FOREST & WILDLIFE RESEARCH CENTER 2019

ANNUAL REPORT

MISSISSIPPI STATE UNIVERSITY™
FOREST AND WILDLIFE RESEARCH CENTER

FOREST & WILDLIFE RESEARCH CENTER 2019 ANNUAL REPORT

EDITOR
Karen Brasher

DESIGNER
David Ammon

WRITERS
Vanessa Beeson
Karen Brasher
Janiece Pigg
Reagan Poston

PHOTOGRAPHERS
David Ammon
Dominique Belcher
Russ Houston
Janiece Pigg

fwrc.msstate.edu

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

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

MISSISSIPPI STATE UNIVERSITY™
FOREST AND WILDLIFE RESEARCH CENTER

ON THE COVER: *A Mississippi gopher frog bred in captivity. Mississippi State is home to the world's first genome resource bank for threatened amphibians. For more on the research, read "Hopping from Extinction to Success," on page 20. (Photo by Dominique Belcher)*

CONTENTS

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 public and private research sponsors. In fiscal year 2019, we had 88 sponsors provide support for 280 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 $2.08 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 economic powerhouses 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!

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.

GROWING OLD FORESTS

Scientists have found that landowners are willing to extend rotation of pine plantations for a price premium. (Photo by David Ammon)

PLANTATION PINE TREES COVER OVER 37 MILLION acres in the Southeastern U.S. These timber resources provide wildlife habitat, carbon sequestration, recreation, and other environmental benefits. Importantly, for landowners, these resources provide revenue.

Conventional rotation or optimal harvest age in loblolly pine plantations is typically 30 to 33 years. Other species such as longleaf pine have much longer optimal rotation ages. However, the more a tree grows, the better the wood.

Forest economists in the Forest and Wildlife Research Center recently studied how much more income it would take for landowners to extend their final harvest by 10, 20, or 30 years.

"Southern pine are among the most intensively managed forests in the world," said Dr. Don Grebner, professor and head of the Department of Forestry. "Growing southern pine plantations on shorter rotations increases the proportion of juvenile wood in harvested saw logs when compared to growing older trees."

Wood quality increases with age, but there are risks and lost revenue, when extending the rotation from 30 years to 40, 50, or 60 years, Grebner added.

To determine the price premium landowners would require to extend the rotation, the economists simulated four southern pine stands for growth and yield using the Forest Vegetation Simulator southern variant.

"We simulated 48 management regimes from both even- and uneven-aged systems that included a combination of site indices and planting densities including maximum diameters in an uneven-aged pine system," Grebner said.

The economists found that landowners would be willing to delay harvest of even-aged loblolly pine for 10 years for a price premium of $5.06 per ton, 20 years for $17.77 per ton, and 30 years for $37.92 per ton. The premium would be on top of the current stumpage value of timber. Loblolly is the most grown species of the four main southern pine species and had the lowest price premium. Longleaf generated the highest premium in the simulations.

For uneven-aged pine, scientists looked at delaying rotation by five years. In these scenarios, price premiums ranged from $1.40 to $3.39 to extend harvest from five to 10 years. Slash pine garnered the highest premium, while longleaf rendered the smallest price increase.

Armed with information on landowner premiums, the economists wanted to know if sawmills were willing to pay a premium.

"To our knowledge, this is the first time sawmills have been surveyed to determine if they are willing to pay a premium price for high quality pine sawtimber," Grebner said.

Scientists surveyed 517 sawmills in the Southeast, 26 percent of which completed the survey.

"We found that 64 percent of the sawmills surveyed were interested in obtaining high quality sawtimber," Grebner said. "Over half of the sawmills were willing to pay a premium price for sawtimber, an extra $10 per ton for standing timber, and $13 per ton for delivered logs."

The sawmills specified that they would be willing to pay a premium to purchase Grade 1 sawtimber, Grebner added.

The information is useful to landowners considering delaying harvest to grow sawtimber.

"Most forest landowners want to grow sawtimber for a multitude of competing interests, including revenue and wildlife habitat," Grebner said. "Delaying harvests could allow landowners to generate a premium price for their sawtimber while providing habitat for a suite of wildlife that need older grown timber to thrive." ❖

The study was the topic of graduate research conducted by Arun Regmi. In addition to Grebner, Drs. Robert Grala, forestry professor, and John Willis, former assistant professor, worked on this project. This research was funded by the U.S. Forest Service and the MSU Forest and Wildlife Research Center.

HOW MUCH CARBON DO U.S. FORESTS CAPTURE?

Roughly one third of the land area of the United States is made up of forested land. That's estimated at over 800 million acres of forests. Trees remove CO_2 from the atmosphere through photosynthesis. This carbon is stored in the roots and trunk, making forests a globally important carbon storage system. A single tree can sequester about 88 pounds of carbon per year; so just how much carbon does the entire U.S. capture? A scientist in the Forest and Wildlife Research Center is hoping to answer that question.

Dr. Krishna Poudel, assistant professor in the Department of Forestry and his collaborators have been working on the project, which began in 2012 and ends in 2020. They will find a better way to measure forest biomass on a national scale. Better estimating biomass will help them determine a more accurate measure of carbon sequestration across U.S. forests.

Poudel said the current tools used to measure biomass on a national scale are not as accurate as they could be.

"Our analysis indicates the component ratio method—which is the current standard in biomass estimation—underestimated aboveground biomass by 3.7 percent for the species in the western U.S. and 12.2 percent for the species in the east. Additionally, my research found that the method produced a wide range of inaccurate estimation from an underestimation of 70 percent to an overestimation of 31.6 percent for some species in the western U.S.," Poudel said.

For his part of the research, Poudel collected destructive samples from several species across ten western states while collaborators collected information on species in the eastern U.S. The team hopes to use all of the data collected to build better models for estimating biomass in order to better determine how much carbon U.S. forests capture.

Poudel began the research as part of his doctoral work at Oregon State University, where he earned a Ph.D. in forest biometrics in 2015, staying on as a post-doctoral researcher after graduation. He continued the work when he joined MSU as an assistant professor in 2018.

The team has developed new methods and models for estimating aboveground biomass for U.S. tree species, developing and testing approaches to link volume to whole tree biomass and also estimating the biomass of different components including main stem, bark, branch, and leaves.

Once they have determined the best method for estimating aboveground biomass, they will incorporate that model using the U.S. Forest Service's Forest Inventory and Analysis, or FIA program. From there, they should be able to determine an estimated aboveground biomass for U.S. forests that can illustrate how much carbon our forests are capturing.

"Reliable tree-level estimates are needed to characterize the actual state of resources and to accurately inform forest management and policy decisions," Poudel said. "This study will improve the quality and availability of equations for application by all forest scientists and managers making assessments of forest biomass and carbon."

Poudel pointed out that the research will ultimately benefit federal resource managers, private and industrial landowners, and the public as well.

"In addition to helping determine how much carbon forests capture, this will also determine things like fuel loads which can help measure the forest's vulnerability to fire, and more," Poudel said. ❖

An aboveground view of forests. Forests capture or sequester carbon in the atmosphere (Photo submitted)

This research is funded by USDA Forest Service Pacific Northwest Research Station. In addition to MSU which joined when Poudel began as an assistant professor at the university in 2018, universities involved in the research are Oregon State University, University of Montana, Northern Arizona University, University of Georgia, Michigan State University, Virginia Tech, and the University of Maine.

THE CHANGING TIDE OF TRADE

As the global forest products industry shifts over time, how can stakeholders better understand emerging trends? A scientist in the Forest and Wildlife Research Center has made it his life's work assessing the international trade of forest products and communicating vital insight to the industry's stakeholders.

Dr. Changyou Sun has studied the forest products industry for more than 20 years. In that span of time, globalization has shifted the trade tremendously. As markets across the globe increasingly become integrated, Sun studies trends to discover commonalities and anomalies in order to provide insight to industry stakeholders as the market continues to expand.

In one project, Sun studied the ins and outs of the export of U.S. roundwood to Asian countries. A billion dollars of U.S. roundwood—or softwood logs—is exported to countries including China, Japan, and South Korea each year.

Sun said that while trade with Japan and South Korea has been going on for a half a century or more, trade with China is still fairly young.

"We began trading with Japan and South Korea in the 1950s and 1960s while trade with China didn't occur until the 1980s. Even so, it wasn't until 2001, when China became a part of the World Trade Organization, that trade between U.S. and China became really robust," Sun said.

Sun also pointed out that—at least for the forest products industry—trade between the U.S. and China increased again following the 2008 global financial crisis.

"Since 2008, China has turned to the U.S. for roundwood and we have become a leading exporter of the material. Russia was a big factor in the change. Before 2008, Russia supplied the bulk of Chinese demand but after the global crisis, Russia began imposing tariffs on the export. That's when the market shifted to us," Sun said.

Sun sought to examine the extent and degree of market integration of softwood log exports from the U.S. Pacific Northwest to China, Japan, and South Korea.

"There is a critical need to examine the dynamics and integration of Asian export markets of U.S. roundwood, in order to understand what's happening now and what long-term trends we may see in the future," he said.

Scientists analyze exports of U.S. softwood logs to Asian countries. (Stock photo)

Sun examined roundwood exports from five custom U.S. districts from Anchorage, Alaska to Los Angeles, California over a period of 22 years from 1996 to 2018. He analyzed each market against the three destination countries of Japan, South Korea, and China.

Sun said there were some surprises in the analysis, noting that export price varied greatly depending upon the product's district of origin and its final destination.

"You would expect each U.S. district to be highly integrated without much difference in pricing between them but over time and in relation to specific destination countries we see the final price paid by each destination country vary significantly," Sun said. "For instance, the average price per cubic meter of softwood log export ranges from $184 when it's traveling from the Columbia-Snake Customs District to Japan all the way up to $369 when it goes from Los Angeles to China."

Sun said overall, the project demonstrated how China as its own market behaves differently from the markets of Japan and South Korea.

"We learned that the Japanese and South Korean markets are much more integrated, and that China's prices have been evolving more independently," Sun said. "This rigorous research revealed that China's behavior in the market is very different from our marketplace experience with Japan and South Korea historically. Knowing this helps stakeholders understand that trade with China requires a completely different approach." ❖

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

HELPING PYROPHYTES FIGHT BACK

Prescribed fire is most often associated with pine, however, research suggests that fire suppression in upland forests across the Southeastern U.S. is inhibiting oak regeneration. The shift from pyrophytic, or fire-dependent, oaks and pines to more shade-tolerant, fire-sensitive species can change forest dynamics. Since pyrophytic species provide many ecosystem services, from nutrient cycling to wildlife habitat and more, researchers in the Forest and Wildlife Research Center hope to learn more about ways to protect these systems.

Dr. Heather Alexander—who has studied fire in forests from the deep South to Siberia—is researching the effects of fire suppression on dwindling upland oak and pine populations. Historically, upland forests have consisted of a large population of fire-dependent oak species that contribute to a positive feedback cycle within the forests. An example of this cycle is when fire sweeps through a forest, the fire-resistant oak seedlings and saplings are able to survive in a greater abundance than their competition, grow up, and drop flammable leaves to offer kindling for the next fire.

"These upland oaks and pines influence their growing environment in a way that helps them but hinders their competition," Alexander explained.

However, without fire as a part of the ecosystem, these oaks are being rapidly beaten-out for resources by their fire-sensitive competitors, or mesophytes, who, in turn, participate in a positive feedback cycle of their own. Without fire, these mesophytes beat out their oak competitors for resources, grow up, and drop water-logged leaves in order to suppress or lessen any future fires and perpetuate their advantage.

Alexander is studying the properties of these leaves, as well as what the ratio of these two leaf types in leaf litter means for fire and for the broader ecosystem.

"Those mesophytic species don't often provide the same ecological services that upland oaks and pines do in terms of habitat or food for wildlife. The question then becomes, what is it about them that discourages fire? Is there a point where, once you have so many of these mesophytic species in the forest, even if you tried to put fire back into that system, you couldn't because the litter wouldn't ignite?" Alexander said.

To answer these questions, Alexander and her colleagues set fire to plots of carefully mixed batches of leaf litter, with each plot containing a specified ratio of mesophytic to pyrophytic leaf litter. They then measured a number of factors to determine the volatility of the fires, including rate of spread, flame height, and ground consumption. From there, they determined whether or not there was a suppression of fire as the mesophytic litter became more dominate.

"What we found is that there is a linear response. The more mesophytic species there are, the less flammable our forests are," Alexander explained. "Take winged elms, for example. They're very weedy, very abundant, and they are the least flammable tree species I've come across. We tried to burn winged elm leaf litter. It went about as far as the gasoline from the drip torch and just died."

With less productive fires, fewer of the oaks and pines will survive into adulthood, meaning that the already meso-leaning forest composition may, one day, become completely unable to burn, putting the upland oak and pine positive feedback cycles in danger.

"We're very concerned about our upland oaks and pines," Alexander said. "We'll never lose them completely. We can create very specific conditions for them to grow, clear-cut plots and the open conditions they like to grow in, but it's like animals in the zoo. It's very different than letting it unfold naturally. What we're doing is much more about recreating a sort of natural disturbance plan."

Alexander hopes, through her research, to be able to provide forest managers with a guide as to how to most effectively burn in forests, in order to restore the desired forest composition. ❖

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

Fire in upland oak and pine forests lessens competition from undesirable species. (Photo by David Ammon)

LANDOWNER PERCEPTIONS ON OIL AND NATURAL GAS ACTIVITY ON FOREST LAND

As advances in technologies in the oil and gas industry increase onshore drilling in the United States, landowners and policymakers alike must find ways to navigate the new terrain from an economic, social, and environmental standpoint.

Dr. Rachael Carter is an economist and community development specialist for the MSU Extension Service's Center for Government and Community Development. As oil and natural gas leasing increased in Mississippi, Carter received more and more questions about the subject from policymakers, landowners, and various stakeholders. In an effort to find the answers government officials and constituents needed, Carter sought to learn more about the industry herself.

She made the topic the subject of her recent doctoral dissertation in forest resources. She earned her doctorate in December 2018 under the direction of Dr. Stephen Grado, professor of forestry and scientist in the Forest and Wildlife Research Center.

"This is a topical area that isn't often researched that will be key for policymakers and landowners alike going forward," Grado said. "Rachael was diligent in uncovering and analyzing important information about existing policies and learning about landowner perceptions when it comes to oil and natural gas leases."

Carter set out to investigate the balance of power at the federal, state, and local level in states considered large markets for drilling. She also delved into land use policies currently in place. Last, she sought to learn more about the perspective of landowners to determine what influenced their decision-making processes from buying land to leasing practices to support of resource management policies.

When Carter examined the political landscape across nine USDA Forest Service regions to determine how that balance impacts environmental regulation, she found that oftentimes the bulk of the authority rests with the individual state. Federal policies tended to settle disputes and municipal policies were overruled when they conflicted with state regulations.

She then surveyed 1,200 Mississippi landowners with more than 10 acres of land in six counties in the southwestern portion of the state situated on top of the Tuscaloosa Marine Shale play. The region had seen an uptick in drilling in the last five years and the mailed surveys were designed based on prior research of landowner and land use information. With a 24 percent response rate, Carter found that more than 63 percent of landowners gave equal priority to economic returns and environmental protections when it came to potential drilling.

"This data was particularly interesting to me because more than 50 percent of the landowners said they had a friend or family member employed by the oil and gas industry, and yet they still believed that more transparency, communication, and better leasing practices were needed," she said.

Carter said the research should help policymakers when it comes to developing oil and natural gas regulations.

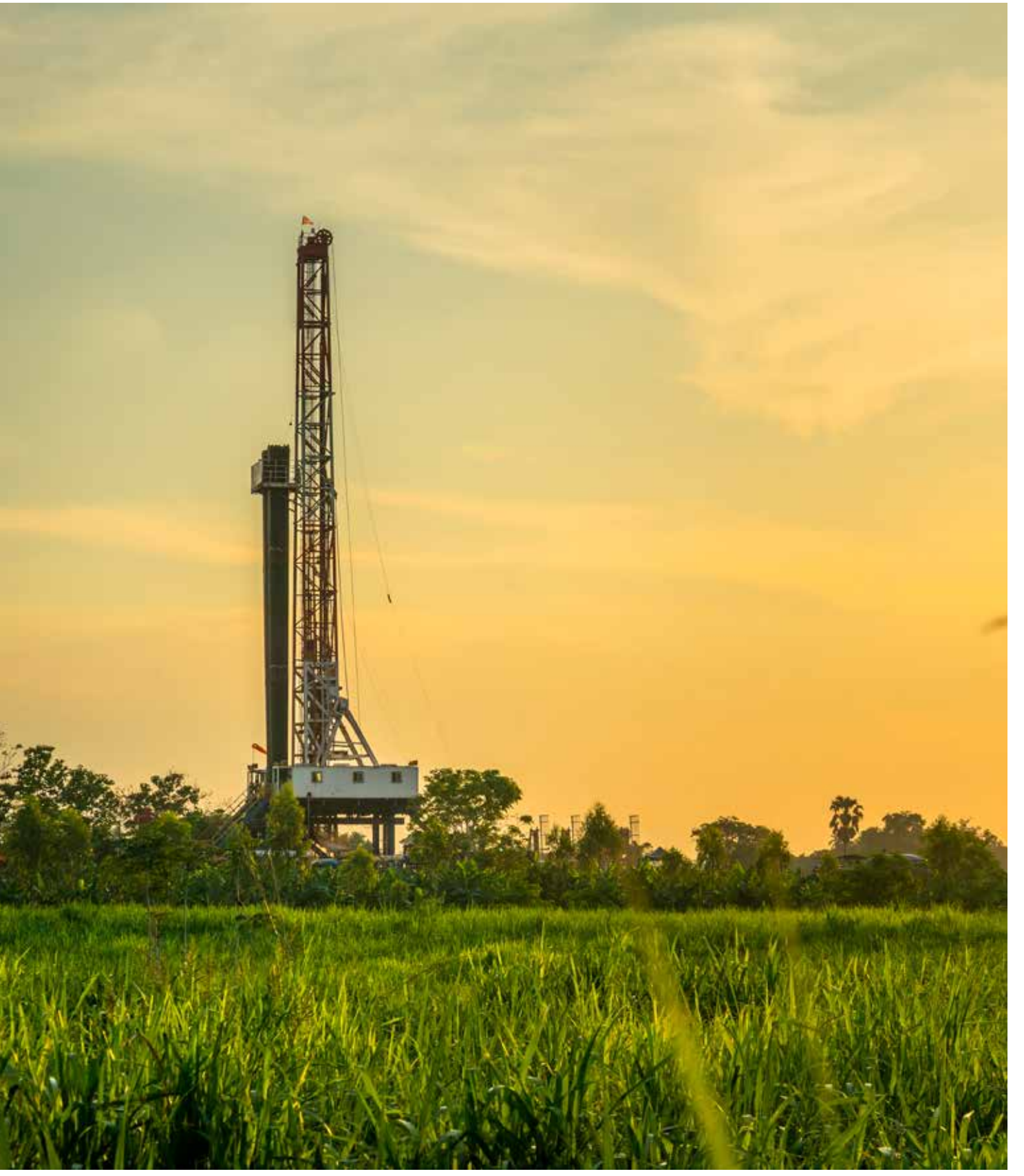
"Landowner values such as reasons for landownership, economic stability, and potential community impacts, influenced decision making. Policymakers should be aware landowners are concerned about the need for policies that protect their property for investment and future generations, as well as the benefits to the local economy," Carter said.

She said she was most excited about discovering that landowners sought that balance between environmental protection and economic gain.

"These landowners, many of whom have close ties to the oil and natural gas industry, say that there needs to be a balance. While they are interested in the potential economic benefit an oil and natural gas lease may bring, they also place priority on preserving the land to hand it down to future generations. They are seeking sensible, responsible development," Carter said. ❖

The research is funded by the MSU Forest and Wildlife Research Center, the Houston Advanced Research Center, the Environmentally Friendly Drilling Alliance, and the Southern Risk Management Education Center. Dr. W. Daryl Jones, extension professor in the Department of Wildlife, Fisheries and Aquaculture; Dr. Steve Martin, associate director of the MSU Extension Service; and Dr. Marty Wiseman, Professor Emeritus of Political Science and Public Administration and Director Emeritus of the Stennis Institute of Government at Mississippi State University, also served on Carter's committee and contributed to the work.

Onshore drilling rig next to an agricultural field. (Stock photo)



Graduate Student Profile:

Thu Ya Kyaw

HOMETOWN: Sintgaing, Mandalay Region, Myanmar

CAN TREES AID IN NUTRIENT MANAGEMENT IN THE LOWER MISSISSIPPI ALLUVIAL VALLEY?

Thu Ya Kyaw collects water samples in the field. (Photo submitted)

A FIRST-GENERATION FORESTER FROM MYANMAR is trying to help improve water quality in the Lower Mississippi Alluvial Valley.

The Lower Mississippi Alluvial Valley, or LMAV, consists of 25 million acres spanning seven states. This floodplain is responsible for draining 40 percent of the contingent United States. The LMAV is home to forested and wetland habitat critical to native and migrating wildlife and birds. The area is also home to some of the country's richest agricultural lands. Over the last several years, nutrients from agricultural production have degraded water quality in the region impacting the tributaries that flow into the Mississippi River and down to the Gulf of Mexico.

As part of his doctoral dissertation, Thu Ya Kyaw focuses on improving water quality in the LMAV. Kyaw, works under the direction of Dr. Heidi Renninger, assistant professor; Dr. Courtney Siegert, associate professor; and Dr. Randall Rousseau, extension and research professor all in the Department of Forestry and scientists in the Forest and Wildlife Research Center.

The team has set up a plantation in Sidon consisting of short rotation woody crops (SRWCs) between agricultural fields and waterways in a riparian area in the Mississippi Delta of the LMAV. Another SRWCs plantation will be established in Satartia, which is also part of the Mississippi Delta. The project, which will conclude in 2022, will evaluate several genotypes of three tree species such as willow, eastern cottonwood, and sycamore to see if they help mitigate the nitrogen moving into the watershed. They planted 300 trees each of willow and cottonwood in June 2018, and open-pollinated sycamore families were planted during fall 2019. They will assess the ecosystem services the plants provide including their ability to remove nitrogen from the soil. Additionally, the team will evaluate the productivity of the trees, as potential revenue of woody biomass on lands adjacent to agriculture. The sites were selected because they are marginal lands where conventional agriculture is less profitable because of seasonal flooding and low water availability in the summer and fall. Researchers hope to identify species and genotypes that farmers can plant on lands like this as a potential source of extra income.

"If we plant trees between agricultural lands and the river, our hypothesis is that if the nutrients have to pass through our plantation, our trees will absorb the nutrients, diminishing runoff into the river. We are trying to remove the excess nitrogen from the system to improve water quality," Kyaw said.

Kyaw continued, "We hope to identify specific genotypes of these species that can achieve superior productivity on marginal lands in this region while also providing optimal water use and nitrogen efficiency."

Kyaw earned an undergraduate degree in forestry from the University of Forestry and Environmental Science in Myanmar in 2012. For the next four years, he worked for the Myanmar Forest Department as a range officer. After that, in 2016, Kyaw was one of ten candidates in the country selected by the Fulbright Foreign Student Scholarship Program to pursue a master's degree abroad. Kyaw chose to earn a master's in forest and natural resources management at the State University of New York College of Environmental Science and Forestry (SUNY ESF) in Syracuse, New York. After completing that degree, he came to MSU for his doctoral studies.

Kyaw said this particular project is exciting for two reasons—one because the study itself is unique and two because it gives him exposure to so many different areas of expertise.

"I will be excited to see which species and genotypes are best suited when it comes to excess nitrogen removal, water use efficiency and biomass production, the combination of which hasn't yet been researched extensively in the U.S.," Kyaw said. "This project is also professionally interesting to me because I get to learn about hydrology, chemistry, soils and plant physiology. Simultaneously, I am attempting to integrate hyperspectral remote sensing, spatial analysis and programming knowledge into the project. After this, I will have skills in a lot of different areas. At the end of the project, I can define myself as a computational ecologist." ❖

The research is funded by the MSU Forest and Wildlife Research Center and is based upon work that is financially supported by the Agriculture and Food Research Initiative [#2018-67020-27934] from the U.S. Department of Agriculture's National Institute of Food and Agriculture.

FACULTY

Donald L. Grebner
George L. Switzer Professor of Forestry and Head

Heather Alexander
Associate Professor

John B. Auel
Assistant Extension Professor

Stephen C. Grado
George L. Switzer Professor of Forestry

Robert Grala
Professor, James R. Morton Fellow in Forestry

Joshua Granger
Assistant Professor

John D. Kushla
Extension/Research Professor

Ian A. Munn
Sharp Professor of Forestry, CFR Associate Dean

Krishna Poudel
Assistant Professor

Heidi Renninger
Assistant Professor

Randall Rousseau
Extension/Research Professor, James R. Morton Fellow in Forestry

Brady Self
Associate Extension Professor

Courtney Siegert
Assistant Professor

Changyou "Edwin" Sun
George L. Switzer Professor of Forestry

Jia Yang
Assistant Professor

EMERITUS FACULTY

Stephen G. Dicke
William Elam
David L. Evans
Andrew W. Ezell
John E. Gunter
H. Glenn Hughes
Bob Karr
Samuel Land
Tom Monaghan
Scott D. Roberts
William Watson

ADJUNCT FACULTY

David N. Appel
Quang V. Cao
Daniel C. Dey
Zhaofei (Joseph) Fan
Matthew A. Freeman
Emile S. Gardiner
Jeff A. Hatten
Tracy S. Hawkins
Richard F. Keim
John S. Kush
Theodor D. Leininger
Michael M. Loranty
Albert Mayfield III
Ryan McEwan
James S. Meadows
Thomas A. Monaghan
Ying Ouyang

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.

A TOOLKIT FOR GULF RESTORATION

The Deepwater Horizon oil spill happened nearly a decade ago. In 2012, the RESTORE Act—aimed at restoring the long-term health of the Gulf's ecosystem and economy after the spill—was signed into law and continues to allocate funds for conservation projects focused on restoration across the Gulf states.

As restoration efforts are underway, scientists are confronted with designing and communicating research proposals that highlight the proposed project's environmental benefits. That is why scientists in MSU's Forest and Wildlife Research Center have collaborated with the U.S. Fish and Wildlife Service to build a toolkit to make planning strategic conservation across the Gulf much easier.

In the second year of a three-year project, the Strategic Conservation Assessment research team is developing tools that estimate the environmental benefits of a proposed project in order to help researchers, states, and agencies better plan and fund land conservation projects along the Gulf.

Dr. Kristine Evans, an FWRC scientist in the Department of Wildlife, Fisheries and Aquaculture, said the project is aimed at strategically implementing conservation at the landscape level.

"Our goal is to help support a land conservation strategy that builds upon the existing network of state, federal, and private conservation areas and working lands to expand the scale of conservation lands across administrative and political boundaries. This project supports management and land stewardship for the public or private entity best suited for meeting long-term conservation objectives all while incorporating emerging information on the ecological benefits of conservation," Evans said.

The team engaged stakeholders in Mississippi, Alabama, Florida, Louisiana, and Texas, through two rounds of Gulf-wide meetings.

"We wanted to understand what priorities existed at the community level according to the people already invested in land conservation there," Evans said.

Once the team collected data from stakeholders, they set to building the toolkit.

The first tool is a searchable inventory of conservation plans and priorities across the Gulf.

"If stakeholders want to understand what conservation plans already exist on the landscape, they access an interactive map and essentially pick the point in space to see what kind of plans are already out there that cover that area," Evans said.

The second tool called the conservation prioritization tool, or CPT, gives stakeholders a chance to evaluate an area of interest for conservation value and even lets stakeholders explore key datasets within their own areas of interest.

Jennifer Roberts, research program manager, said the CPT offers stakeholders different ways to evaluate their proposed projects.

"The CPT is an evaluation tool that categorizes proposed conservation projects according to how well they meet individual RESTORE goals and helps users identify opportunities for developing proposals that best align with RESTORE Council's funding priorities," Roberts said.

The third tool, called the strategic conservation assessment, or SCA for short, currently in development, will provide users access to maps that depict where land conservation may best match their sets of priorities across the Gulf landscape.

"The CPT will let stakeholders explore their own areas of interest and use the prioritization feature to analyze known potential project sites and quantify benefits. Meanwhile the SCA enables users to search the Gulf Coast region to identify potential locations where land conservation can protect habitat, water quality, living coastal and marine resources, community resilience, and the Gulf economy," Roberts said.

Evans said she's excited about the project's impact on the Gulf Coast well into the future.

"Fifty years from now, when somebody looks at a protected area on the Gulf Coast, there is a good chance that these tools helped in protecting that site. MSU is essentially helping shape the future of the entire Gulf of Mexico region," Evans said.

For more information on the project, visit www.landscope.org/gulfcoast/. ❖

This work is funded through the Gulf Ecosystem Restoration Council through the Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies, or RESTORE Act. Priorities include restoration and conservation of habitat, water quality, and quantity; replenishment and protection of living coastal and marine resources, enhancement of community resilience; and restoration and revitalization of the Gulf's economy.

Alligator Lake at Bon Secour. (Photo by Keenan Adams)

AMAZON SECRETS HELP MISSISSIPPI'S SINGING RIVER

Dr. Sandra Correa plants seeds removed from fish stomachs in Pantanal, Brazil. (Photo submitted)

When an FWRC scientist first saw the Pascagoula River, she thought of the rivers back home. Dr. Sandra Correa grew up in Colombia, South America, and has studied the Amazon River and tributaries for more than 20 years. She saw parallels between the 4,000-mile-long behemoth and the Pascagoula.

Known as the Singing River, the Pascagoula is an 80-mile long river that is the largest undammed river in the contiguous United States. Both the Pascagoula and the Amazon flood for extended periods of time each year and Correa said from an ecological and evolutionary standpoint, these flooded rivers provide unique insight into the fish who have to adapt to these changing habitats.

"Because annual flooding is predictable, it allows for plants and animals to develop adaptations to survive the flood and take advantage of the dry and flood cycles," Correa said.

In the Amazon, Correa said that the flooding season lasts up to six months with the river rising more than 30 feet. Her research there focused on studying fish communities and how seasonal changes in the water level influenced their associations with particular habitats. In particular, she investigated the diets of fish during the flood stage, which also happens to be the peak of fruit tree production in the forest.

"I found that during the flood season, fruit-eating fish have a very narrow diet highly dominated by fruits. But as the availability of fruit decreases with the reduction in water level, each fish species respond in a different way: some fish eat forest insects while others eat leaves or flowers or adopt very broad diets. These shifts in diet allow a large number of fish species to coexist during periods of food scarcity and reduce potential for competition on limited resources," Correa said.

Correa is now applying her work in the Amazon to Mississippi's Singing River—the Pascagoula—which floods from three to six feet for approximately three months each year.

Essentially, Correa's lab research is focused on how the flooded forest contributes to maintaining fish productivity.

"We want to know how resources brought by flooding influence fish diversity and how habitat complexity influences species diversity," she said. "We are also interested in the ecological role of fish in floodplain forests. For instance, in the Amazon, we found that a single fish is responsible for the dispersal of up to 8,000 seeds that are viable for germination. That's critical for the 90 percent of woody plants in tropical forests that depend on fruit-eating animals to disperse their seeds."

Thus far, the team is collaborating with scientists in the Department of Forestry to better understand land diversity around the Pascagoula. The team will establish plots to monitor forest composition including vegetation, evaluating diversity, age, and primary productivity. They will then determine how this composition influences fish diversity in the river.

"My ultimate goal is to understand the ecosystem because in a flooded forest in the U.S., you have a huge diversity of animals—everything from crayfish to black bears. What I believe is that bottomland hardwood forests are maintaining wildlife diversity. I am starting with the first step—to prove bottomland hardwood forests are maintaining fish," Correa said.

She pointed out that the research provides an opportunity to save these diminishing landscapes.

"This is an opportunity to see flooded forests as functional landscapes with a natural cycle of flooding. How can we apply the lessons we learned in the Amazon to the Pascagoula and demonstrate that these flooded forests are providing important habitat for wildlife and fish here in Mississippi?" she said. "By answering this question, we can protect this land and these waters." ❖

Collaborators include Dr. Joshua Granger, assistant professor in the Department of Forestry. Wildlife, fisheries and aquaculture team members include master's student, Conner Owens; doctoral student, Karold Coronado Franco; and post-doctorate Dr. Lucelia Carvalho. Dr. Pablo Tedesco, with the Institute of Research for Development in Toulouse, France, is also a collaborator. This work is funded by the MSU Forest and Wildlife Research Center. Previous research has been funded by the Eppley Family Foundation, National Geographic, and The Wildlife Conservation Society.

SCIENTISTS SEARCH FOR PEAK 'GOBBLE' SEASON

EACH SPRING, TURKEY HUNTERS COVER THEMSELVES from head to toe in camouflage, head into the woods to find the perfect spot, take out a small wooden box and begin moving the top of the box to make a screeching sound which mimics a female. Their objective is to engage the elusive male turkey.

Spring turkey hunting is a mix of tradition, culture, and economics. It occurs when turkeys are at the height of courtship. Males gobble and strut in full-force to bring in as many female hens as possible and ward off other males within their territory.

Recently, turkey hunters in the southern part of the state thought the season began too late, after peak gobbling activity had ended. At the other end of the state, northern Mississippi hunters thought the season began too early, before turkeys began their ritual vocalizations and courtships.

The Mississippi Department of Wildlife, Fisheries and Parks, the state agency responsible for setting the hunting season, called on Dr. Francisco J. Vilella, a scientist in the U.S. Geological Survey's Cooperative Fish and Wildlife Research Unit and a professor in the MSU Forest and Wildlife Research Center, to determine if the supposed disparity occurred.

To determine peak gobbling season, Vilella, graduate students, and biologists in the Mississippi Department of Wildlife, Fisheries and Parks, analyzed gobbling activity in the northern and southern parts of the state.

FWRC researchers hope to better determine peak gobbling season. (Photo submitted)

"We divided the state into two surveying regions, north of Highway 82 and south of Highway 84," Vilella said. "We did not survey the central part of the state."

Scientists conducted eight surveys in the northern part of the state and seven surveys in the southern part of the state. Each route consisted of 10 stops approximately one mile apart. Each route was surveyed twice a week beginning 30 minutes before sunrise during the hunting season. At each stop, scientists would listen for four minutes and record the number of gobbles and gobblers heard. Scientists conducted the study over two hunting seasons.

"We found that gobbling intensity did vary between the southern and northern parts of the state with a 10- to 14-day difference in peak gobbling activity," Vilella said. "However, the majority of all gobbling activity occurred within the spring hunting timeframe established by MDWFP regardless of location."

While the scientists weren't surprised to find a difference in the timing of peak gobbling activity between the northern and southern regions of the state, they were surprised to find the effect of weather on the ritual turkey courtship.

"The claim by hunters that there is a latitudinal gradient in peak gobbling activity agrees with the common biological hypothesis that seasonal breeding behavior is triggered with an increase in the length of daylight, which also follows a latitudinal gradient," Vilella said.

While latitude can influence the onset of the wild turkey breeding season, weather conditions can affect within season behavior or the turkeys' propensity to gobble, Vilella added.

Scientists assessed daily variation in weather conditions from categories generated from the Spatial Synoptic Classification (SSC) system. The SSC uses surface-based data to establish air-mass types for an area and then classifies those types in seven categories: dry moderate, dry polar, dry tropical, moist moderate, moist polar, moist tropical, and transitional.

Scientists aggregated the SSC categories based on humidity or temperature. The three humidity categories were dry, moist, and transitional. The four temperature categories were polar, moderate, tropical, and transitional.

"We found that the odds of hearing a turkey gobble on dry days were far greater than the odds of hearing gobbling on moist or transitional days," Vilella said. "We found that days with low humidity and winds from the north or west, generally following a cold front, are the best days to hear turkeys gobble during the spring gobbling season."

The information could prove valuable to turkey hunters who spend an estimated $90 million annually in the state through direct, indirect, and induced expenditures.

"Turkey hunting is a rich tradition in the state, but perhaps before hunters take to the field, they should first check the weather, to better their chances for a productive hunt," Vilella added. ❖

Matt Palumbo, a former wildlife, fisheries and aquaculture graduate student contributed to this study. This study was funded by the Mississippi Department of Wildlife, Fisheries and Parks and the Mississippi Chapter of the National Wild Turkey Federation.

WHERE HAVE ALL THE BUCKS GONE?

IT'S FINALLY HERE AND IT FEELS LIKE YOU'VE WAITED all year for this. The trail cams have been set out for months. You've been watching. You think you know who's who. There's one in particular. A ten-point buck you've seen on the camera a half a dozen times at least. It's a perfect predawn Saturday with a calm breeze. You head to the blind. You wait and wait and wonder where has the buck gone?

This scenario happens more often than many hunters care to admit. They see nice-sized bucks on trail cameras around their hunting club or property and then once hunting season commences, it's like the prized bucks have vanished into thin air. That's why researchers in the MSU Forest and Wildlife Research Center partnered with the Mississippi Department of Wildlife, Fisheries and Parks to study both buck and hunter locations in order to determine things like behavior and geographic overlap.

Dr. Bronson Strickland, the St. John Family Professor of Wildlife Management in the Department of Wildlife, Fisheries and Aquaculture and researcher in the Forest and Wildlife Research Center, said the team sought to answer questions that perplex hunters again and again.

"Hunters were primarily interested in learning whether or not big bucks moved out of range during hunting season and whether or not hunting impacted the time of day bucks were on the move," Strickland said.

The team used GPS collars to track bucks intensively for two years. They studied approximately 50 bucks collecting their location every 15 minutes during hunting season, which runs from October 1 through January 31, and every few hours during the rest of the year.

The study area encompassed 60,000 acres of diverse habitat along the Big Black River in Madison and Yazoo counties in Mississippi.

The team determined that in some cases the hunters were correct in thinking that the large buck they'd set their sights on had moved to another home range.

"When it comes to home range, we learned that bucks fell into one of three categories," Strickland explained. "One third of the bucks were home bodies who didn't leave their home range while another third established one home range before moving to an entirely different home range later on. The rest were somewhere on the scale between these two extremes."

Another hunter hunch was that bucks tended to move at night or during the middle of the day once hunting season commenced. Strickland says the data did not support this tidbit of conventional wisdom.

"We did not detect a temporal shift in buck movement during hunting season. The bucks still tended to move the most during sunrise and sunset with very little movement during the middle of the day or night," Strickland said.

FWRC researchers home in what defines the home range for area bucks. (Photo by Steve Gulledge)

Strickland said a unique aspect of this particular study was that in addition to collecting data on the bucks, the team asked hunters to self-report hunting data in the area. Hunters were able to record hunt start and finish time, hunt location, and deer harvested on the MSU Deer Lab app. That way researchers were able to truly investigate how buck behavior might change in the face of hunting pressure. More than 100 area hunters uploaded hunting data.

On that front, researchers found bucks in heavily hunted areas did tend to have smaller home ranges. They also determined that bucks tended to avoid areas frequently visited by hunters.

"This data tells us that over time bucks may learn to avoid areas with high traffic from humans. Instead of returning to the same stand every Saturday, it might be wiser for a hunter to wait for ideal conditions to hunt a particular area and then give that area a rest for a few weeks after the hunt."

Next steps include analyzing the data to better determine how bucks respond to hunting pressure and delving into details about what kind of vegetation and habitat bucks seek when selecting a home range. Wildlife, fisheries and aquaculture master's student Ashley Jones will investigate hunting pressure while wildlife, fisheries and aquaculture master's student Colby Henderson will focus on habitat.

Strickland said the study should help establish best management practices that help landowners and hunters alike.

"This information should help us determine ways land managers can manage—and not manage—for deer depending on their ultimate goals. The study also provides insight into certain questions hunters have wanted answered for years and will ultimately help them learn new ways to make the most out of their time in the blind." ❖

Collaborators include Drs. Stephen Demarais and Garrett Street. This work is funded through the Mississippi Department of Wildlife, Fisheries and Parks; the U.S. Forest Service; and the MSU Forest and Wildlife Research Center.

HOPPING FROM EXTINCTION TO SUCCESS

An unlikely amphibian, the Mississippi gopher frog, is on the road to recovery with the help of Mississippi State scientists. Listed in 2001 as an endangered species by the U.S. Fish and Wildlife Service, the population is now being reintroduced to the wild.

Dr. Andy Kouba, professor and head of the Department of Wildlife, Fisheries and Aquaculture, began working with populations of the Mississippi gopher frog in 2003 in his role as director of conservation research at the Memphis Zoo.

"The Mississippi gopher frog is one of the most, if not the most, endangered frog in the U.S.," Kouba said. "As an indicator species for the health of its surrounding ecosystem, it is important to understand why populations of the frog are disappearing and try to help the population recover."

Kouba went on to explain that amphibians, like frogs and salamanders, are considered indicator species because anything happening in the environment soaks through their permeable skin. Also, they have two life stages, an early aquatic stage and a terrestrial stage, which lets scientists know what is happening in two different environments.

"Globally, it is estimated that 40 percent of amphibians are threatened with extinction," Kouba added. "In the U.S., that number is closer to 50 percent, which tells us that something is going on in their environment. Although the major threat to amphibians in the U.S. is habitat loss, other stressors such as disease, invasive species, and climate change are contributing to the declines."

Amphibians are the canary in the coal mine, Kouba added, one of the first animals to show declines in the wild due to poor environmental conditions.

In the case of the Mississippi gopher frog, a new disease was discovered in their last remaining breeding pond in Mississippi. Scientists were concerned that the animal would go extinct, so they sent tadpoles to the Memphis Zoo as an assurance colony. Memphis Zoo staff began raising the only Mississippi gopher frogs in captivity and tried to breed the frogs naturally but were unsuccessful.

Kouba brought the problem to scientists at Mississippi State to help develop assisted reproductive technologies to breed the frogs in captivity, to boost their population and provide animals for reintroduction.

The reproductive technologies they developed for amphibians, such as hormone therapy and in vitro fertilization, are very similar to those developed for humans, except even simpler since amphibians have external fertilization. The team also successfully cryopreserved sperm from the males to preserve the amphibian's genes, which could be used long into the future even after an animal's death.

In 2007, the scientists were able to breed the first test tube Mississippi gopher frog. The team quickly went to work, producing new frogs through these assisted breeding technologies.

"All of a sudden we had thousands of Mississippi gopher frogs," Kouba said. "We actually had more after assisted breeding events than what was estimated to be left in the wild."

The frogs were distributed to different zoos, along with transferring the breeding technologies, and once new ponds were located, zoos began releasing frogs into the wild. Dr. Ruth Marcec, former doctoral student and now director of the National Amphibian Conservation Center at the Detroit Zoo continues to travel around the country producing gopher frogs for the reintroduction program using the Mississippi State protocols.

When Kouba accepted a position at Mississippi State as a professor in the Forest and Wildlife Research Center, he set out to develop a national repository of reproductive cells for threatened amphibians that could be used to generate new live offspring.

Funded largely by the Institute of Museum and Library Services, Mississippi State became home to the world's first genome resource bank for threatened amphibians.

"We are trying to preserve as much of the amphibian biodiversity

around the country as possible as a hedge against extinction," Kouba said. "For example, we are collecting and cryopreserving sperm from wild and captive male amphibians that are threatened with extinction so that species are not permanently lost due to a catastrophic disease outbreak."

To date, ten amphibian species have had their genetics deposited in the frozen genome bank, including the Puerto Rican crested toad, Fowlers toad, Tiger salamander, Boreal toad, Houston toad, Chiricahua leopard frog, and the Mississippi gopher frog, among others. Kouba hopes to add more to the collection and look at a similar system for threatened reptiles.

"In the past, when animals were threatened with extinction, U.S. Fish and Wildlife Service working in collaboration with zoos, would often go collect some of these animals as an assurance colony, to preserve the species," Kouba said. "Occasionally additional animals would need to be removed to bolster the genetic diversity due to aging or non-reproductive animals. Now, we can go capture their genetics in reproductive cells, leave the animals in the wild, and grow the population to sustainable levels using frozen-thawed sperm to produce mixed wild-captive offspring. It's a new strategy for how to conserve amphibians and we are excited to be on the cutting-edge of this research to save wildlife." ❖

This research is funded by the Institute of Museum and Library Services, Morris Animal Foundation, MSU Forest and Wildlife Research Center, MSU Mississippi Agricultural and Forestry Experiment Station (MAFES), and the Association of Zoos and Aquariums. Approximately 10 zoos throughout the country have supported this research, in addition to many federal partners. In addition to Kouba, Dr. Scott Willard, MSU College of Agriculture and Life Sciences' associate dean and professor, and Dr. Carrie Vance, a MAFES scientist and assistant research professor in the Department of Biochemistry, Molecular Biology, Entomology and Plant Pathology, contributed to this research.

Master's student, Isabelle Burger, is engaged in research to help increase the population of the Mississippi gopher frog, listed as endangered in 2001. The frog is among ten amphibian species to have had their genetics deposited in the National Amphibian Genome Bank at Mississippi State. (Photo by Dominique Belcher)

Graduate Student Profile:

Shannon Westlake

HOMETOWN: Cayuta, New York

CONNECTING POLLINATORS AND PEOPLE

Doctoral student Shannon Westlake developed an extensive survey about the usage of pollinator practices. (Photo by Dominique Belcher)

Wildlife, fisheries and aquaculture doctoral student, Shannon Westlake, has been a nature fanatic since she was roaming around upstate New York in diapers. With most of her childhood being spent chasing bees and butterflies, it is no wonder that she ended up researching pollinator species at Mississippi State University.

Westlake was a biology major during her undergraduate career at the State University of New York at Potsdam, but has always had her eye on conservation. She completed a master's degree from Green Mountain College.

She said, "For my master's project, I created pollinator gardens. My hope was to connect people through food. We did both pollinator and food gardens at a local community center."

She explained that her master's research is what steered her to Mississippi State University. Westlake said, "What I was doing, and didn't realize it at the time, was human dimensions work because I was learning about how to connect different individuals to the land. Coming from a more rural area myself, I wanted to figure out how to do that with larger landowners."

Westlake had a vision to take her small scale master's research to a larger, more impactful audience. With the guidance of Dr. Kevin Hunt, wildlife, fisheries and aquaculture professor, she investigated the motivations and attitudes towards pollinator habitat adoption by large scale landowners.

She said, "How do we connect larger landowners within pollinator conservation? No one has really looked deeply into that. The majority of pollinator research is focused on the biological and ecological components, and I really wanted to look at the sociological aspects."

Westlake developed an extensive survey about the usage of pollinator conservation practices. Along with the survey, she also developed a leaflet with information about pollinators and the habitat crisis they are facing each day.

She found that 60 percent of the population sampled has already adopted pollinator conservation tactics as of Summer 2018. Westlake also discovered that over 30 percent of survey participants had plans to adopt pollinator conservation techniques within the next year.

She admits that the reasoning behind the adoption of these practices may not be specifically intended for pollinator conservation. Some may have other motivations in adopting these conservation efforts. She explained, "Pollinator habitat is very beneficial for many other species such as, quail and turkey. This habitat is really beneficial for predatory pest insects in an agricultural landscape, as well. By putting these pollinator passages in their fields, landowners can benefit by drawing in these beneficial pollinator species."

She added, "The percentage rate of adoption was much higher than expected. But again, landowners may not be doing it for pollinators. They may be doing it for other benefits, but it will still benefit pollinators."

Westlake explained how her research confirmed that, overall, individuals have favorable attitudes towards pollinator species and pollinator conservation. The largest deterrents for widespread adoption were knowledge and skills.

She said, "What was really holding landowners back from doing more conservation efforts was knowledge and other constraints like time, skills, and resources. That really speaks to the idea that it's not that people don't like pollinators or don't want to adopt these practices. It's that they just don't have the knowledge or skills to be able to do them."

Westlake concluded, "The bottom line is that more pollinators in an ecosystem will lead to more biodiversity on the landscape. We want to support pollinators, other wildlife, and put more native species back into the ground. If we are able to do that, we will create a healthier ecosystem overall." ❖

Westlake's research was funded through the MSU Forest and Wildlife Research Center's Human Dimensions and Conservation Law Enforcement Laboratory.

FACULTY

Andrew Kouba
Dale H. Arner Professor of Wildlife Ecology and Management and Head

Suja Aarattuthodiyil
Assistant Research Professor

Peter Allen
Associate Professor

Jimmy Avery
Extension Professor

Christopher Ayers
Instructor

Beth Baker
Assistant Extension Professor

Leslie Burger
Assistant Extension Professor

Wes Burger
Giles Distinguished Professor and Associate Direector, FWRC

Just Cerbrian
Research Professor

Michael Colvin
Assistant Professor

Sandra Correa
Assistant Professor

Chad Dacus
Extension Instructor

Brian Davis
James C. Kennedy Endowed Associate Professor in Waterfowl and Wetlands Conservation

Steve Demarais
Taylor Chair in Applied Big Game Research and Instruction, Dale H. Arner Professor of Wildlife Ecology and Management

Marcus Drymon
Assistant Extension Professor

Scott Edwards
Extension Instructor

Kristine Evans
Assistant Professor

Terrence Greenway
Assistant Professor

Stacy Hines
Instructor

Kevin Hunt
Sharp Professor of Human Dimensions

Ray Iglay
Assistant Professor

Daryl Jones
Extension Professor

Ganesh Karunakaran
Assistant Research Professor

Menghe Li
Research Professor

Mark McConnell
Assistant Professor

Steve Miranda
Professor

Charles Mischke
Research Professor

Dana Morin
Assistant Professor

Wes Neal
Extension Professor

Scott Rush
Associate Professor

Andrew Smith
Extension Instructor

Eric Sparks
Assistant Extension Professor

Garrett Street
Assistant Professor

Bronson Strickland
St. John Family Endowed Professor of Wildlife Management

Adam Tullos
Extension Instructor

Francisco Vilella
Professor

Guiming Wang
Professor

David Wise
Research Professor

Mark Woodrey
Assistant Research Professor

EMERITUS FACULTY

David Burrage
Lou D'Abramo
Eric Dibble
Donald Jackson
Harry Jacobson
Jeanne Jones
Rick Kaminski
Bruce Leopold
Jim Miller
Randall Robinette
James Steeby
Craig Tucker

ADJUNCT FACULTY

Travis DeVault
Brian Dorr
Kris Godwin

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.

TAKE THE STAIRS

FWRC scientists are studying the strength of hardwood and softwood species used in the construction of stairs. (Photo by Dominique Belcher)

Oftentimes, we'll take the stairs to get in those few extra steps. As we climb toward better health, do we consider how much strength lies in the wood beneath our feet? While we may not think twice about the actual steps we take, there are others who do. The Stairbuilders and Manufacturers Association has partnered with scientists in the MSU Forest and Wildlife Research Center to assess the wood commonly used in constructing stairs.

Dr. Fred França, assistant research professor in the Department of Sustainable Bioproducts, is co-principal investigator on a three-year study that evaluates design values of domestic species in stair and guard construction. The team includes Drs. Jason Street, Rubin Shmulsky, Dan Seale, and Thomas Lim. França's group is focused on wood used in stair construction while Lim's team evaluates wood used in stair guard construction. The study is in its second year.

França's group is evaluating 1500 boards from five U.S. tree species. Four species are hardwoods including hard maple, yellow poplar, red, and white oak. The team is also evaluating the softwood, southern yellow pine. França said this is one of the first studies of its kind in almost 100 years.

"Much of the research stair builders and manufacturers currently rely on was conducted in the early twentieth century," França explained. "Our goal is to examine current design values used for domestic species and grades used in stair and guard systems and provide necessary technical information to update them as needed."

The team is conducting destructive testing on 300 boards from each species and assessing four mechanical properties including static bending, compression parallel to the grain, compression perpendicular to the grain, and Janka hardness—the resistance of wood to denting and wear. They are also assessing the physical property of specific gravity and two growth characteristics: the number of rings per inch and the percent of latewood, the part of the wood in a growth ring produced later in the season.

Lim, an assistant professor in the Department of Sustainable Bioproducts, is developing a computer model that can simulate the structural behavior of staircase guard systems. The modeling focus will be on predictions of the structural performance of the joints keeping the guards together. The model's accuracy will be confirmed using destructive test data, which will be collected as a part of the project.

"The successfully developed tool will be an alternative means over expensive destructive tests in evaluating the structural performance of staircase guards built with different wood species and dimensions," Lim said.

While the research is still ongoing, França hopes the ultimate findings will help stair builders and manufacturers select for wood species that result in sturdier steps.

"The development of design values for appearance grade domestic lumber will provide innovative ideas and solutions for the use of U.S. lumber in stair and guard construction," França said. "The opportunity to increase world demand of high-grade U.S. lumber for structural and architectural millwork is timely. U.S. building regulations are striving to enforce stricter structural requirements with more than an approving jump on the stairs or bump of the rail as has been the case for years in residential construction."

Graduate students on the project include sustainable bioproducts doctoral student, Nathan Irby, and master's students: Laurice Mara Spinelli Correa, Cristian Grecca Turkot, and Marly Carmona Uzcategui. ❖

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

PROTECTING A NEW BUILDING MATERIAL

A new building material is making its way into the U.S. market. Cross-laminated timber, or CLT, which has been used to construct large buildings in Europe for the last two decades is experiencing growth as a building material in the U.S. and Canada.

"As of March 2019, there are currently 545 buildings in North America either built or in the design phase using mass timber products such as CLT," said Dr. Beth Stokes, scientist in the Forest and Wildlife Research Center. "That's up from less than 20 buildings two years ago."

Doctoral student Gabrielly Dos Santos Bobadilha and Dr. Beth Stokes test CLT to protect from environmental elements. (Photo by Dominique Belcher)

CLT is one type of mass timber product used to compete with steel and concrete in custom large-scale projects. Thus far, there are three manufacturers producing CLT in the U.S.—two are in the Pacific Northwest (Oregon and Montana) and a third began operations in Alabama in 2018.

Stokes, who is an assistant professor in the Department of Sustainable Bioproducts, pointed out that the turn-key building approach CLT affords has plenty of benefits.

"When you build with CLT, it's like putting a puzzle together. The pieces are manufactured specifically for the building. Everything is taken to the site and bolted into place," Stokes said. "This material cuts down on construction costs, waste, and time to completion. Additionally, it's a sustainable, renewal resource that's great for carbon sequestration, reducing a building's carbon footprint."

Stokes said one issue is protecting the product during transportation and construction before it's installed and sealed into the building envelope.

"We hope to find a way to protect CLT from elements such as rain, heat, and high humidity," she said.

Stokes, along with doctoral student, Gabrielly Dos Santos Bobadilha, and others, are evaluating various coatings to protect CLT. They evaluated nearly 36 coatings, which they winnowed down to 12.

"Gaby performed water repellency tests on the dozen coatings that showed the most promise. We evaluated the results and selected the top five," Stokes said.

Now the team is researching how those five coatings hold up to water, heat, fungal decay, and more.

"We have several samples exposed to natural weather events that we will observe over the next five years. We are also conducting accelerated weathering tests, where the samples are exposed to large amounts of water and UV rays over a shorter period of time. We are measuring for things like water uptake and evaluating characteristics like color change using a spectrophotometer to determine how each individual coating best protects the CLT while maintaining a 'natural' appearance," Stokes said.

The research—in its fourth year—is part of a five-year study Stokes hopes to continue as the CLT industry grows.

"CLT is a product that's changing the building industry. Overall, CLT production is great for the timber industry because it means we can use smaller timbers to make a bigger product, potentially using a lot of the excess wood that would typically be destined for the paper and pulp industry and even some of the roundwood that those industries can't use. Additionally, our research, in particular, could also help open up a potential new market for coatings to protect this emerging timber product," she said. ❖

The research was funded by the USDA Forest Service Forest Products Laboratory. MSU collaborators include Dr. Mike Barnes, Dr. Thomas Lim, Chris McGinnis, David Butler, Brian Mitchell, and Beau Lovelace. USDA Forest Products Laboratory collaborator is Ms. Katie Ohno, an MSU alumna.

A BETTER, STRONGER WOOD PELLET

FWRC researchers hope to improve wood pellet strength, durability, and water resistance. (Photo by Dominique Belcher)

Wood pellets are big business as an export item. Europe consumes much of the U.S. wood pellet market to generate energy according to the USDA Foreign Agricultural Service. In fact, in 2018, the combined value of sales from the U.S. exports of wood pellets totaled $812 million or 6.04 million metric tons with transfers to the U.K. topping $646 million or 4.71 million metric tons. Since much of the pellet production in the U.S. comes from southern yellow pine in the Southeast, researchers in the Forest and Wildlife Research Center are studying ways to make a better, stronger wood pellet out of southern yellow pine.

Dr. Jason Street, assistant professor in the Department of Sustainable Bioproducts, and researcher in the Forest and Wildlife Center, is finding ways to improve wood pellet strength, durability, and water resistance. His team is evaluating hardwood, planer shavings, additives, and storage air-flow to improve the properties of southern yellow pine energy pellets.

"Essentially our goal has been to use particular additives to improve wood pellet characteristics while also lowering the power consumption required to produce southern pine energy pellets. We produce the pellets on an industrial scale and then test the performance of each additive according to the pellet's energy content, bulk density, moisture content, ash content, and durability," Street said.

Street said the research will help discover uses of byproducts from lumber mills to make an existing product better.

"One question I am constantly asked is how to get rid of all the residuals found at sawmills. We are attempting to improve the quality of wood pellets using materials that are currently thought of as waste and we have had successful trials already using various concentrations of these materials in the pelleting process," he said.

The three-year project, now in its second year, sought to investigate how different additives effected the performance and characteristics of southern yellow pine pellets. They tested southern yellow pine derived biochar and bio-oil as well as cornstarch, vegetable oil, sweet potatoes, microcrystalline cellulose, micronized rubber powder, and mixed hardwood planner shavings to see how each additive impacted pellet durability, bulk density, and higher heating value. They also conducted an economic feasibility study to determine if the additives could increase profit of the mill compared to the controls. They found that certain additives used for pellet production showed the potential to improve the overall properties of the wood biomass pellets while improving profits. These additives included hardwood planer shavings, biochar, micronized rubber powder, and bio-oil.

The team is continuing to home in on the best methodology.

"Many of the materials now considered waste can be used in pelleting if it's not dragged through the dirt or mud. Byproducts can also be upgraded to a bio-oil or biochar, which when added to the pelleting process improves the durability and energy content of the product," he said.

He hopes to continue to find ways to use limited-value materials while helping pellet manufacturers make more money.

"We are continuing to make improvements to southern yellow pine pellets while also lowering production costs with just a small percentage of renewable additives. We hope that this will eventually lead to an increased market demand on materials that are currently thought of as by-products. Utilizing as much of the wood product as possible can potentially lead landowners to be able to recover more revenue in timber production," Street said. ❖

Collaborators include James Wooten, extension associate III in the Department of Agricultural and Biological Engineering in the College of Agriculture and Life Sciences; Brian Mitchell, research associate III; and Cody Blake, doctoral student, both in the Department of Sustainable Bioproducts. Blake graduated in December 2018. Sponsors include Drax Biomass and USDA-Agricultural Research Service.

PLANT-BASED CHEMICALS OF THE FUTURE

FOSSIL FUELS ARE DECAYED PLANTS AND ANIMALS that have been converted to oil, coal, and natural gas through years of exposure to heat and pressure in the earth's crust. Petroleum, a common fossil fuel, is used to create over 6,000 different products.

There are issues related to the extended use of petroleum including environmental pollution and global warming. Add to this the diminishing reserves of fossil fuels. So, how do we replace this important chemical used in pharmaceuticals, solvents, fertilizers, pesticides, and plastics?

Dr. El Barbary Hassan, a chemist in the Department of Sustainable Bioproducts, and numerous other scientists are looking for a solution, which begins and ends with one of the principal components of fossil fuel creation...trees and woody plants.

Wood is a natural composite material consisting of different polymers such cellulose, hemicellulose and lignin. Cellulose is the substance that makes up most of a plant's cell walls and it is the most abundant natural material on earth.

"Cellulose is traditionally used to make paper, but it is currently considered as one of the major potential sources for production of fuels and industrial chemicals," Hassan said. "Converting cellulose to chemicals and fuels feedstock requires a catalyst, similar to the catalyst of time and pressure on plants and animals that created fossil fuels in the earth."

Synthesizing a catalyst that will render high yields of desirable chemicals at an affordable cost is a critical component to using plant-based biomass. Catalyst or catalytic systems can be metallic or non-metallic and are generally considered a one-use type system. Hassan and his team are working on developing an effective and inexpensive catalytic process with magnetic properties.

"We are developing a cost-effective nano catalytic system with magnetic properties which allows for the recovery of the catalyst so that it can be used repeatedly," Hassan said. "These magnetic nano catalysts have shown good stability and easy separation from the desired chemical compounds that we are producing compared to other catalysts used."

The scientists set out to convert cellulose to hydroxymethylfurfurlal, or HMF. This organic compound is a carbon-neutral feedstock used in the production of fuels and chemicals.

"HMF is an excellent molecule or building block from which chemicals and products can be made" Hassan said. "One of the most important oxidized derivatives of HMF is 2,5-furandicarboxylic acid, or FDCA, which is a building block for production of sustainable polymeric materials."

FDCA is a bio-based and environmentally-friendly substitute for terephthalic acid that is produced from petroleum crude oil. In the plastic industry, FDCA is widely used for the production of polyethylene terephthalate bottles and films.

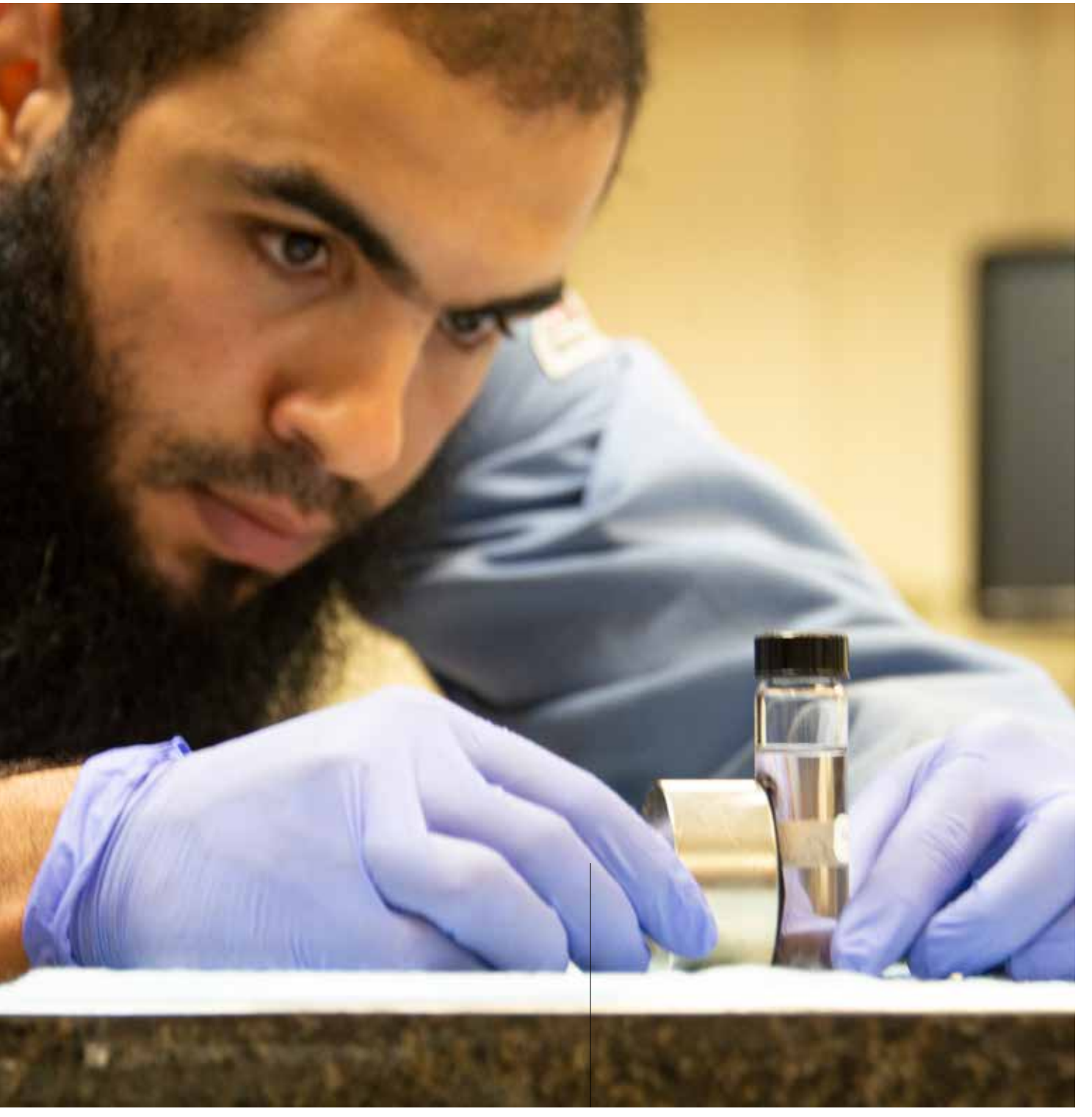
HMF can also be converted to 2,5-Dihydroxymethylfuran, or DHMF, which is an important component in the production of resins, fibers, foams, drugs, and polymers, among other products.

"Our goal is to develop chemical building blocks that can be combined and used to ultimately replace fossil fuels used in the production of numerous products which currently rely on petroleum," Hassan said. "Developing a magnetic catalyst that can be reused will save costs while also allowing us to perfect the chemicals of the future."

While the research is ongoing, Hassan's team has developed a catalyst that has been used repeatedly without losing any of the necessary properties needed to turn cellulose into chemicals. The catalyst has also demonstrated high yields in the production of important chemical building blocks. ❖

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

Postdoctoral associate Islam Elsayed is working with Dr. El Barbary Hassan to develop chemical building blocks that can be combined and used to ultimately replace fossil fuels. (Photo by Dominique Belcher)



FINDING A BETTER MODEL

IT IS ESTIMATED THAT THE AVERAGE SINGLE-FAMILY home in the U.S. includes 16,000 board feet of lumber for framing. Architects and engineers select grades and sizes of lumber for various components in construction of housing and buildings based on design values.

In 2013, after several years of testing and reassessment, the design values for southern pine dimension lumber were adjusted. This change impacted the utility value of several lumber grades and sizes, which in turn affects the value of pine logs on timberland in general.

When a statistician from the USDA Forest Products Laboratory (FPL) realized some of the models in the standards did not fit actual graded lumber data very well, FPL began cooperating with scientists in the Forest and Wildlife Research Center to help determine if a better model was available.

Dr. Frank Owens, a sustainable bioproducts assistant professor, and doctoral student Guangmei Anderson, began working on a project to evaluate various statistical models to determine if, perhaps, there was a better model for lumber standards.

Design values are strength-related values that appear in the back of lumber grading rule books. Engineers use them to help determine which grades, sizes, and quantities of lumber are needed to safely carry structural loads.

Strength design values are based on the propensity of the lumber to fail. If the propensity to fail is underestimated, building component failure may occur. Conversely, if the propensity to fail is overestimated (overly conservative), the value of lumber is diminished.

In general, the process of developing design values produces conservative (that is very safe) numbers and wood-frame building techniques use repetitive or redundant members.

Two of the main design values are on modulus of elasticity, or MOE, which measures stiffness, and modulus of rupture, or MOR, which measures strength. MOE can be obtained through either destructive or non-destructive testing, while MOR requires destructive testing. These two values are ultimately used to develop statistical models that are the basis for lumber standards.

"The existing models in the standards may lead to overly conservative conclusions about how well graded southern pine lumber can perform," Owens said. "Ultimately this costs Mississippi landowners and devalues pine lumber."

According to Owens, a lot has changed since the statistical models were developed.

"Our ability to compute and try on different models with our data has advanced significantly since the 60s, 70s, and 80s, when the sampling and statistical methods were evolving into the kinds we use today," Owens said.

Plus, the data Owens and Anderson are collecting is a little different than those used to develop the previous models.

"We are using mill-run lumber—all qualities of lumber that develop when logs are sawn—those that make grade and even those that fail to make grade and might otherwise be thrown out," Owens described. "Once we determine appropriate models for mill-run lumber, we should be able to mathematically derive better performance models for individual lumber grades."

The team has tested strength and stiffness of 2,000 specimens of mill-run 2x4 kiln dried softwood lumber from six U.S. sawmills. They have tested southern yellow pine from four Mississippi mills, and red pine and spruce from two northern mills.

The scientists are now analyzing how the strength and stiffness values are distributed statistically, how they relate to each other, and how they compare to current models in the standard.

"We have affirmed that the current models in the standards are not accurate and our testing has suggested that better models exist," Owens said. "While the research is on-going, we are optimistic that we can develop improved models for mechanical properties of graded lumber populations that will more accurately reflect how lumber actually performs."

Ultimately, more accurate assessment of lumber strength and stiffness values brings about better stumpage prices and higher sustainability. ❖

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

Doctoral student Guangmei Anderson, under the direction of Dr. Frank Owens, is evaluating various statistical models to determine a better way to determine lumber standards. (Photo by David Ammon)

Graduate Student Profile:

William Griffin

HOMETOWN: Jackson, Mississippi

MODELING THE FUTURE

Master's student William Griffin is collecting data to determine the profitability of a prospective sawmill location based on different aspects of production. (Photo by David Ammon)

With 19.7 million acres of forestland and 125,000 forest landowners, Mississippians understand the value of natural resources. In fact, the state is dominated by forests, with over 60 percent of the land area covered in forestland. Most of this land, 72 percent, is owned by private, non-industrial landowners.

Despite abundant natural resources in the state, Mississippi may not be getting its fair share of new forest products industry compared to other southern states.

William Griffin, a forester and a Sustainable Bioproducts graduate student, noticed that Mississippi may be overlooked for investment by forest products companies during his time as a forestry student.

"During my last semester of my forestry degree, I took a class with Dr. Dan Seale, a professor in Sustainable Bioproducts," Griffin said. "We began discussing the apparent disparity between states regarding the investment of forest products industry."

The conversation led to Griffin beginning a graduate program under the direction of Seale to work on a marketing study. The study hopes to build a decision tool to help industry evaluate the cost and available resources to place mills in the state.

Using Microsoft Access and a Linear Programming Solver developed by Seale, Griffin is collecting data to determine the profitability of a prospective sawmill location based on different aspects of production.

The team is measuring several factors that go into decision making for sawmills, including workforce readiness, distance to lumber markets, competing mills locations, competing mills production capacity, and state tax rates, among other variables. The team is also collecting electricity costs for different providers throughout the South.

The model contains data for each county in the Southeast, some 11 states and 1,104 counties. A large part of the data includes the distance from a potential mill to a potential market.

"We have built a file that has the mileage from every county seat to every lumber demand source," Griffin said. "We want to demonstrate that locating in Mississippi is profitable for companies. Our ultimate goal is for more mills to come to Mississippi, which in turn improves local economies, creates new jobs, and improves the selling price of timber for landowners."

While we can't make mills invest in the state, we can equip lawmakers and economic developers with the tools they need to incentivize forest products companies to locate in Mississippi, Griffin added.

For Griffin, the best part of the research is seeing both sides of natural resources. As an undergraduate, he became well versed in forestry. Now as a sustainable bioproducts graduate student, he has the opportunity to see how the end product is produced and sold.

"I have learned so much about the forestry side of our industry, growing timber, and now the forest products side, manufacturing timber into useful products," Griffin said. "I am excited about the future and how this model may contribute to economic prosperity in the state." ❖

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

FACULTY

Rubin Shmulsky
Head and Warren S. Thompson Professor of Wood Science and Technology

H. Mike Barnes
Warren S. Thompson Professor of Wood Science and Technology

Frederico França
Assistant Research Professor

Tamara França
Assistant Professor

El Barbary Hassan
Associate Professor

Yun Sang Kim
Assistant Professor

Hyungsuk Thomas Lim
Assistant Professor

Darrel D. Nicholas
Professor

Frank Owens
Assistant Professor

R. Dan Seale
Warren S. Thompson Professor of Wood Science and Technology; James R. Moreton Fellow in Sustainable Bioproducts

C. Elizabeth "Beth" Stokes
Assistant Professor

Jason Street
Assistant Professor

Jilei Zhang
Warren S. Thompson Professor of Wood Science and Technology

EMERITUS FACULTY

Terry Amburgey
Hamid Borazjani
Susan V. Diehl
Leonard Ingram, Jr.
Moon Kim
Duane Lyon
Philip Steele
Fred Taylor

ADJUNCT FACULTY

Zhiyong Cai
Patrick Donahue
Michael Dowd
Dragica Jeremic
Grant Kirker
Iris Montague
Robert Ross
Juliet Tang
Xiping Wang

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.

MSU JOINS URBAN WILDLIFE INFORMATION NETWORK

Researchers from Mississippi State University are teaming up with the Urban Wildlife Information Network (UWIN) to discover the secret life of animals in our urban and suburban neighborhoods in Mississippi. (Stock photo)

HAVE YOU EVER CONSIDERED ALL OF THE WILDLIFE that live hidden around your neighborhood, tucked in small patches of woods? Where does the raccoon that riffles through the garbage bin or the deer that eats your mother's azaleas go once the sun rises at dawn?

Researchers from Mississippi State University are teaming up with the Urban Wildlife Information Network (UWIN) to discover the secret life of animals in our urban and suburban neighborhoods in Mississippi.

Adam Rohnke, senior wildlife extension associate, and Dana Morin, assistant professor of wildlife ecology, both in the MSU Department of Wildlife, Fisheries and Aquaculture, will be working with UWIN, Master Naturalist volunteers, and graduate student Brittney Palode to learn what urban mammals are doing in Mississippi.

Morin, a scientist in the Forest and Wildlife Research Center, said urban wildlife are on the front lines of human-wildlife interactions.

"At a time where many animal populations are in decline due to an increasingly growing anthropogenic footprint, some species persist and even thrive in these environments becoming ambassadors for nature to a large part of the human population," said Morin, who pointed out that positive interactions can inspire curiosity, respect, and empathy.

She continued, "Negative interactions, or even just the threat of negative interactions, however, can inspire fear and cause confusion, resulting in cascading consequences on human quality of life and natural biodiversity. By studying animals in urban landscapes and in relation to the perspectives of the people in these areas we can better predict areas where conflicts may occur and generally facilitate human-wildlife coexistence to the benefit of both."

The researchers—by using remote-triggered game cameras—hope to identify what species are inhabiting different habitats such as parks, golf courses, cemeteries, and other natural areas in and around cities and towns. The images will also be used to tease out interesting information about behavior, such as what animals are not active when humans are around or what spaces animals may avoid when other, larger animals are present.

UWIN, initiated by the Lincoln Park Zoo, Chicago, IL, is a partnership of researchers from 21 cities across North America who are dedicated to studying wildlife in urban areas. The goal of UWIN is to standardize survey methods and share information gathered by the partners to identify urban wildlife population and behavioral trends with the intent to better understand urban wildlife ecology across cities. At the same time, data collected for a specific city can help inform urban planning, wildlife management, and promote public education about wildlife in our own backyards.

Morin directs the Carnivore and Population Ecology Laboratory at Mississippi State University. The lab is a part of the MSU Forest and Wildlife Research Center. Rohnke coordinates the Central MS Master Naturalist Program and provides educational programming to homeowners and landowners in Mississippi. ❖

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

UNDERGRADUATE RESEARCH

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

Undergraduate Student Profile:

Rachel Nation

HOMETOWN: Milton, Florida

THE IMPACT OF FIRE ON OAK GROWTH IN UPLAND FORESTS

Rachel Nation is studying the impact of fire on oak growth in upland forests. (Photo Submitted)

OAK SPECIES ARE ESSENTIAL IN UPLAND HARDWOOD forests and a decline in oaks can have detrimental impacts on such a forest, both economically and ecologically.

"From an economic standpoint, oaks are typically considered a high-value timber species which is used to produce lumber, furniture, flooring, and even whiskey barrels. From an ecological standpoint, oak species are important because they produce acorns, an important food source for wildlife such as deer and squirrels," said Rachel Nation, undergraduate researcher in the College of Forest Resources.

Nation is a senior MSU forestry major with a wildlife management concentration under the direction of Dr. Heather Alexander, assistant forestry professor in the Forest and Wildlife Research Center who studies and teaches forest and fire ecology. Nation hopes to further protect oak species in upland landscapes by studying how prescribed fire affects acorn germination.

In an environment whose flora composition is shifting away from the species, Nation said maintaining oak populations is vital and while fire can help in that restoration, scientists need to better understand how prescribed fire can impact acorn germination.

"Since fire is increasingly being used as a management tool to restore upland oak forests, the research suggests that—while prescribed fire is important for encouraging fire-tolerant oaks—it may be best to conduct the burns before acorns drop in the fall to avoid damaging them," Nation explained.

In an effort to explore the effects of prescribed fire, specifically fall burns with increasing fine fuel loads, such as leaf litter, on acorn germination and early oak seedling establishment, Nation worked alongside Alexander; Dr. Geoff Denny, an assistant extension professor in plant and soil sciences; Dr. Alison Paulson, a postdoctoral associate in forestry; and Jennifer McDaniel, a forestry graduate student. They implemented small-scale experimental burns in upland oak stands in northern Mississippi in December 2018. They tested four fuel load treatments: unburned, un-manipulated fuels, doubled fuels, and tripled fuels.

Nation placed acorns in plots with increasing levels of fuel loads during the late fall and then burned them. She then collected the acorns after burning and planted them in trays in the Mississippi Agricultural and Forestry Experiment Station's Environmental Plant Physiology Lab greenhouse at the R. R. Foil Plant Science Research Center to determine if the acorns would germinate, and if so, how fast they would grow.

Nation found that acorn mortality increased with increasing fuel loads. Acorns burned under un-manipulated fuel loads experienced 40-60 percent mortality, but they grew just as fast as seedlings originating from unburned acorns, while acorns burned at 2-3 times the control fuel loads showed almost full mortality. Nation's team studied both red and white oaks and found the Shumard oak, a subsect of red oak, had a higher germination rate. The researchers think that the higher germination rates of Shumard oak acorns compared to white oaks may be due to their thicker outer coating, which may better protect the inside of the acorn from fire damage.

"Our results suggest that although some acorns were able to survive fires with lower fuel loads, managing for oak regeneration may require use of prescribed fire prior to acorn drop due to a decrease in germination rates," Nation said.

The team is currently working on measuring the biomass of the taproots, fine roots, stems, leaves, and acorns of half of the unburned and un-manipulated fuel treatment seedlings to pinpoint any differences between them.

Alexander pointed out that Nation's work should help forest managers make better decisions when it comes to prescribed fire in upland oak systems.

"Rachel's research is important for helping forest managers understand if prescribed fires have negative impacts on oak acorns," Alexander said. "For serious students like Rachel, undergraduate research can make a tremendous difference for future career success." ❖

Undergraduate Student Profile:
Jennifer Sublett
HOMETOWN: Pensacola, Florida

THE TRUTH AND LIES AFFECTING FRUIT FLIES

Jennifer Sublett is studying dishonest signaling using the fruit fly. (Photo by Dominique Belcher)

RESOURCE AVAILABILITY IS A MAJOR DRIVING FORCE for distribution of animals in nature. But what if a food source that has low nutrient quality presents itself as attractive to a particular species? Conversely, a nutrient-rich food source may present itself as unattractive. This phenomenon, known as dishonest signaling, may impact resource availability.

Senior wildlife, fisheries, and aquaculture major, Jenny Sublett, is using the fruit fly (*Drosophila melanogaster*) as a model to figure out how resources high or low in nutrients deemed unattractive or attractive by the animal impact fitness and distribution of the individuals. She hopes to better understand how dishonest signaling from resources might affect habitat selection on a broader scale.

Sublett, a native of Pensacola, Florida, explained, "A higher quality resource would have more animals on it, hypothetically, and we're looking at what would happen if those resources aren't sending honest signals about their quality."

In order to better understand how fruit flies select the resources they use, Sublett and her team—including research mentors, Dr. Garrett Street, assistant professor in the Forest and Wildlife Research Center's Department of Wildlife, Fisheries and Aquaculture, and Dr. Natraj Krishnan, associate professor in the Mississippi Agricultural and Forestry Experiment Station's Department of Biochemistry, Molecular Biology, Entomology and Plant Pathology—set up and documented movement of flies in fifteen by fifteen inch enclosed arenas. Within these arenas, resources were provided on a gradient of varying actual qualities as well as on a gradient of perceived qualities, based on added attractants and repellents. With the observation arena in place, the team observed which of the resources the flies were inclined to use.

"It's a combination of what they've chosen to use and what they have shown an interest in, focused on, or avoided," said Sublett.

Beyond that, it is the test of generations. Sublett, herself the second of three iterations of students to work on this research project, is looking across eight generations of fruit flies to determine whether or not the fruit flies of not just one generation, but multiple, have the capacity to see beyond the false signaling of repellents or attractants.

"Our hypothesis is that the fruit fly population will have difficulty adapting to the false signaling," Sublett said.

Though the data collection of Sublett's study has yet to conclude, the findings of the previous student's work suggest that the dishonest signaling is preventing the fruit flies from adapting and using resources effectively.

"This is relevant from a management perspective because resources are invested in their survival as well. For example, plants are invested in not being eaten. They're not just benign parts of the environment; plants do fight being eaten. You can expect that the environment might not want to be sending honest signals. It's invested in lying to its predators or its consumers," Sublett said.

Sublett is looking forward to seeing the end results from three generations of student toil.

"Regardless of whether it's the outcome we're predicting it's going to be, it'll be nice to see it all finished," said Sublett.

Krishnan, one of Sublett's mentors, said the work has been unique in a myriad of ways.

"The fruit fly has been preeminently employed as a model organism for studying development and human diseases, but it can also serve as a useful tool to investigate aspects in ecological communities which have implications for how larger animals in nature respond to dishonest signaling with respect to resource availability," Krishnan said. "Advantages of short generation time, the low cost of conducting such experiments, and an extensive repository of knowledge on fruit fly behavior makes the fruit fly an excellent model system to answer big questions on ecological communities." ❖

This research is funded by the Forest and Wildlife Research Center, the Undergraduate Research Scholars Program, and the Office of the Provost and Executive Vice President.

Undergraduate Student Profile:

Xandra Sullivan

HOMETOWN: Tuscaloosa, Alabama

REDUCING 3D PRINTING'S CARBON FOOTPRINT

Xandra Sullivan is testing the durability of bio-based ink for 3D printing. (Photo by Dominique Belcher)

THREE-DIMENSIONAL PRINTING, OR ADDITIVE MANufacturing, is an emerging technology that is changing the way the world creates. From housing to toys to food and even medical prosthetics, 3D printing is a less expensive, more efficient way to manufacture goods. To help make the process of 3D printing more environmentally-friendly, an undergraduate researcher in the Department of Sustainable Bioproducts is studying the properties and testing the durability of bio-based ink.

In an effort to find a better, more sustainable ink, junior sustainable bioproducts major, Xandra Sullivan, is researching properties of bio-based plastics. She hopes her research will pave the way for improved filaments that are strong enough to get the job done while being better for the environment.

Although still a relatively new technology, researchers and engineers alike are constantly searching to expand the boundaries of application for 3D printers. The printer acts as a vertical hot-glue gun, laying down layer after layer of melted plastic through the directions of a pre-determined code. What gets built up is completely customizable, allowing the printers to create everything from miniature lions, to water bottles, to biomedical equipment. Traditionally, the "ink" of a 3D printer is a filament made of synthetic thermoplastics, which are petroleum-based and non-biodegradable. PLA plastics are becoming more available as an alternative to the synthetic plastics. PLA plastics are biodegradable and derived from agricultural crops such as corn, sugarcane, and cassava.

Sullivan is studying PLA plastic filaments containing woody biomass.

"The lumber industry has byproducts that can be used to make PLA plastics. It would be great to use the woodchips and sawdust and bark left behind in the lumber manufacturing process to make a biodegradable filament," Sullivan said. "We're testing how much biodegradable or natural material we can put into the ink without losing its durability and functionality."

Sullivan is printing parts of simple everyday products, including the tip of a condiment dispenser and a bearing that connects pipes before studying how durable the part is under repetitive use and how fast it degrades after the end of the product's life. She is also comparing the PLA-wood filament performance against other types of filaments, while creating an index of bio-based plastics and their various properties.

As wide-spread as the applications of her research are, Sullivan admits there are drawbacks. Cost efficiency is a major concern, considering first the cost of the 3D printer, the training of someone to use it, and of course, the outsourcing of ink-creation.

"There's not a large-scale place that manufactures bio-based ink or bio-based plastic, and the smaller places are more expensive because it's a smaller factory with smaller machinery and less output," Sullivan explained.

Dr. Yunsang Kim, assistant professor in the Department of Sustainable Bioproducts and scientist in the Forest and Wildlife Research Center, serves as Sullivan's research mentor. Kim's research interests center around the conversion of lignocellulosic biomass from woody and agricultural sources into novel functional materials including nanocomposites, nanofibers, and coatings, which can be used in applications in buildings, electronics, and energy. Kim said researching bio-based filaments for 3D printers is a natural extension of that research and that Sullivan has been an eager and innovative student.

"I got to know Xandra when she took my class, "Biomass to Bioproducts," during the 2019 Spring semester. She is enthusiastic about getting hands-on research experience and applying her ideas to real research projects. Although I gave her some initial direction, she always comes back to me with more interesting and sometimes wild ideas, so working together on this project has been exciting," he said. ❖

This research is funded by the Forest and Wildlife Research Center, the Undergraduate Research Scholars Program, and the Office of the Provost and Executive Vice President

FACULTY REFEREED PUBLICATIONS

JULY 1, 2018 - JUNE 30, 2019

Aghzjani, H., E. Bari, M. Bahmani, M. Humar, M. Ghanbury, **D. D. Nicholas**, E. Zahedian. 2018. Influence of relative humidity and temperature on cultivation of Pleurotus Species. Maderas Ciencia y Technologia 20(4):571-578.

Alexander, H. D., S. Natali, M. Loranty, S. Ludwig, S. Davydov, N. Zimov, I. Trujillo, M. Mack. 2018. Soil burn severity impacts on larch recruitment on permafrost soils of far northeastern Siberia. Forest Ecology and Management 417:144-153.

Allen, P. J., W. A. Baumgartner, E. L. Brinkman, R. DeVries, H. Stewart, D. Aboagye, S. Ramee, M. Ciaramella, C. Culpepper, L. Petrie-Hanson. 2018. Fin healing and regeneration in sturgeon. Journal of Fish Biology 93:917-930.

Allred, S., W. Shao, **M. W. Schilling**, L. Petrie-Hanson, **P. J. Allen**. 2019. An assessment of red fillet prevalence in the catfish industry. Aquaculture 507:203-210.

Barnes, H. M., M. D. Aro, A. L. Rowlen. 2018. Decay of thermally modified engineered wood products. Forest Products Journal 68(2):99-104.

Barton, B. T., **M. A. Lashley**, R. Altig. 2018. *Ascaphus montanus* (Rocky Mountain tailed frog) diurnal breeding at ephemeral site. Herpetological Review 49(2):299.

Bastos, A., P. Friedlingstein, S. Sitch, C. Chen, A. Mialon, J.-P. Wigneron, V. K. Arora, P. R. Briggs, J. G. Canadell, P. Ciais, F. Chevallier, L. Cheng, C. Delire, V. Haverd, A. K. Jain, F. Joos, E. Kato, S. Lienert, D. Lombardozzi, J. R. Melton, R. Myneni, J. E.M.S. Nabel, J. Pongratz, B. Poulter, C. Rodenbeck, R. Seferian, H. Tian, C. van Eck, N. Viovy, N. Vulchard, A. P. Walker, A. Wiltshire, **J. Yang**, S. Zaehle, N. Zeng, D. Zhu. 2018. Impact of the 2015/2016 El Nino on the terrestrial carbon cycle constrained by bottom-up and top-down approaches. Philosophical Transactions of the Royal Society B: Biological Sciences 373(1760).

Bjorkman, A., I. Myers-Smith, S. Elmendorf, S. Normand, H. Thomas, **H. D. Alexander**. 2018. A database of plant traits spanning the tundra biome. Global Ecology and Biogeography 27(12):1402-1411.

Bjorkman, A., I. Myers-Smith, S. Elmendorf, N. Ruger, S. Normand, **H. D. Alexander**. 2018. Plant functional trait change across the tundra biome over three decades of warming. Nature Climate Change 562:57-62.

Brooke, J., S. Basinger, J. Birkhead, **M. A. Lashley**, M. McCord, J. Nanney, C. Harper. 2018. Does fertilization and crown release of white oaks influence acorn production or quality. Forest Ecology and Management 433:305-312.

Cai, L., D. Jeremic Nikolic, **H. Lim**, **Y. Kim**. 2019. β-Cyclodextrins as sustained-release carriers for natural wood preservatives. Industrial Crops & Products 130:42-48.

Calamari, N. C., **F. J. Vilella**, Y. V. Sica, P. A. Mercuri. 2018. Patch and landscape responses of bird abundance to fragmentation in agroecosystems of east-central Argentina. Avian Conservation and Ecology 13(2):3.

Cao, Y., **J. T. Street, H. Lim**. 2018. Analytical and experimental evaluation of the effect of knots on rolling shear properties of cross laminated timber (CLT). World Conference in Timber Engineering 2018.

Cao-Anderson, G., **R. Shmulsky**, M. Liu, E. D. Entsminger, B. K. Via, **H. Wan**. 2019. Characterizing star-sawn pattern produced and orthogonally glued specimens of Southern pine. Forest Products Journal 69(1):53-60.

Celestino, L. F., F. J. Sanz-Ronda, **L. Miranda**, M. C. Makrakis, J. H. P. Dias, S. Makrakis. 2019. Bidirectional connectivity via fish ladders in a large Neotropical river. River Research and Applications 35(3):236-246.

Cheng, Q., C. Zhou, W. Jiang, X. Zhao, B. Via, **H. Wan**. 2018. Mechanical and physical properties of oriented strand board exposed to high temperature and relative humidity and coupled with near-infrared reflectance modeling. Forest Products Journal 68(1):78-85.

FWRC authors in bold

Chesser, B., C. Green, **P. J. Allen**. 2019. Egg production of Gulf killifish is dependent on broodstock rearing density but not spawning substrate surface area. North American Journal of Aquaculture 81(3):201-210.

Chhetri, S. G., **J. S. Gordon, I. A. Munn, J. E. Henderson**. 2018. Factors influencing the use of consulting foresters by non-industrial private forest landowners in Mississippi. The Forestry Chronicle 94(3):254-259.

Colvin, M., S. Reynolds, R. B. Jacobson, L. L. Pierce, K. D. Steffensen, T. L. Welker. 2018. Overview and progress of the pallid sturgeon assessment framework design process. U.S. Geological Survey Open-File Report 2018–1166.

da Silva, P. S., **L. Miranda**, S. Makrakis, L. de Assumpcao, J. H. P. Dias, M. C. Makrakis. 2019. Tributaries as biodiversity preserves: An ichthyoplankton perspective from the severely impounded Upper Paraná River. Aquatic Conservation: Marine and Freshwater Ecosystems 29(2):258-269.

Dahal, R., **R. K. Grala, J. S. Gordon**, D. R. Petrolia, **I. A. Munn**. 2018. Estimating the willingness to pay to preserve waterfront open spaces using contingent valuation. Land Use Policy 78:614-626.

Dangal, S., H. Tian, R. Xu, J. Chang, J. G. Canadell, P. Ciais, S. Pan, **J. Yang**, B. Zhang. 2019. Global nitrous oxide emissions from pasturelands and rangelands: Magnitude, spatio-temporal patterns and attribution. Global Biogeochemical Cycles 33(2):200-222.

Demirel, S., O. Tor, X. Yu, **J. Zhang**. 2018. Lateral loads of stapled-glued surface-to-surface joints in oriented strandboard for furniture. Wood and Fiber Science 50(3):280-290.

Djukic, I., S. Kepfer-Rojas, **H. D. Alexander**, I. Schmidt, K. Larsen, C. Beier, B. Berg, K. Verheyen. 2018. Early stage litter decomposition across biomes. Journal of Science of the Total Environment 628-629:1369-1394.

Dollar, J. G., T. J. Schauwecker, S. K. Riffell, **L. W. Burger**. 2018. Responses of forb communities to management of grassland buffers. In J. G. Hill and J. A. Barone (Ed.), Southeastern Prairies: Biodiversity, Ecology and Management, University of Alabama Press, Tuscaloosa, AL.

Dykes, J. L., **B. K. Strickland, S. Demarais**, D. B. Reynolds, **M. A. Lashley**. 2018. Soil nutrients indirectly influence plant selection in white-tailed deer. Basic and Applied Ecology 32:103-109.

Entsminger, E. D., J. W. Guyton, **R. B. Iglay**, J. C. Jones. 2018. Highway right-of-way mowing regimens in Northeastern Mississippi: Effect on native prairie plant species. In J. G. Hill and J. A. Barone (Ed.), Southeastern Prairies: Biodiversity, Ecology and Management, University of Alabama Press, Tuscaloosa, AL.

Entsminger, E. D., J. C. Jones, J. W. Guyton, B. D. Leopold, **B. K. Strickland.** 2019. Mowing effects on woody stem density and woody and herbaceous vegetation heights along Mississippi highway right-of-ways. Journal of Fish and Wildlife Management 10(1):19-37.

Ezell, A. W., **A. B. Self**. 2018. Crop tolerance of oak seedlings in herbaceous weed control applications using indaziflam. Proceedings of the 19th Biennial Southern Silvicultural Research Conference 9-13.

Foggia, J., **S. A. Rush**, T. B. Wigley, D. A. Miller, J. A. Martin. 2018. Effects of forest stand structure and edge proximity on predation risk. Wilson Journal of Ornithology 42(3):237-245.

Franca, F., A. P. Maciel, **T. Amorim**, J. Sliva, D. Batista. 2019. Air-drying of seven clones of *Eucalyptus grandis* x *Eucalyptus urophylla* wood. Bioresources 14(3):6591-6607.

Franca, F., R. D. Seale, R. J. Ross, **R. Shmulsky, T. Amorim**. 2018. Using transverse vibration nondestructive testing techniques to estimate stiffness and strength of southern pine lumber. USDA FS FPL Research Paper FPL-RP-695.

Frey, B. R., J. Stoll, R. Leite, E. Boerger, C. Sabatia. 2018. A synthesis of growth data for bottomland hardwood species commonly planted in the Lower Mississippi Alluvial Valley. Biennial Southern Silvicultural Research Conference.

Gilliland, C., **M. Colvin, S. A. Rush**, S. Reagan. 2018. American alligators are predators of paddlefish: An undocumented predator-prey linkage affecting paddlefish population dynamics. Foodwebs 16:e00087.

Granzotti, R. V., **L. Miranda**, A. A. Agostinho, L. C. Gomes. 2018. Downstream impacts of dams: Shifts on invertivorous fish assemblages. Aquatic Sciences 80:28.

Greene, R. E., **R. B. Iglay, K. Evans**, T. B. Wigley, D. A. Miller. 2019. Estimating capacity of managed pine forests in the southeastern U.S. to provide open pine woodland condition and gopher tortoise habitat. Forest Ecology and Management 432:200-208.

Guy, E., **P. J. Allen**. 2018. Tank acclimation and induced spawning of the catostomid, Black Buffalo. North American Journal of Aquaculture 80:294-300.

Henderson, C. B., E. S. Michel, **S. Demarais, B. K. Strickland**. 2018. Camouflage patterns are highly heritable but predictability varies among three populations of white-tailed deer. Ecosphere 9(3):e02169.

Hornslein, N., **C. M. Siegert, H. J. Renninger**. 2019. Changes in physiological functioning in loblolly pine trees undergoing bark beetle simulated mortality. Forest Science 65(3):312-323.

Hornslein, N., **C. M. Siegert, H. J. Renninger**. 2019. Physiological response of mid-canopy sweetgum trees to overstory loblolly pine mortality. Trees 33(1):139-151.

Hu, W., H. Guan, **J. Zhang** 2018. Finite element analysis of tensile load resistance of mortise-and-tenon joints considering tenon fit effects. Wood and Fiber Science 50(2):121-131.

Iglay, R. B., T. J. Conkling, T. L. DeVault, J. L. Belant, J. A. Martin. 2019. Forage or biofuel: Assessing native warm season grass production among seed mixes and harvest frequencies. Southeastern Naturalist 18(1):1-18.

Jones, P. D., **B. K. Strickland, S. Demarais, G. Wang, C. M. Dacus**. 2018. Nutrition and ontogeny influence weapon development in a long-lived mammal. Canadian Journal of Zoology 96:955-962.

Keretz, K., C. Dinken, **P. J. Allen, M. Colvin**, H. L. Schramm. 2018. The effect of water temperature, angling time, and dissolved oxygen on the survival of largemouth bass subjected to simulated angling and tournament handling procedures. North American Journal of Fisheries Management 38(3):606-622.

Khanal, P., T. J. Dean, **S. D. Roberts, D. Grebner**, T. S. Straka. 2018. Explaining first-year seedling survival from quality distributions of bare-root seedlings and microsites in industrial plantations. Open Journal of Forestry 8:362-379.

Klein, Z., B., M. C. Quist, **L. Miranda**, M. M. Marron, M. J. Steuck, K. A. Hansen. 2018. Commercial fisheries of the upper Mississippi River: A century of sustained harvest. Fisheries 43(12):563-574.

Kushla, J. D., S. G. Dicke, **J. S. Gordon**, **J. E. Henderson**, A. J. Londo. 2019. Economic impact of a large-scale, collaborative forest health project: A model for making a difference. Journal of Extension 57:10.

Leonard, L., **K. Evans**. 2019. Arthropod Diet. In: J. Vonk and T. K. Shackelford (Ed.), *Encyclopedia of Animal Cognition and Behavior*, Springer.

Li, M., X. Zhou, Z. Wu, **J. Zhang**. 2018. Cushion stiffness of upholstered wooden seat foundations when subjected to human sitting forces. BioResources 13(3):6542-6554.

Liao, C., S. Chen, S. S. d. Silva, **S. B. Correa**, J. Yuan, T. Zhang, Z. Li, J. Liu. 2018. Spatial changes of fish assemblages in relation to filling stages of the Three Gorges Reservoir, China. Journal of Applied Ichthyology 34(6):1293-1303.

Loranty, M. M., L. T. Berner, E. Taber, H. Kropp, S. Natali, **H. D. Alexander**, S. Davydov. 2018. Understory vegetation controls on active layer dynamics and carbon dioxide fluxes in open-canopy Siberian larch forests. PLoS ONE 13(3):e0194014.

Loranty, M. M., H. Kropp, S. M. Natali, **H. D. Alexander**, M. C. Mack, N. Zimov, S. Davydov. 2018. Vegetation indices do not capture forest cover variation in upland Siberian larch forests. Remote Sensing 10:1686.

FWRC authors in bold

Lu, C., H. Tian, J. Zhang, Z. Yu, S. Pan, S. Dangal, B. Zhang, **J. Yang**, N. Pederson, A. Hessl. 2019. Severe long-lasting drought accelerated carbon depletion in the Mongolian Plateau. Geophysical Research Letters 46(10):5303-5312.

Ludwig, S., **H. D. Alexander**, K. Kielland, P. Mann, S. Natali, R. Ruess. 2018. Fire severity effects on soil carbon and nutrients and microbial processes in a Siberian larch forest. Global Change Biology 24(2).

Mao, A., W. Xu, E. Xi, Q. Li, **H. Wan**. 2018. Evaluation of phenol-formaldehyde resins modified and blended with pyrolysis bio-oil for plywood. Forest Products Journal 68(2):113-119.

Marchant, A., **K. Evans**. 2019. Incomplete Penetrance. In: J. Vonk and T. K. Shackelford (Ed.), Encyclopedia of Animal Cognition and Behavior, Springer.

McConnell, M. D., A. P. Monroe, R. Chandler, W. E. Palmer, S. D. Wellendorf, **L. W. Burger, Jr.**, J. A. Martin. 2018. Factors influencing northern bobwhite recruitment, with implications for population growth. The Auk 135:1087-1099:

Miles, T. P., T. G. Rosser, **S. A. Rush**. 2019. Morphological, molecular and phylogenetic characterisation of *Eimeria macyi* Wheat, 1975 (Apicomplexa: Eimeriidae) in the eastern red bat *Lasiurus borealis* (Müller, 1776) from Mississippi, USA. Systematic Parasitology 96(2):245–255. o

Miranda, L. 2019. Largemouth bass natural history. In: J. Tidwell, S. Coyle, L. A. Bright (Ed.), *Largemouth Bass Aquaculture*, 5M Books.

Miranda, L., L. Bull, **M. Colvin**, W. Hubbard, L. Pugh. 2018. Segmentation of Mississippi Lakes. Lake and Reservoir Management 34(4):376-391.

Miranda, L., R. V. Granzotti, D. J. Dembkowski. 2019. Gradients in fish feeding guilds along a reservoir cascade. Aquatic Sciences 81(15).

Miranda, L., K. J. Killgore, W. T. Slack. 2019. Spatial organization of fish diversity in a species-rich basin. River Research and Applications 35(2):188-196.

Morina, D., **S. Demarais**, G. D. Chesser, J. W. Lowe, **B. K. Strickland**. 2018. Antler manipulation procedures for use in social and behavioral studies of deer. Wildlife Biology 2018(1).

Neal, J. W., M. C. Lloyd. 2018. Response of fish populations to floating streambed wetlands. Journal of the Southeastern Association of Fish and Wildlife Agencies 5:64-78.

Nicholas, D. D. 2018. Comparative field performance of oilborne pentachlorophenol versus the substituted isothiazolone DCOI as a wood preservatives. International Wood Products Journal 9(4):171-175.

Omer, A. R., J. L. Dyer, J. Czarnecki, R. Kroger, **P. J. Allen**. 2018. Development of a water budget for tailwater recovery systems in the Lower Mississippi Alluvial Valley. Journal of Irrigation and Drainage Engineering 144(6):05018001.

Omer, A. R., M. T. Moore, L. J. Krutz, R. Kroger, J. Czarnecki, B. Baker, **P. J. Allen**. 2018. Potential for recycling of suspended solids and nutrients by irrigation of tailwater from tailwater recovery systems. Water Science and Technology: Water Supply 18(4):1396-1405.

Omer, A., **J. E. Henderson**, L. L. Falconer, R. Kroger, **P. J. Allen.** 2019. Economic costs of using tailwater recovery systems for maintaining water quality and irrigation. Journal of Environmental Management 235:186-193.

Owens, F. C., S. C. Verrill, **R. Shmulsky**, R. J. Ross. 2019. Distributions of modulus of elasticity and modulus of rupture in four mill-run lumber populations. Wood and Fiber Science 51(2):183-192.

Paolini, K. E., **B. K. Strickland**, J. L. Tegt, K. C. VerCauteren, **G. M. Street**. 2018. Seasonal variation in preference dictates space use in an invasive generalist. PLoS ONE 13:e0199078:

Parrish, M. C., **S. Demarais**, T. B. Wigley, S. K. Riffell, **A. W. Ezell**, P. D. Jones. 2018. Operational green tree retention and land cover patterns in intensively managed pine forest landscapes of the southeastern U.S. Forest Science 64(5):564-576.

Poudel, K. P., J. Flewelling, H. Temesgen. 2018. Predicting volume and biomass change from multi-temporal lidar sampling and remeasured field inventory data in Panther Creek Watershed, Oregon, USA. Forests 9(1):28.

Poudel, K. P., H. Temesgen, P. J. Radtke, A. N. Gray. 2019. Estimating individual-tree aboveground biomass of tree species in the Western USA. Canadian Journal of Forest Research 49(6):701-714.

Renninger, H. J., A. T. Hall, N. Hornslein, **A. W. Ezell**. 2018. Seasonal physiology and growth of bottomland oaks of differing planting stocks in afforestation sites on the U.S. Gulf Coastal Plain. Restoration Ecology 26:702-711.

Renninger, H. J., C. H. Miles, **A. W. Ezell**. 2019. Seasonal physiology and growth of planted oaks with implications for bottomland hardwood restoration. New Forests.

Roberson, H., **K. Evans**. 2019. Taxa. In: J. Vonk and T. K. Shackelford (Ed.), Encyclopedia of Animal Cognition and Behavior, Springer.

Rush, S. A. 2018. Pantherophis guttatus (red cornsnake). Geographic record. Herpetological Review 49(1):78.

Rush, S. A., J. R. Rodgers, III, E. C. Soehren, J. Trent. 2018. Spatial and temporal changes in emergent marsh and associated marsh birds of the Lower Mobile-Tensaw River Delta in Alabama, USA. Wetlands.

Samiappan, S., J. Czarnecki, H. Foster, **B. K. Strickland**, J. L. Tegt, R. J. Moorhead. 2018. Quantifying damage from wild pigs with small unmanned aerial systems. Wildlife Society Bulletin 42(2):304-309.

Self, A. B., A. W. Ezell, E. B. Schultz. 2018. Residual effects of mechanical site preparation on soil compaction in oak plantings. Proceedings of 19th Biennial Southern Silvicultural Research Conference.

Siegert, C., M., N. Clay, J. Tang, L. G. Garrigues, J. J. Riggins. 2018. Indirect effects of bark beetle generated coarse woody debris impacts to biogeochemical properties of forest floor substrates following one year of decomposition. Oecologia 188(4):1209-1226.

Siegert, C., M., H. J. Renninger, S. Karunarathna, J. J. Riggins, N. A. Clay, J. T. Tang, N. Hornslein, B. L. Chaney. 2018. Biogeochemical hotspots around bark beetle-killed trees: carbon sinks or carbon sources? Proceedings of the 19th Biennial Southern Silvicultural Research Conference.

Soehren, E. C., S. G. Hereford, K. M. Morris, J. A. Trent, J. N. Walker, M. S. Woodrey, **S. A. Rush**. 2018. Winter use of wet pine savannas by yellow rail (*Coturnicops noveboracensis*) along coastal Alabama and Mississippi. Wilson Journal of Ornithology 130(3):615-626.

Soni, B., B. Mahmoud, K.-C. Chang, E. M. El-Gian, **E. B. M. Hassan**. 2018. Physicochemical, antimicrobial and antioxidant properties of chitosan/TEMPO biocomposite packaging films. Food Packaging and Shelf Life 17:73-79.

Stevenson, B., **M. A. Lashley**, M. C. Chitwood, J. Garabedian, M. Swingen, C. S. DePerno, C. E. Moorman. 2019. Resource selection by coyotes (*Canis latrans*) in a longleaf pine ecosystem: Effects of anthropogenic fires and landscape features. Canadian Journal of Zoology 97(2):165-171.

Street, G. M., T. Avgar, L. Börger. 2018. Net displacement and temporal scaling: Model fitting, interpretation, and implementation. Methods in Ecology & Evolution 9:1503-1517.

Sun, C., X. Zhang. 2018. Duration of U.S. forest products trade. Forest Policy and Economics 95(1):57-68.

Tian, H., C. Lu, S. Pan, **J. Yang**, R. Miao, W. Ren, Q. Yu, B. Fu, F.-F. Jin, Y. Lu, J. Melillo, Z. Ouyang, C. Palm, J. Reilly. 2018. Optimizing resource use efficiencies in the food-energy-water nexus for sustainable agriculture: From conceptual model to decision support system. Current Opinion in Environmental Sustainability 33:104-113.

FWRC authors in bold

Tian, H., **J. Yang**, R. Xu, C. Lu, J. G. Canadell, E. A. Davidson, R. B. Jackson, A. Arneth, J. Chang, P. Clais, S. Gerber, A. Ito, F. Joos, S. Lienert, P. Messina, S. Olin, S. Pan, C. Peng, E. Saikawa, R. L. Thompson, N. Vuichard, W. Winiwarter, S. Zaehle, B. Zhang. 2019. Global soil nitrous oxide emissions since the preindustrial era estimated by an ensemble of terrestrial biosphere models: Magnitude, attribution, and uncertainty. Global Change Biology 25(2):640-659.

Tripathi, S., **H. Lim**. 2018. Evaluation of adhesive systems for treated cross-laminated timber (CLT). World Conference in Timber Engineering 2018.

Verrill, S. P., **F. Owens**, D. E. Kretschmann, **R. Shmulsky**, L. S. Brown. 2019. Visual and MSR grades of lumber are not 2-parameter weibulls and why this may matter. Journal of Testing and Evaluation (ASTM International) 48(5):17.

Wang, G. 2018. Machine learning for inferring animal behavior from location and movement data. Ecological Informatics 49:69-76.

Wang, J. Y., R. Stirling, P. I. Morris, A. Taylor, J. Lloyd, G. Kirker, S. Lebow, M. E. Mankowski, **H. M. Barnes**, J. J. Morrell. 2018. Durability of mass timber structures: A review of the biological risks. Wood and Fiber Science 50:110-127.

Wang, Y., **J. Zhang**. 2018. Contribution of face and core layers to lateral load resistance of single-shear metal-to-particleboard single-screw connections. BioResources 13(4):8911-8929.

Xingan, **G. Wang.** 2018. Spatiotemporal dynamics of mesocarnivore populations. Wildlife Biology 2018(1).

Xu, R., H. Tian, S. Pan, S. A. Prior, Y. Feng, W. D. Batchelor, J. Chen, **J. Yang.** 2019. Global ammonia emissions from synthetic nitrogen fertilizer applications in agricultural systems: Empirical and process-based estimates and uncertainty. Global Change Biology 25(1):314-326.

Yan, Q., J. Li, **J. Zhang**, Z. Cai. 2018. Thermal decomposition of kraft lignin under gas atmospheres of argon, hydrogen, and carbon dioxide. Polymers 10(7):729.

Yan, Q., J. Li, X. Zhang, **E. B. M. Hassan**, C. Wang, **J. Zhang**, Z. Cai. 2018. Catalytic graphitization of kraft lignin to graphene-based structures with four different transitional metals. Journal of Nanoparticle Research 20:223.

Yan, Q., J. Li, X. Zhang, **J. Zhang**, Z. Cai. 2018. Synthetic bio-graphene based nanomaterials through different iron catalysts. Nanomaterials 8(10):840.

Yang, J., W. Ren, Y. Ouyang, G. Feng, B. Tao, **J. Granger**, **K. P. Poudel**. 2019. Projection of 21st century irrigation water requirement across the Lower Mississippi Alluvial Valley. Agricultural Water Management 217:60-72.

Zhang, J., H. Tian, **J. Yang**, S. Pan. 2018. Improving representation of crop growth and yield in the dynamic land ecosystem model and its application to China. Journal of Advances in Modeling Earth Systems 10(7):1680-1707.

Zhang, X., **Y. Kim**, T. L. Eberhardt, **R. Shmulsky**. 2019. Lab-scale structural insulated panels with lignin-incorporated rigid polyurethane foams as core. Industrial Crops and Products 132:292-300.

DISSERTATIONS

Blake, C. D. 2018. Using agricultural wastes and additives to improve properties and lower manufacturing costs associated with biomass energy pellets. Dissertation, Department of Sustainable Bioproducts, Mississippi State University.

Cai, L. 2019. Beta-cyclodextrins as agents for improved protection methods of wood and strand-based wood composites. Dissertation, Department of Sustainable Bioproducts, Mississippi State University.

Cao, Y. 2019. Analytical and experimental evaluation of the effect of knots on rolling shear properties of cross-laminated timber (CLT). Dissertation, Department of Sustainable Bioproducts, Mississippi State University.

Carter, R. M. 2018. Landowner perceptions of oil and gas development in Mississippi, and policies associated with managing the industry and natural resources. Dissertation, Department of Forestry, Mississippi State University.

Chen, C. 2019. Process improvement of door manufacturing through time study and simulation using lean concepts. Dissertation, Department of Sustainable Bioproducts, Mississippi State University.

Cole, J. 2019. Acoustic and strength characterization of concrete and wood-based composites comprised of micronized rubber powder. Dissertation, Department of Sustainable Bioproducts, Mississippi State University.

KhademiBami, L. 2018. Nano-chitosan wood treatment: A combined fire-retardant and anti-fungal treatment. Dissertation, Department of Sustainable Bioproducts, Mississippi State University.

Ming, L. 2018. Mixed used urea formaldehyde and isocyanate resins for wood composites. Dissertation, Department of Sustainable Bioproducts, Mississippi State University.

Parrish, M. C. 2018. Effects of green tree retention on birds of Southern pine plantations. Dissertation, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Stratton, J. N. 2019. Developing a bio-based wood composite using refined cottonseed protein adhesives. Dissertation, Department of Sustainable Bioproducts, Mississippi State University.

Telmadarrehei, T. 2018. Study of subterranean termite gut symbionts as affected by chitosan treatment of wood. Dissertation, Department of Sustainable Bioproducts, Mississippi State University.

Verly Lopes, D. J. 2019. Boron leaching control by heat treatment and tannin impregnation. Dissertation, Department of Sustainable Bioproducts, Mississippi State University.

West, V. S. 2019. Variation in crown morphology, top dieback characteristics, and growth and yield metrics for two varietal ideotypes of loblolly pine at age nine. Dissertation, Department of Forestry, Mississippi State University.

Zhang, X. 2018. Temporary trade barriers investigation and duty imposition in the forest products industry. Dissertation, Department of Forestry, Mississippi State University.

THESES

Anderson, M. P. 2019. LiDAR measurements of afforested bottomland hardwoods in the Lower Mississippi Alluvial Valley. Thesis, Department of Forestry, Mississippi State University.

Ban, B. 2018. The patterns and determinants of roundwood exports from United States Pacific Northwest. Thesis, Department of Forestry, Mississippi State University.

Bankston, J. B. 2019. Sample-plot size and diameter moments/percentiles prediction model effects on stand diameter distribution recovery accuracy. Thesis, Department of Forestry, Mississippi State University.

Barela, I. A. 2018. Transferability of MaxEnt and expert opinion models for American beaver. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Bies, J. M. 2019. Sampling techniques for research and management of cichlid species in lentic systems. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Coppola, G. 2018. Performance of submerged cool-season annual crops as a potential fish habitat enhancement strategy of reservoir mudflats. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Dentinger, J. E. 2018. An unsupervised machine-learning framework for behavioral classification from animal-borne accelerometers. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

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.

Feura, J. M. 2018. Estimating clapper rail (*Rallus crepitans*) survivorship and implementation of estimates into individual-based population models. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Firth, A. G. 2018. Investigation of a low-external-input sustainable rice production system to identify ecosystem services towards adoption costs and benefits. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Fulgham, D. T. 2019. Growth of clonal red maples on varying site conditions in Mississippi and response to pneumatic fracturing and liquid injection. Thesis, Department of Forestry, Mississippi State University.

Hatcher, H. R. 2018. Establishing and evaluating agricultural plantings and supplemental cover on reservoir mudflats as a means to increase juvenile game fish abundance and growth. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Jargowsky, M. B. 2019. Life history patterns and the spatial and trophic ecology of batoids in a northern Gulf of Mexico estuary. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Kautz, T. M. 2018. Factors influencing white-tailed deer mortality risk within a multi-predator system in Michigan, USA. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Miles, C. H. 2019. Assessing the early growth performance and survival of two oak species and three planting stocks on Hurricane Katrina damaged land. Thesis, Department of Forestry, Mississippi State University.

Regmi, A. 2019. Price premiums for growing higher quality southern pine sawtimber on longer rotation ages. Thesis, Department of Forestry, Mississippi State University.

Shirley, C. A. 2018. Refining spawning protocols for crappie. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Simek, S. L. 2018. History, status, and resource selection of the American black bear in Mississippi. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University.

Stout, K. B. 2019. Attitudes and perceptions of the millennial generation surrounding wood products and the wood products industry. Thesis, Department of Sustainable Bioproducts, Mississippi State University.

Wainscott, C. 2019. Auger reactor co-pyrolysis of southern pine, micronized rubber powder, and a food-grade polymer under the influence of sodium carbonate and nickel oxide catalysts. Thesis, Department of Sustainable Bioproducts, Mississippi State University.

Youngmann, J. L. 2018. Genetic assessment of native and non-native white-tailed deer (*Odocoileus virginianus*) in the southcentral U.S. Thesis, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University

BY THE

NUMBERS

PEOPLE

77
Master's students (Fall 2018)

45
Doctoral students (Fall 2018)

54
Faculty (FY19)

RESEARCH PROJECTS

280
Projects Active (FY19)

88
Research Sponsors (FY19)

137
Refereed Publications (FY19)

$11.9M
Total Sponsored Research Funding (FY19)

RESEARCH SPONSORS

Alabama Division of Wildlife
Alaska Department of Fish and Game
Applied Building
Arch Wood Protection
Arkansas Game and Fish
Association of Zoos & Aquariums
BASF Corporation
Bayer
Cargill
Colgate University
Cooperative Ecosystems Studies Units
Delta F.A.R.M.
Drax Biomass International Inc.
Ducks Unlimited
DuPont
Eastman Chemical Company
Ensafe
Flexsteel
Formology
FP Innovation
FuturaGene
Genics Inc.
Gulf Coast Cooperative Ecosystems Studies Unit
Jernigan Copeland
Jonathan Louis International Ltd.

TOTAL FWRC FUNDING, FY19

$18.48M

30.97% STATE APPROPRIATIONS
04.64% FEDERAL APPROPRIATIONS
64.39% GRANTS AND CONTRACTS

Joint Fire Protection Service, Bureau of Land Management
Kop-Coat Inc.
Koppers Holdings Inc.
Koppers Inc.
Koppers Utility and Industrial Products
Lanxess Corporation
Lonza Wood Protection
Louisiana Pacific Corporation
Louisiana Wildlife and Fisheries
Michigan Department of Natural Resources
Mike Freeman
Mississippi Department of Environmental Quality
Mississippi Department of Revenue
Mississippi Department of Wildlife, Fisheries, & Parks
Mississippi Forestry Association
Mississippi National Guard
Mississippi Soybean Promotion Board
Mississippi Tree Farm Committee
Mississippi Wildlife, Fisheries, and Parks Foundation
Missouri Department of Conservation
Mississippi Implementation Committee for the Sustainable Forestry Initiative
MSU Assure Research and Development Corporation
National Council for Air and Stream Improvement Inc.
National Science Foundation
National Turkey Federation
Norbord Inc.
NTA Inc.
Oregon State University
Osmose Inc.
Penta Task Force
Railway Tie Association
Reservoir Fisheries Habitat Partnership
Safari Club International Foundation
Sierra Pacific Industries
Southern Ionics
State of Mississippi Military Department
Structurlam Mass Timber Corporation
Sustainable Forestry Initiative Inc.
Swiss Krono
Taylor Endowed Chair
Tennessee Valley Authority
Tennessee Wildlife Resources
The National Academies of Sciences, Engineering and Medicine
Timber Products Inspection
Troy Chemical
U.S. Endowment for Forestry & Communities Inc.
United Furniture
United States Fish and Wildlife Service
United States Geological Survey
University of California, Davis
University of Maine
University of Tennessee
USDA Agricultural Research Service
USDA Animal & Plant Health Inspection Service
USDA APHIS National Wildlife Research Center
USDA Forest Products Laboratory
USDA Forest Services
USDA National Institute of Food and Agriculture
USDA Natural Resources Conservation Service
Viance, LLC
VIP Cinema
Weyerhaeuser NR Company

MISSISSIPPI STATE UNIVERSITY™
FOREST AND WILDLIFE RESEARCH CENTER

P.O. Box 9680
Mississippi State, MS 39762

NONPROFIT ORG
US POSTAGE
PAID
MISSISSIPPI STATE 39762
PERMIT NO. 81