin, assistant professor in wildlife, fisheries and aquaculture.



EMMA WINTERHALTER

HOMETOWN: *Mansfield, Texas*

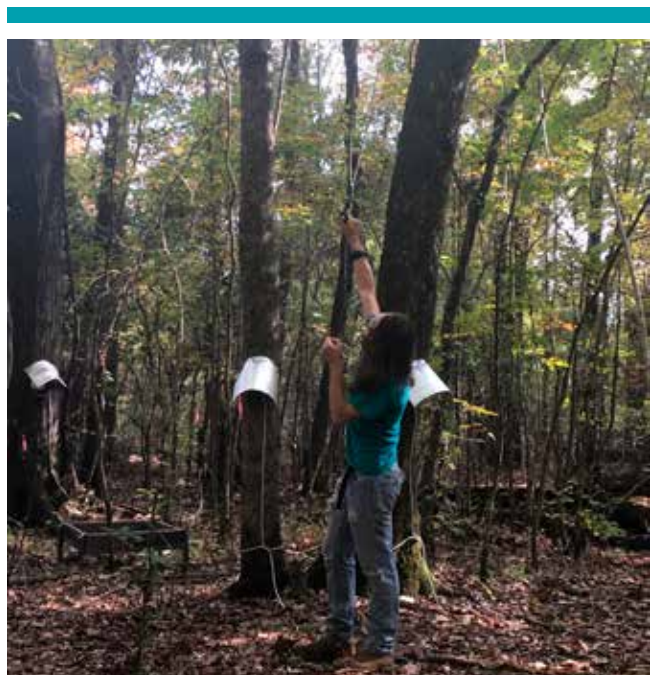
Winterhalter, a wildlife, fisheries and aquaculture major, studied vertebrate use of carrion to document succession. Succession is the directional process of change within an ecological community over time. Carrion, or the decaying flesh of dead animals, is an important basal resource with many vertebrates specializing as scavengers, predators of scavengers, both scavengers and predators, or animals responding to plant community changes caused by carrion. Winterhalter and fellow researchers distributed varying amounts of donated feral swine carrion at the John W. Starr Memorial Forest. Each plot was equipped with a camera trap taking photographs of animals using carrion. A clear pattern of vertebrate succession emerged. Scavengers (e.g. vultures, coyotes) arrived within hours and likely were eating primarily carrion. Insect abundance also increased exponentially stimulating the arrival of their predators (e.g. armadillos, brown thrashers) around five days after carrion deployment. Vertebrates that were predators and scavengers (e.g. opossums) consumed carrion and insects, and were consistently present from deployment for three months. White-tailed deer and gray squirrels, which were not consuming carcasses or insects, appeared last, well after carrion was fully decomposed. Interestingly, vertebrate succession in the carrion food web closely followed the succession of resource availability with scavengers arriving first to consume carrion, predators second to consume scavengers, scavenger/predators present for both resources, and other nonscavenger, nonpredator vertebrates responding to plant community changes after decomposition. The data demonstrates that carrion food webs extend much further than to just scavengers. Winterhalter was advised by Dr. Marcus Lashley, assistant professor in wildlife, fisheries and aquaculture.



MARK PORTER

HOMETOWN: *Columbus, Mississippi*

Porter, a forestry major in forest management, used data from the U.S. Forest Service Forest Inventory and Analysis program and peer-reviewed literature to evaluate differences in relative stocking among several common forest types in the Lower Mississippi floodplain. He assessed the maximum relative density by simple linear regression of plot level data, in addition to evaluating the upper and lower bounds of desirable stocking based on methods used in hardwood stocking guides developed in other regions. More specifically, for lower bounds he evaluated the minimum number of trees of a given size required to achieve crown closure, which is where trees start competing for growing space. Preliminary results on lower bound stocking support the hypothesis that different species will achieve crown closure at different stocking levels. These findings should provide guidance to managers about density management in forest types of different species composition to meet desired stand structural characteristics. Also, by improving knowledge of density relationships related to species composition, this study should help in the design of mixed-species afforestation efforts aimed at restoring floodplain forest cover in the southeastern US. Porter was advised by Dr. Brent Frey, assistant professor in forestry.



JUSTIN YOW

HOMETOWN: *Hernando, Mississippi*

Yow, a forestry major with a concentration in wildlife management, compared stomatal properties across various tree species from three plant families growing in a bottomland forest to determine if stomatal properties correlate with physiological functioning. Sapflow was measured in seven hardwood species using heat dissipation sensors. Vapor pressure deficit (VPD), soil moisture, and photosynthetically active radiation (PAR) were monitored simultaneously. Seasonal water use per unit leaf area and relationships between daily water use and environmental parameters were estimated to determine the response of sapflow to environmental drivers. Leaves were collected from tree canopies at the end of the growing season. Epidermal peels were made and analyzed to quantify stomatal density and length. Among species, stomatal density varied significantly, with American elm having a significantly lower density than all the oaks. Shagbark hickory also had a significantly lower stomatal density than all oak species except water oak. Across all tree species, stomatal density had a significantly negative correlation with seasonal water use per unit leaf area and daily sapflow responses to VPD and PAR. Based on findings, stomatal parameters may be used to predict seasonal water use per unit leaf area and responses of water use to environmental parameters across tree species to increase understanding of relationships between leaf structure and physiological functioning. Yow was advised by Dr. Heidi Renninger, assistant professor in forestry.



BRANSON WETZSTEIN

HOMETOWN: *Meridian, Mississippi*

Wetzstein, forestry major with a concentration in environmental conservation, evaluated additives for pelletizing wood. Southern pine energy pellet production is a growing industry in the United States and supplies overseas countries with millions of dollars of materials to run industrial boilers. In recent years, the pellet industry has found that the use of additives in the pellets can help improve pellet durability, improve BTU content, and lower the energy requirement needed to create the pellets. The goal of the research is to test pellet qualities based on additives, storage temperatures, and storage inflows. In addition, additives were compared for their effect on energy cost to produce vs energy yield of the pellet. Overall out of three types of pellets created (control, bio-oil additive, cornstarch additive), the pellets with the cornstarch additive required less energy to form and also had the best durability. The control had the highest energy content, however the ratio of energy content to the energy used was the lowest. The cornstarch had the highest ratio of energy content to the amount of energy used. While airflow through the barrels influenced moisture content of the pellets, the bulk density and durability characteristics did not change. Based on the findings, the bio-oil additive can improve profit margins if it can be created without extra cost; however, issues regarding durability will have to be addressed before commercial companies can adopt bio-oil as an additive. Dr. Jason Street, assistant professor in sustainable bioproducts, was Wetzstein's faculty advisor.



EVIE VON BOECKMAN

HOMETOWN: *Walls, Mississippi*

Von Boeckman, wildlife, fisheries and aquaculture major, studied how an increase in fire-sensitive, shade-tolerant species (mesophytes) impacts moisture content and drying rates in fuel beds, and if fuel bed wetting method (soaking, rainfall simulation, natural rainfall event) influences these response variables. Mesophytes are becoming dominant in historically fire-maintained and oak-dominated (*Quercus* spp.) forests in the eastern U.S. This could have large impacts on forest flammability, and thus maintenance of oak forests, if mesophyte leaf litter traits influence fuel moisture. Fuel beds were constructed in a laboratory comprised of upland oak litter (*Q. stellata*, *Q. coccinea*) and increasing amounts of mesophyte (*Liquidambar styraciflua*, *Carya* spp, *Ulmus alata*) litter (0%, 33%, 66%, and 100%). Fuel beds were wetted by (1) soaking for 24 hr, (2) simulating a summer precipitation event (0.0072 cm over 10 min), and (3) exposing litter to a natural winter rain event (0.19 cm over 4 hr). All treatments exhibited a rapid initial decrease of moisture followed by a more gradual decline over the 48 hour drying period; however, beds comprised only of mesophyte litter dried slowest, while those with high oak contribution (66% and 100%) dried fastest. The simulated rainfall and rain event produced similar drying rates; soaking, however, showed the highest moisture content initially and less distinction and separation between drying rates. These findings suggest that increased contribution of mesophyte leaf litter to fuel beds will increase moisture and slow drying rates, which could hinder forest flammability in upland oak systems. Von Boeckman was advised by Dr. Heather Alexander, assistant professor in forestry.



MATTHEW VIRDEN

HOMETOWN: *Montgomery, Alabama*

Virden, a wildlife, fisheries and aquaculture major, studied improved production of Gulf killifish. Killifish are inter-tidal spawners found in estuaries in Northeast Florida and along the northern coast of the Gulf of Mexico. There is a high demand for Gulf killifish from bait shops and anglers for use as live bait for sport fishes. This demand has led to a shortage in the overall supply of Gulf killifish, creating an increased interest in production. Adult killifish enter interior marshes during spring high tides to spawn by laying eggs in marsh grasses. The eggs have an adhesive layer, allowing them to stick to the vegetation for incubation until the next high tide. Hatching occurs once the eggs are re-submerged. While this adhesive layer is beneficial in their natural habitat, it makes it difficult to collect the eggs off spawning mats in recirculating aquaculture systems. Currently mats are shaken or tapped against a mesh screen; however, clumps of eggs are still visible within the mat. Studies were performed to assess different treatments to remove the adhesive layer to increase the number of eggs available for collection. Gulf killifish eggs were collected on Spawntex mats that were placed below the water's surface in recirculating aquaculture systems. Individual mats underwent randomized treatments and there was a total of nine treatments with three replicates each. Treatments consisted of urea, tannic acid, cow's powdered milk, and water. The removal efficiency for all treatments were slightly higher than the control. The three urea solutions were the only treatments that were significantly different from the control. Survival and hatching rates did not show any relation to treatments, but this could be the cause of inadequate sample size. Future studies should focus on increasing sample size and focusing on fewer solutions. Virden was advised by Dr. Peter Allen, professor of wildlife, fisheries and aquaculture.

FACULTY REFEREED PUBLICATIONS

JULY 1, 2017 - JUNE 30, 2018

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Clark, K., **H. J. Renninger**, N. Skowronski, M. Gallagher, K. Schafer. 2018. Decadal-scale reduction in forest net ecosystem production following insect defoliation contrasts with short-term impacts of prescribed fires. *Forests* 145(9).

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Davis, A., **G. Wang**, M. A. James, **J. L. Belant**, A. Butler, **S. A. Rush**, D. Godwin. 2017. Landscape-abundance relationships of male Eastern wild turkeys (*Meleagris gallopavo silvestris*) in Mississippi, USA. *Acta Ornithologica* 52:127-139.

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DISSERTATIONS

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Gantchoff, M. G. 2018. Multi-scale spatial selection of a large solitary omnivore, American black bear. Dissertation, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Hill, J. E. 2018. Anthropogenic impacts on wildlife mortality and vertebrate scavenging communities. Dissertation, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Konukcu, A. C. 2018. Tensile strength of dovetail joints in furniture. Dissertation, Department of Sustainable Bioproducts, Mississippi State University.

Lancaster, J. D. 2017. Winter ecology of radiomarked female mallards in Mississippi's Alluvial Valley. Dissertation, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

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THESES

Babl, E. K. 2018. Could mesophyte canopy, bark, and leaf litter traits drive future flammability of upland oak forests? Thesis, Department of Forestry, Mississippi State University.

Bahsi Kaya, G. 2018. Composting of cross laminated timber (CLT) sawdust. Thesis, Department of Sustainable Bioproducts, Mississippi State University.

Bartaula, B. 2017. Stand level growth and survival equations for cutover sites loblolly pine plantations in the mid-Gulf region of southern United States. Thesis, Department of Forestry, Mississippi State University.

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Durbin, T. 2018. Early growth and survival of two oak species and three planting stocks on lands disturbed by Hurricane Katrina. Thesis, Department of Forestry, Mississippi State University.

Fuller-Morris, M. 2018. Effects of hardwood control and switchgrass intercropping on breeding bird communities and resource use in managed loblolly pine stands in Mississippi. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

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Martinez Lanfranco, J. A. 2017. Ecology and conservation of bird assemblages in native and afforested environments in the Northern Campos Grasslands of Uruguay. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

McCollum, J. R. 2018. The effects of habitat management on wildlife use in a managed loblolly pine forest. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

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Rhodes, C. A. 2017. Effects of aquaculture decline on spatial distributions of piscivorous birds. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Shamaskin, A. C. 2018. Evaluating multisystem length limits for inland fisheries. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Siegle-Gaither, M. 2017. Using deuterium and oxygen-18 stable isotopes to understand mechanisms of stemflow generation as a function of tree species and climate. Thesis, Department of Forestry, Mississippi State University.

Smith, A. L. 2018. Investigating the effectiveness of wild pig policy and legislation in the U.S. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Thapa, S. B. 2018. Perceptions regarding longleaf pine ecosystem restoration using prescribed fire. Thesis, Department of Forestry, Mississippi State University.

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BY THE NUMBERS

PEOPLE

93

Master's students (Fall 2017)

43

Doctoral students (Fall 2017)

49

Faculty (FY18)

RESEARCH PROJECTS

282

Projects Active (FY18)

69

Research Sponsors (FY18)

174

Refereed Publications (FY18)

\$11.90M

Total Sponsored Research Funding (FY18)

RESEARCH SPONSORS

Alternative Fuel
American Furniture
Anthony Hardwood Composites
Appalachian Regional Commission
BASF Corporation
Bayer Crop Science
Cargill Industrial Starch
Cate Street Capital
Cullman Cabinet and Supply Company
Drax Biomass International Inc.
Ducks Unlimited, Inc.
Emerald Forest Products, Inc.
EnSafe
Ethan Allen
Exacto
Fitts Industries, Inc.
Forest Products Society
FPIInnovations
FuturaGene
Grain Processing Corporation
Heritage Furniture
Home Street

TOTAL FWRC FUNDING, FY18

\$15.9M

35.35% STATE APPROPRIATIONS
05.60% FEDERAL APPROPRIATIONS
59.22% GRANTS AND CONTRACTS
00.34% SALES

INEOS

Intertek Testing Services

Koch Carbon

Koppers Holdings Inc.

Lane Furniture

Lignotech USA, Inc.

Lonza Wood Protection

Louisiana Pacific Corporation

Mississippi Department of Wildlife, Fisheries, & Parks

Mississippi Tree Farm Committee

Missouri Department of Conservation

**MS Implementation Committee for the Sustainable
Forestry Initiative**

National Council for Air and Stream Improvement, Inc.

National Fish and Wildlife Foundation

National Science Foundation

National Wild Turkey Federation

New South Equipment Mats

Noble Research Institute, LLC

Norbord

North American Wholesale Lumber Association

Oregon State University

Ply Trim

Railway Tie Association

Scimetrics, LTD Corporation

Seminole Furniture

Sustainable Forestry Initiative, Inc.

Tennessee Valley Authority

The National Academies of Sciences, Engineering and Medicine

The University of Maine

Timber Products Inspection

Tisatech

United Furniture

United States Department of Defense

United States Department of the Interior

United States Fish & Wildlife Service

United States Geological Survey

USDA Farm Service Agency

USDA Agricultural Research Service

USDA Animal & Plant Health Inspection Service

USDA APHIS National Wildlife Research Center

USDA Forest Service

USDA National Institute of Food and Agriculture

USDA Natural Resources Conservation Service

Viance

Walton Family Foundation

Weyerhaeuser NR Company

Yak Mat



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