ANNUAL REPORT

FY2019-20

TENNESSEE TECH

Center for the Management, Utilization,
& Protection of Water Resources

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Cover Photo

The Striated Darter, *Etheostoma striatulum,* is one of the rarest fishes in the U.S., and is found only in Tennessee's Duck River. A newly funded study developed by Dr. Carla Hurt and Dr. Kit Wheeler will examine its current distribution, habitat use, and genetics to provide current data to better conserve the species. The Duck River is home to more aquatic species than any other river in Tennessee!

MESSAGE FROM THE DIRECTOR

Dear Stakeholders,

Over the past year, the Center has expanded its role of supporting State needs through research, education, outreach, and science communication despite challenges resulting from the Covid-19 pandemic. Our efforts were slowed dramatically for about two months, but we are once again operating in our traditional manner via stringent safety protocols that have allowed us to re-engage stakeholders and get back to our core mission of research and teaching in support of sustainability and effective water governance for the citizens of Tennessee.

Within the University, we have forged relationships with new faculty who bring fresh perspectives and ongoing work through the collaborations these relationships provide. We have also taken steps to engage undergraduates in research and practice that have enhanced student experience and created new opportunities to learn about water resources.

This year, we have continued our long-standing tradition of partner-inspired research in support of Tennessee resource managers. New projects with the Tennessee Wildlife Resources Agency (TWRA) include investigations of imperiled aquatic organisms, finding new ways of ameliorating the Asian Carp invasion, and even fine-scale telemetry of waterfowl. Our work with the Tennessee Department of Transportation (TDOT) to better understand urban nutrient runoff continues, as do our collaborations with the Tennessee Department of Environment and Conservation (TDEC). We have a broad range of ongoing studies with TDEC that range from providing better understanding of processes occurring within wastewater treatment systems to developing low-cost sensors so that water managers can better predict and respond to flood events. Our ongoing partnership with the U.S. Department of Agriculture (USDA) and The Nature Conservancy is providing valuable insight into how wetland restoration can reduce nutrient input to Tennessee rivers.

One of our most exciting new efforts is a revitalization of our food-water-energy focus area. We have engaged Dr. Brad Cook as a focus area lead and partnered with Tennessee Tech's Rural Reimagined program to look for ways that the Water Center can support the water and energy needs of small, rural farms in disadvantaged and at-risk Tennessee counties. While the efforts are nascent, we have several promising new collaborations that can potentially support both conservation and economic development.

The Water Center has long been a research center, but over the past year we have expanded our role in science communication and synthesis. We hosted the annual Cave and Karst conference in February and the annual Tennessee Rare Fishes meeting in mid-March. Water Center support for these events brought people together to communicate conservation successes, coordinate mutually reinforcing activities by different groups, and identify emerging issues and research needs. The events were coordinated by Tech communications students who had a chance to receive course credits and develop practical experience in event planning. Covid-19 forced us to curtail this effort (three workshops during April and May had to be postponed), but it will continue when it is safe to resume physical meetings.

During the coming year, we hope to provide increased and more consistent support for Water Center students and increase funding by engaging new faculty in externally supported interdisciplinary grants. A major focus will be technology upgrades to our water quality laboratory via new instrumentation that can be grant supported, or cost-shared with other University departments. We remain committed to maintaining our relationships with the many State and Federal agencies within Tennessee and helping resolve the most pressing and difficult water issues facing our State and region.

Sincerely,

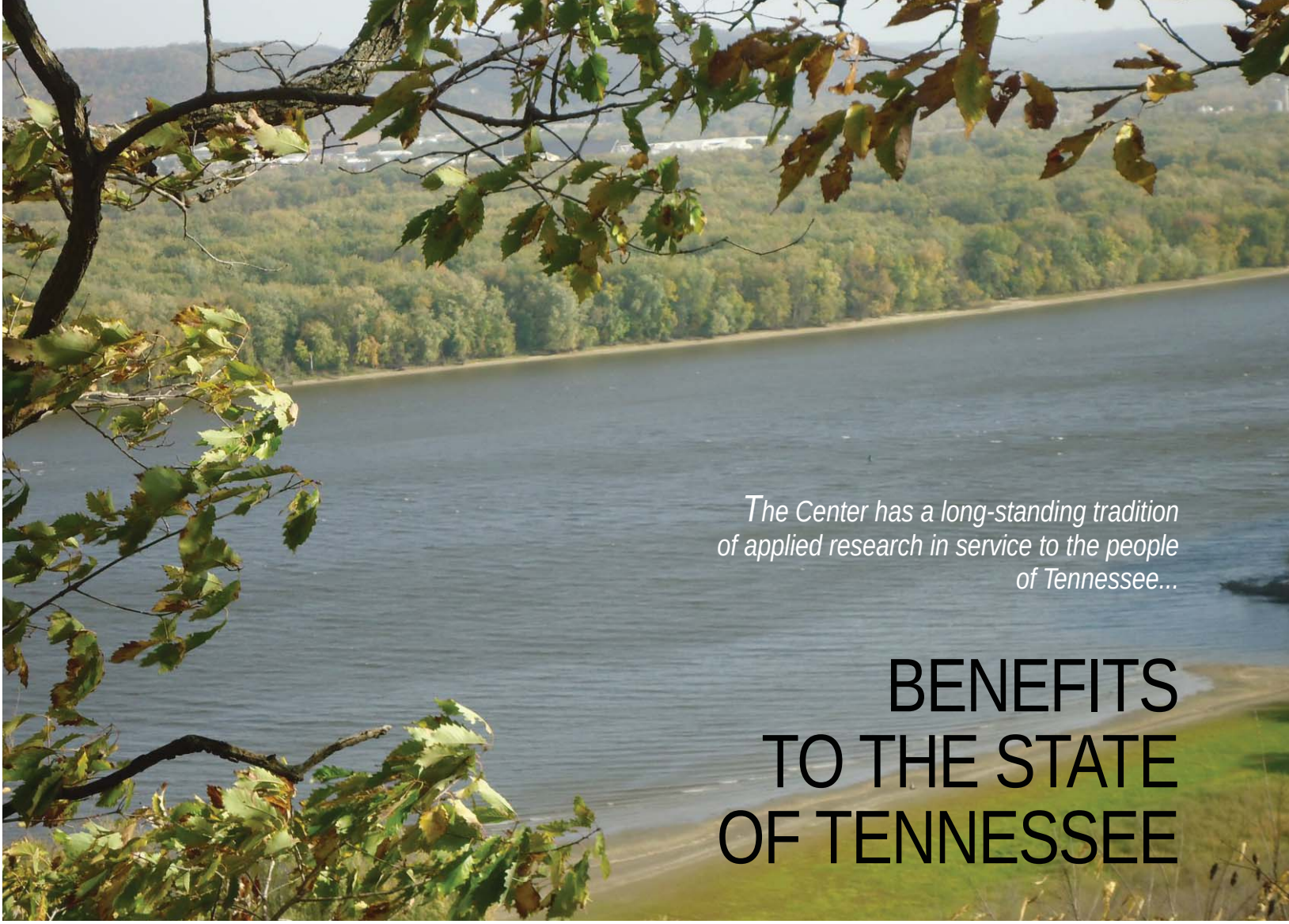
Jeff Schaeffer,

Center Director

CENTER AT A GLANCE 2019-2020

Dr. Tania Datta measuring dissolved oxygen concentrations in a hatchery raceway at Buffalo Springs Hatchery near Rutledge, TN.

- State appropriation of $1.207 million
- External grants totaling $2.367 million
- Thirty-eight active grants, with five nearing completion
- Twenty-five new proposals submitted
- Return per state dollar: $1.96
- Eight staff members
- Four faculty focus area leaders
- Fourteen faculty principal investigators
- Forty-one graduate students
- Sixty-one hourly student workers
- Thirteen peer reviewed publications
- Forty professional presentations



The Center has a long-standing tradition of applied research in service to the people of Tennessee...

BENEFITS TO THE STATE OF TENNESSEE

We carry out research on a broad range of water-related topics on everything from rare fishes to nanostructures within osmosis membranes. For every State dollar we received during 2019-2020, we generated $1.95 in additional funding, almost entirely through 30 funded grant proposals. But how we do that has changed during the past year.

The Center has a long-standing tradition of applied research in service to the people of Tennessee, and many of our researchers have been doing this for years. But over the past year we have re-focused our efforts to better meet the needs of Federal, Regional, State, and local water managers. We did this by asking a simple question: "who are the end users of our research, and is our research meeting and supporting their information needs?"

Our agenda and priorities are now being set by talking with Stakeholders, and especially with State and Regional resource managers to learn about their high-priority research questions. We then assemble scientific teams with the right expertise who can seek external funding to solve problems with specific goals or outcomes. During 2019-2020, we used this process to activate 30 newly funded research projects totaling 2.4 million dollars. We presently have more than 25 submitted proposals to seek new funding, with new proposals being added about every week. The Water Center administers those grants on behalf of both the funders and the faculty researchers, and most funds are allocated to graduate students who will become the next generation of water scientists in the State. And while we support both basic and applied research, virtually all our work has practical applications for better water management and governance within Tennessee. We now strive to disseminate results quickly through regional conferences and workshops, and we are working on ways to involve resource managers during the research process for more continuous feedback.

Another top priority for this year has been to reach out to new faculty and new collaborators to broaden our problem-solving skill set and to broaden our understanding of the wicked problems facing water sustainability in our State. Our goal is to be the best State-focused water center in the Nation, and deserving of the support we receive from the people of Tennessee.

Accomplishments and Awards

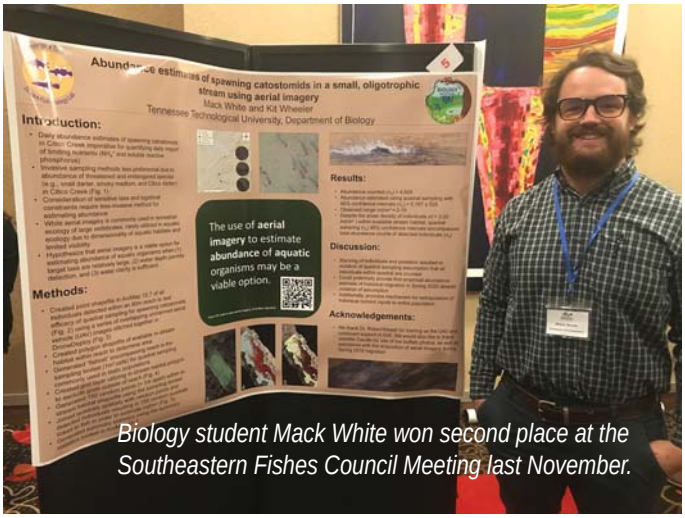
Biology Professor Hayden Mattingly won a Tennessee Tech Faculty Non-Instructional Assignment for a proposal to write and edit a special issue on aquatic fauna of the Barrens Plateau for the *Southeastern Naturalist*. His was one of only two non-instructional assignments awarded by the University in 2019.

Biology Assistant Professor Brad Cohen was invited to present "Mallard Movements and Habitat Use in West Tennessee: Project Summary," co-authored by N.M. Masto, A.G. Blake-Bradshaw, and C. Highway, to the Dyer County Ducks Unlimited Varsity, in Dyersburg, Tennessee, in 2019.

Biology Associate Professor Justin Murdock was invited to present "Wetland Reserve Program Research in Tennessee," coauthored by S. Morris, to the USDA NRCS Tennessee State Technical Committee in Murfreesboro, Tennessee, in August 2019. He was also invited to present "Improving Nutrient Retention in Agricultural Watersheds through Floodplain Wetland Restoration" during the Southeastern Water Pollution Biologists Association Annual Meeting, held in Chattanooga, Tennessee, in October 2019.

Assistant Professor in biology Kit Wheeler's student Mack White won second place among all graduate student posters for his presentation titled "Abundance Estimates of Spawning Catostomids in a Small, Oligotrophic Stream Using Aerial Imagery" at the Southeastern Fishes Council Meeting, held in Knoxville, Tennessee, in November 2019.

Amanda Rosenberger, assistant unit leader of the Tennessee Cooperative Fishery Research Unit and associate professor of biology, was part of the WingsUp 100 group of researchers who earned more than $100,000 in the 2018-2019 fiscal year. Also, her article (Laske et al., 2018) was recognized as the Top Downloaded Article from 2017-2018 by the *Ecology of Freshwater Fish*. She was invited to present "Modeling Fundamentally Suitable Freshwater Mussel Habitat in the Duck River Drainage, Tennessee," coauthored by B. Bajo, during the Organization of Fisheries and Wildlife Information Managers Annual Meeting, held in West Virginia in October 2019.



Biology student Mack White won second place at the Southeastern Fishes Council Meeting last November.

AWARD-WINNING RESEARCH WITH A PURPOSE: Tennessee Tech Student Revolutionizes Flood Simulations to Garner Swiss Award

Computer Science doctoral candidate Mohammed Bulbul Sharif from Tennessee Tech University has received the Best Paper award from the Swiss Platform for Advanced Scientific Computing. The top award was for a paper titled, “Performance Evaluation of a Two-Dimensional Flood Model on Heterogeneous High-Performance Computing Architectures”.

Computer based flood simulations are a powerful tool for protecting lives and property. They allow scientists and emergency managers to visualize what happened during a flood so that communities can be better prepared for next one, and they allow forecasting of future “what if” events so that emergency preparedness can be set up beforehand. The problem is that the computer simulations are time consuming. If you begin a large area flood simulation with your Monday morning coffee, you won’t receive results until Saturday morning. Mohammed’s work gives you results in less than 20 minutes.

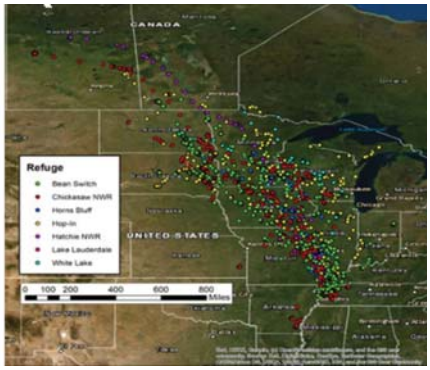
“During my internship at Oak Ridge National laboratories (ORNL) last summer, I was fortunate to have access to one of the world’s two fastest computers,” said Sharif. “The code (TRITON) I developed on the Summit supercomputer is the fastest two-dimensional flood simulation code in the world and performs 200,000 trillion calculations per second

“Sharif simulated the 2017 Hurricane Harvey at 5-meter resolution using TRITON on the Summit under 20 minutes” said Dr. Sheikh Ghafoor, professor of Computer Science at Tech and Sharif’s research advisor. The simulation was 390 times faster than the previous fastest simulation. Fast simulations like this can help researchers to experiment and improve the flood prediction models enabling emergency planners to prepare for impending flooding from events such as dam breaks and hurricanes.

Computer Science doctoral student Mohammed Bulbul Sharif won the Best Paper Award from the Swiss Platform for Advanced Scientific Computing.

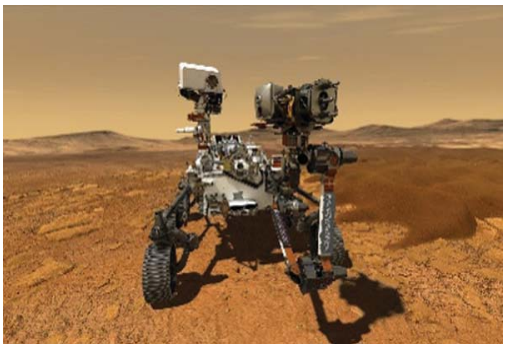
Sharif’s peer-reviewed paper was published in the Association for Computing Machinery conference proceedings. The flood modeling research is a large collaborative effort between ORNL scientists Mario Morales-Hernandez, Shih-Chieh Kao, Sudershan Gangrade, Katherine J. Evans, TTU faculty Alfred Kalyanapu, Sheikh Ghafoor and doctoral students Md. Bulbul Sharif, Thomas Hines, and Tigstu Dullo. The flood modeling research was funded by the U.S. Air Force via ORNL. Sharif has been invited to present the paper at the PASC conference in Geneva, Switzerland in 2021.

Sometimes, It is not Just About Water



Dr. Cohen holds a male mallard affixed with a GPS-transmitter. The transmitters to mallards provide critical information on their spatial ecology and habitat selection that can be tracked in real-time. The information gleaned better informs managers about waterfowl use of different habitats and helps the TWRA's management of western Tennessee wetlands. Other uses for those data include understanding effects of disturbance on waterfowl movement, and delineating migration routes and stop-over sites in the Mississippi Flyway.

We are all about Tennessee's Water Resources, but the Water Center also supports several national and international research grants dealing with wildlife, agriculture, and geology. We are experts in the administration of exceptionally large grants, and both faculty and grantmaking agencies appreciate our ability to handle them efficiently and effectively with fiscal accountability and regulatory compliance. In many cases, those studies have many of the same attributes as our Tennessee water-focused studies, so they are a good fit for us. Some examples are Dr. Jeanette Wollak's studies of water-created geological features on Mars, Dr. Brad Cohen's work on mallard duck population, and Dr. Brian Leckie's agricultural genetics to improve crop production for rural Tennessee growers. Those studies do have potential applications to the State in that water-based geological processes occur in Tennessee, the cutting-edge technologies used to study ducks are likely going to be applied to a range of aquatic species, and an important component of plant genetics is development of drought resistant cultivars. Their work also paves the way for stronger future collaborations between the Water Center and academic departments throughout the University.



Water Center scientist Jeannette Wolak studies lake deposits on Earth and Mars. As part of her work, she'll follow the landing of the Mars Perseverance rover as it lands in February 2021. The rover will explore Jezero Crater, a paleolake that may have hosted water and life in the ancient past.

CENTER-INITIATED RAPID RESPONSE RESEARCH

Helping Fisheries Managers Provide Healthier Trout

Through judicious and conservative spending, the Water Center has begun supporting Center-initiated research. Funding is available so that faculty can initiate research quickly on acute problems and high-priority issues identified by partners, but for which no funding mechanism exists or where it would cause harm to wait up to a year to write traditional proposals for the grant-funding cycle that peaks during the winter. Our first rapid response effort focuses on water quality in State fish hatcheries.

The TWRA relies on hatchery trout for stocking into our nationally recognized tailwater fisheries, and maintaining large numbers of healthy trout is vital. But, TWRA personnel are faced with nitrogen supersaturation in the springs that supply water to many hatcheries. The reasons underlying supersaturation are not well understood, but they cause trout to experience what human divers would call "the bends." This makes them less healthy, and can even kill fish. Hatchery staff flood incoming water with oxygen to strip off excess nitrogen, but enough nitrogen can remain to create issues, and the truckloads of liquid oxygen required to support the process are expensive.

Savannah Fernholtz, a recent graduate from the Cooperative Fishery Research Unit, holding a 32 pound Asian Carp. The Water Center collaborates with the Fishery Unit on Asian Carp invasion research in an effort to control their expansion in Tennessee. She is now employed with the Iowa Department of Natural Resources.

A team of nine undergraduate chemical engineering students explored ways of reducing nitrogen by testing different ways to set up the stripping columns. They partnered with Red Silo Brewery to created chilled supersaturated water in the laboratory and were collecting data when forced to leave campus due to Statewide pandemic lockdowns. However, they were able to help us understand system dynamics prior to going home.

Annelies van der Bleek setting up a test column at Red Silo Brewery. Red Silo helped students create nitrogen-saturated spring water in their brewing room.

As soon as it was safe to do so, we resumed the project using a graduate student who has transitioned the work to field experiments at Buffalo Springs hatchery. Using the laboratory data, he created a novel diffuser column, and field trials are underway. While we need to accomplish extensive field testing under different conditions, initial results suggest that we can provide more oxygen and reduce nitrogen saturation at far higher efficiencies than the present systems. It requires far less pure oxygen to produce the water quality needed by trout, and should substantially reduce the amount of liquid oxygen that the hatchery needs to purchase. And, the student's invention can be constructed primarily from about 100 dollars of materials that one can find at the hardware store.

The Water Center is looking forward to new opportunities to work with the State on hatchery water quality. We have interdisciplinary expertise, and the students love working on real-world issues.

FOCUS: Biodiversity

“Buffalo” fish travel upstream to Citico Creek

Buffalo in Citico Creek, April 6, 2019

Every spring in east Tennessee, tens of thousands of fishes called buffalo make the short trip upstream from Tellico Reservoir into a small tributary called Citico Creek to reproduce. Although their journey is far less dramatic than the much-celebrated salmon of the Pacific Northwest, these buffalo likely share at least one important similarity with the salmon: through their migrations, they transport large quantities of essential nutrients between aquatic habitats. Given their ability to act as conveyor belts of materials that fuel production in habitats used for spawning, researchers at Tennessee Tech are left to wonder, are suckers the salmon of the South?

Nearly half of the 30,000+ fishes in the world use freshwater habitats, and many of these fishes regularly move back and forth between different habitats to find food, reproduce, or seek shelter. These regular movements, often called migrations, serve a wide variety of functions. In many parts of the world, migratory fishes are a critical food source for humans while in other places, they serve as the base of economically valuable fisheries. Less recognized, though equally important, is the role of fish migrations in moving essential nutrients like nitrogen and phosphorus between habitats. Perhaps the most well-known examples of migratory fishes in the world are the Pacific salmon. These fishes are born in freshwater before migrating to the ocean where they spend most of their adult lives. Eventually, adult salmon migrate back to the freshwater systems where they were born to reproduce and start the cycle anew. These reproductive, or spawning, migrations from the ocean to inland rivers and lakes have the potential to transfer substantial amounts of nutrients from marine to freshwater habitats. In some cases, the receipt of these marine-derived nutrients facilitates the growth of development of biota across multiple levels of freshwater food chains. While the ecological importance of salmon migrations is now widely recognized, many unanswered questions remain about the potential significance of other migratory fishes, including those that move exclusively among freshwater habitats.

“Buffalo” fish travel (cont.)

Catostomids, a group of fishes commonly called suckers, are distributed across the United States, and frequently represent a considerable proportion of fish communities in the Southeast. Many suckers are known to make annual spawning migrations between freshwater habitats in the spring. These migrations can result in the aggregation of hundreds of thousands of individuals over relatively small spaces and short times. Moreover, suckers are relatively large-bodied fishes that produce and eventually deposit large numbers of eggs when they spawn. Consequently, they have the potential to serve the same function in Southeastern freshwaters as their more famous salmon relatives in the Pacific Northwest. However, the ecological role of suckers is poorly understood, largely due to their status as non-game species of little commercial or recreational value.

We are conducting research to determine the magnitude and ecological significance of the nutrient subsidy delivered by migratory suckers in Southeastern rivers and streams. Initially, our work is focused in Citico Creek, a small tributary to the Little Tennessee River in east Tennessee. Citico Creek flows into Tellico Reservoir, and one particular type of sucker called buffalo moves en masse into Citico from the reservoir every spring to spawn. After spawning, adult buffalo move downstream to return to the reservoir, and they are followed shortly thereafter by great numbers of tiny larval buffalo floating with the current of the creek. These very small, very young buffalo are extremely vulnerable to a suite of aquatic predators during their downstream journey. Moreover, the vast majority of buffalo eggs deposited during spawning do not ever reach the larval stage due to predation or decomposition. Thus, nutrients contained within buffalo eggs and larvae represent a contribution to Citico Creek, as do other nutrients that are released by spawning buffalo via excretion and by decomposing buffalo that die during the reproductive migration.

The first step of our research involves estimating the amount of nutrients being contributed to Citico Creek by migratory buffalo. Once that estimate is generated, we can compare it with ambient or background nutrient levels in Citico Creek. If buffalo-derived nutrients are comparatively large, it indicates their ecological importance in the system.

Given the ubiquity of suckers like buffalo across Southeastern freshwater habitats, we plan to study other systems for comparison with the Citico Creek buffalo migration, and such a broadening of our research would facilitate more effective conservation and management of water resources. With a more complete understanding of the ecological role played by migratory suckers in the Southeast, we can use historical data to estimate nutrients that have been lost due to diminished sucker migrations in river networks that have been fragmented by structures like dams and culverts and degraded by poor land use practices. Additionally, we will be better positioned to identify what can be gained by restoring aquatic connectivity and habitat conditions, thereby providing critical information to resource managers and decision makers.

Incoming Tennessee Tech biology graduate student Ryan Hudson holding a migratory smallmouth buffalo (Ictiobus bubalus).

FOCUS: Water Security and Sustainability

Student Juliet Ohemeng-Ntiamoah preparing the co-substrate mixes for co-digestion.

Bioprocess Engineering and Applied Microbiology Used to Evaluate Cost-effective Biological Nutrient Removal Processes

Wastewater treatment systems are a lot like tropical fish aquariums, except the focus is on raising microorganisms instead of fish. The microorganisms within the system are actually doing the hard work of breaking down the pollutants in wastewater into non-toxic components. Most systems do this aerobically by adding oxygen to the wastewater stream and generating carbon dioxide that off-gasses into the atmosphere. But, if one can run the system anaerobically (without oxygen), certain microorganisms generate methane that can be captured and burned as a fuel to generate enough electrical power to make the treatment plant self-powered. That approach has been used by large treatment systems but has not been applied widely to smaller systems because they need high efficiency to work well. Our work is studying how to improve efficiency via anaerobic co-digestion, which is a process by which plant operators can add high-strength organic substrates such as food waste to augment biogas production. But what should be added, and how does the microbial community respond? That determines success or failure.

Our research evaluated the effects of co-digesting waste activated sludge (WAS) with food waste and fats, oils and greases (FOG) on digester performance and microbial community structure and activity under stable and inhibitory conditions. Furthermore, stepwise incremental addition of the co-substrates was evaluated as an optimization technique to avert process inhibition. Long-term, laboratory-scale experiments showed that 75% food waste increased the methane yield by 70-fold when compared to mono-digestion of WAS. A 16.5-fold increase in methane yield was achieved at 50% FOG fraction, beyond which process inhibition occurred. Stepwise increment of food waste enabled the microbial communities to adapt to this substrate and successfully avert inhibition; however, this was no true for FOG. The co-substrates changed the microbial community structure and activity by selecting for different communities during the co-digestion process. Functional redundancy and resilience of the microbial community was found to be key in ensuring stable digester performance during the co-digestion process. Overall, this study showed that through stepwise increment of food waste, microbial communities can be acclimatized to

Bioprocess Engineering and Applied Microbiology (cont.)

handle higher organic loading and avert inhibition in co-digestion systems. We observed significant differences between community structure and activity, which informs that optimization strategies for co-digestion systems need to be targeted at the active microbial community. The operational strategies and the microbial community elucidated in this research will aid water resource recovery facilities to implement resilient co-digestion systems for enhanced methane yield towards energy neutrality.

With the optimized operational strategy we developed in this research that successfully averted process inhibition during high strength food waste co-digestion, we are exploring the implementation of anaerobic co-digesters in small-scale systems. If successful, many small-scale water resource recovery facilities, farm and food-digesters, as well as house-hold level digesters in developing countries can be improved towards higher biogas production.

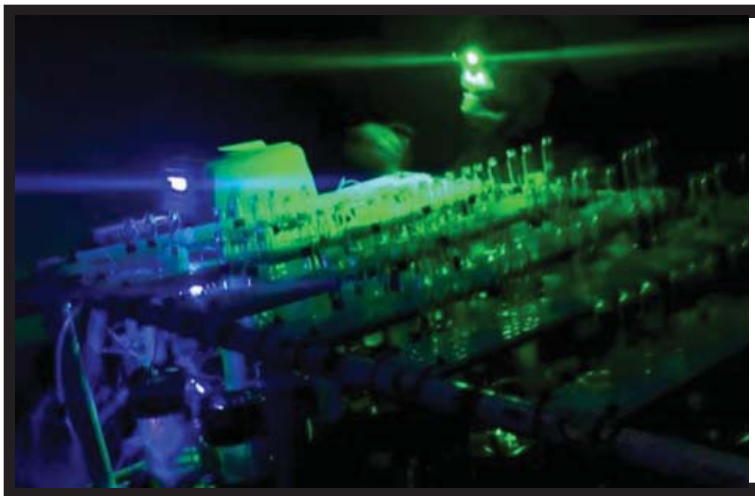
Another research project that explored improving the current understanding of microbiology in beneficial bioprocesses involved biological nutrient removal (BNR) at water resource recovery facilities. As regulatory limits on nutrient discharge from water resource recovery facilities become more stringent, understanding the microbial communities in BNR systems can become beneficial for process optimizations. Traditional BNR occurs in more than one reactor to accommodate nitrification, denitrification and enhanced biological phosphorus removal (EBPR) processes. However, unconventional BNR includes optimizing a single reactor, such as an oxidation ditch, to have a dissolved oxygen gradient to accommodate these processes simultaneously. As an emerging practice, process optimization often encounters instabilities that can be averted by understanding the factors contributing to the structure, function, and stability of the BNR community, especially with regards to polyphosphate accumulating organisms (PAOs). Therefore, to contribute to the body of knowledge of unconventional BNR microbiology and process performance, this study evaluated how microbial communities adapt to unconventional operations of oxidation ditches and assessed whether the community and process stabilize over time after an optimization. Specifically, this research addressed whether the community structure and potential function change in response to optimization and attempted to further characterize the PAO community. Full and laboratory-scale studies were conducted to address the research goals. The full-scale optimized WRRF of this study modified the aeration patterns of their oxidation ditches to accommodate BNR. Two additional facilities were investigated to establish how a microbial community might change over time without the influence of optimization. One of these facilities operated a conventional oxidation ditch, while the other was designed and operated for BNR. The optimized water resource recovery facility was able to accomplish simultaneous nitrification and denitrification, while fluctuating ortho-P concentrations were observed in the oxidation ditch. Supporting evidence provided by measured P-release and uptake rates suggested that the facility has the potential to accommodate EBPR. Furthermore, the community of this facility changed differently compared to the other water resource recovery

Student Grace McClellan sampling at City of Cookeville's oxidation ditch.

Bioprocess Engineering and Applied Microbiology (cont.)

Oxidation ditch at City of Cookeville's Water Resource Recovery Facility.

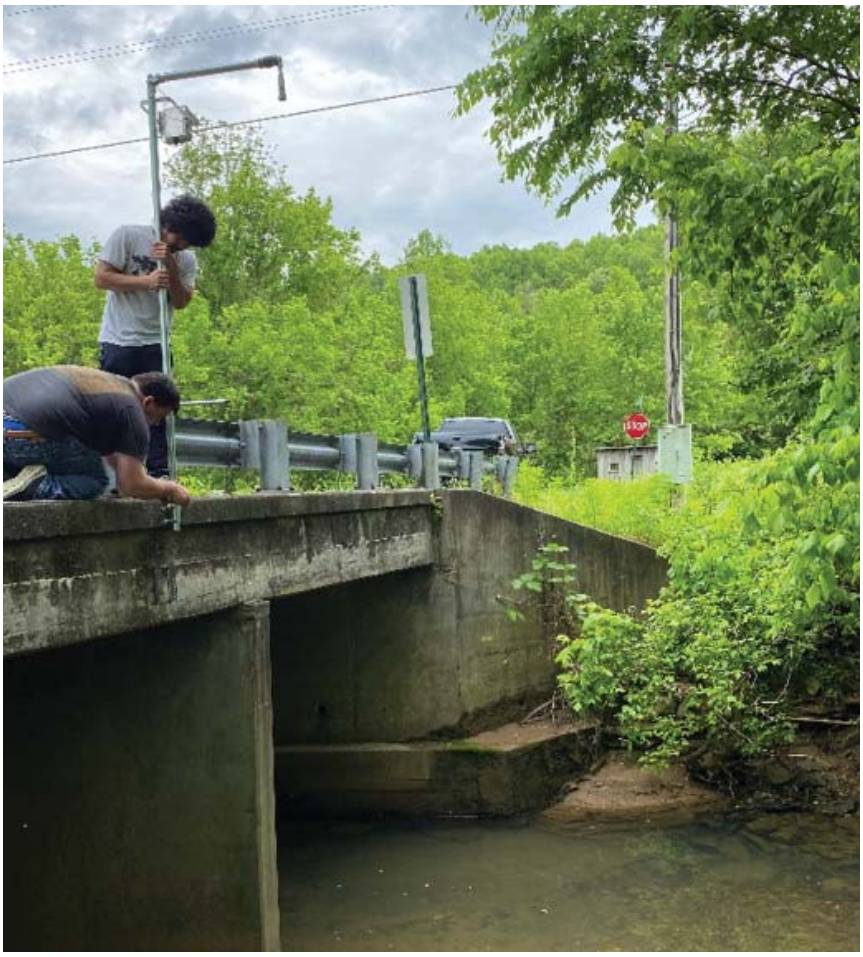
facilities, implicating that the changes were in response to optimization and were not completely temporal. Furthermore, dissolved oxygen correlated with the diversity of the optimized facility, whereas temperature was correlated with the reference facilities. PAOs were detected as active in the optimized oxidation ditch when the facility did not exhibit characteristics that would support PAOs. During the laboratory-scale study, Dechloromonas and a glycogen accumulating organism were detected as active and possibly more important to the denitrifying EBPR process than the well-known PAO, Candidatus Accumulibacter phosphatis. The outcomes of this study suggested optimization of oxidation ditches for BNR has the potential to be a successful and reliable practice.



Ryan Hudson collecting gas samples from wetland soil cores. The samples measure denitrification rates, which tell us how efficient different parts of the wetland are at moving nitrogen pollution from the water into the atmosphere, where it becomes harmless.

FOCUS: Modeling Analysis and Simulation

Low-cost, real-time water monitoring in rural Tennessee



Graduate students Chris and Note installing the RDF gage at Adams Acres Road site.

With an annual average rainfall of more than 52 inches, the state of Tennessee experiences frequent floods annually. Some of the "flash" floods that have recently occurred in the Cummins Falls State Park in Jackson County have gained a lot of media attention, but most rural floods do not capture the news headlines because these occur in rural areas. The magnitude of these floods may not be very significant, but their frequency results in many city, county and public utility agencies stretched for resources, especially in the rural areas. Preparing for floods would require a robust infrastructure of continuous streamflow monitoring gages. These gages should have the ability to be installed rapidly and be resilient enough to withstand extreme environmental conditions including winds, lightning and short periods of flooding.

Continuous surface water level and water quality monitoring is a cost-intensive venture that requires resources and close-coordination among federal and state government agencies across the United States. But, do we have enough gages to have the data we need for flood preparedness?

To answer that question, researchers looked at gage locations in HUC-10 spatial units. An HUC-10 is a watershed classification used by scientists that identifies "smaller" watersheds of 40 to 250 thousand acres. In Tennessee, a spatial analysis of

Graduate student Chris explaining the use of Trimble GPS unit to the undergraduate students.

Modeling analysis and simulation (cont.)

HUC-10 boundaries from National Hydrography Dataset (NHD) and streamflow locations from National Water Information System (NWIS) revealed that out of the 272 HUC-10 basins within Tennessee, only 90 (i.e., ~ 33%) have at least one or more stream gaging stations. Gages are prevalent along the major waterways including the Tennessee and Cumberland Rivers, or metropolitan areas. However, for smaller watersheds with smaller urban centers (e.g., Cookeville, McMinnville, etc.) across the state, there is a scarcity of streamflow gaging sites. In this context, performing watershed management studies in smaller watersheds (i.e., HUC-10 or less), or in watersheds with resource-limited semi-urban areas becomes a challenge.

Using low-cost water level sensing will help in reducing the cost of equipment installation and data collection methods, which is very crucial for managing smaller (or resource-strapped) watersheds. Additionally, cloud-based real-time services have become more common with advances in information and technology, and lowered data storage charges. Utilizing these new advances in hydrological sciences is a growing area with a need for more scientific investigations.

At Tennessee Tech, Principal Investigator Alfred Kalyanapu and co-PI Tania Datta, both associate professors of environmental engineering and associates of the Water Center, are addressing this very important issue by developing low-cost rapidly deployable flood (RDF) gages that cost a fraction of the cost of the commercially available gages. This student-faculty driven project uses Internet-of-things technology and combines commonly available micro-controllers and do-it-yourself electronic and electrical components into robust RDF gages. These gages have technology built-in to record the water levels using ultrasonic sensors at regular intervals and streams this data over the Internet in real-time using cellular connection to TTU's cloud-hosted data service called CHORDS. This water level data is broadcasted to general public and government agencies using dynamic GIS maps. (For example, visit: https://www.techwarms.org/fwrrt-map.) This map shows the real-time water level situation in the Falling Water River Watershed in Putnam County.

The project has been funded by USGS 104B program with major support from the Water Center and from a University Faculty Research Grant. The project team is currently working on a USGS 104B funded project to develop a low-cost, real-time water quality monitoring system for the State of Tennessee.

FOCUS: Food, Water, Energy Nexus

Rural Reimagined: Could small-scale aquaculture benefit rural landowners?

Tennessee Tech has embarked on a Grand Challenge; Rural Reimagined, whose goal is to support rural Tennessee rural communities by harnessing science, technology, and innovation in ways that can support sustainable economic development. The Water Center is supporting Rural Reimagined by investigating whether small-scale aquaculture has potential for fish production, especially as bait for sport fishing. Many farms in middle Tennessee have small ponds that were built for irrigation, watering livestock, and recreation. Many are too shallow, small, or have marginal water

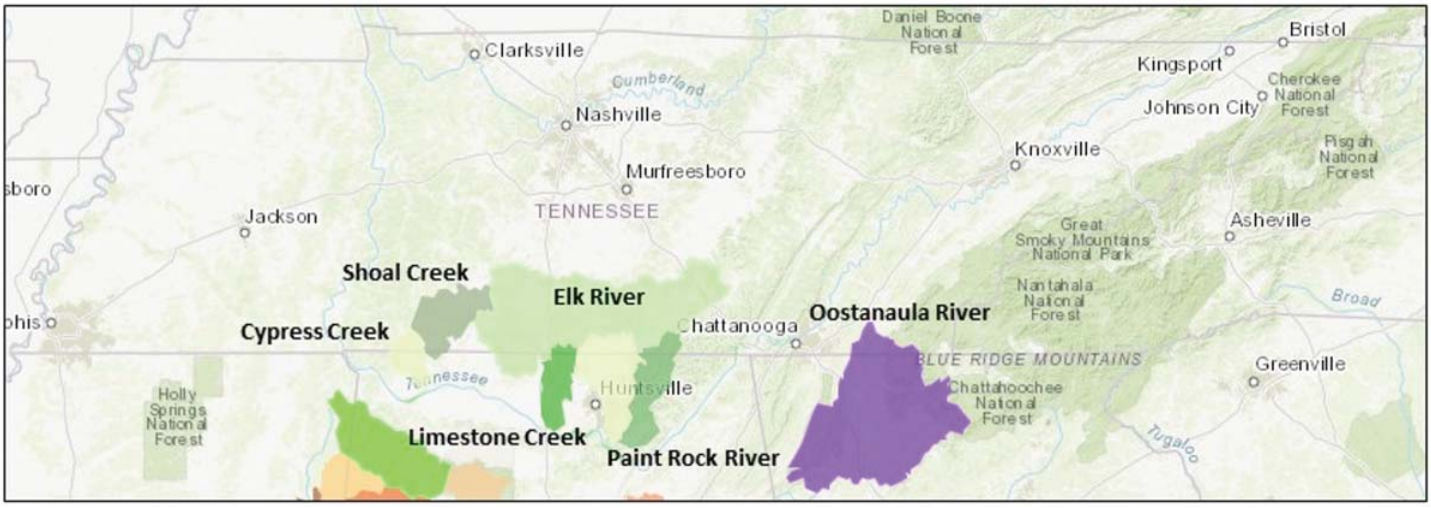
quality such that they do not support good fishing. However, small-scale aquaculture may offer another use for these waters. Ponds in rural Tennessee likely provide the perfect setting for culturing Fathead Minnows *(Pimephales promelas)* that can provide pond owners with income through the sale of baitfish (approximately $10 per pound of live fish) for a market that has unmet demand. And, baitfish culture differs from many other fish rearing efforts in that it does not require a big investment in facilities to produce fish.

We are partnering with Oakley Farm in Livingston, Tennessee, to carry out feasibility research; ponds on this property are typical of many small farm ponds found in our region. Students enrolled in Fisheries Management (WFS 4710), Fish Culture (WFS 4760), and Special Topics courses will be actively involved in the project. In addition, the Tennessee Tech Student Fisheries Association will help feed and harvest the Fathead Minnows.

Specific objectives of this project will be to:

1. Determine if small ponds in rural middle Tennessee can be used to economically produce fish as a cash crop;
2. Identify if water quality of farm ponds not originally intended for aquaculture limits fish production; and
3. Determine the most economically feasible methods for producing Fathead Minnows to maximize production and landowner profits in rural Tennessee farm ponds.

If we can demonstrate that Tennessee farm ponds have the capability of producing bait minnows, we will then partner with Tech's College of Business Administration to work out business plans and development of supply chains.



Alabama Strategic Habitat Units that extend into Tennessee. These watersheds support some of the highest aquatic biodiversity in the nation.

A rivers and streams network for Tennessee?

The Water Center is exploring development of a Tennessee Rivers and Streams network (TRSN) based on an approach that has been highly successful in Alabama. A rivers and streams network is a conservation planning tool that brings researchers, managers, and stakeholders together to identify and implement strategic conservation in the right places at the right scale. Faunal experts identify watersheds and stream reaches that are high priority, and those places are mapped as Strategic Habitat Units (SHUs) or even Strategic River Reach Units (SRRUs). The value in this approach is that many conservation planning efforts are large-scale (often Statewide), but restoration projects tend to be local. The SHUs provide that middle ground that allows local efforts to be more strategic and coordinated. This helps ensure that scarce restoration dollars are spent as efficiently as possible on projects that are as effective as possible. In particular, it brings together the people who work on different organisms (fish, mussels, and others) to look for conservation actions that can benefit multiple species.

We hope to build consensus for a TRSN during 2021. Tennessee has over 300 fish species – almost more than any other State. Conservation of our natural heritage is a priority for every Federal, State, Regional, and non-governmental entity with a natural resources mission, and we suggest that a TRSN would be an effective tool.

However, success occurred in Alabama because there was consensus among researchers and managers that the network had value. During 2021, we will canvas collaborators to see it this approach would be helpful. If so, the Water Center will coordinate Network development.

Valerie Jones, a recent graduate, surveying Bluemask Darters in the Collins River. She is now employed with the Kentucky Department of Fish and Wildlife.

OUR STUDENTS

Maci Arms

My name is Maci Arms, and I am a senior undergraduate Honors student pursuing dual-degrees in Civil Engineering and Foreign Languages. I study local stormwater management and flooding issues in Gainesboro, Tennessee, with Dr. Tania Datta and Dr. Alfred Kalyanapu. I chose to concentrate in environmental engineering because I am interested in learning how to apply engineering concepts to design a more sustainable future.

My research is a University-Community partnership. In the summer of 2018, Gainesboro experienced significant flooding that impacted the town's Emergency Management Services (EMS) building, the Jackson County Public Library, and even surrounding residential and commercial areas. Under the supervision of Drs. Datta and Kalyanapu, I am collecting and analyzing a broad range of historic weather and land-use data, topographical information, soils, hydrological data on local streams, flood maps, and even storm drain and sewer maps. The comprehensive database will help the Gainesboro community plan for improved stormwater management. The project is funded by TDEC's 604(b) water quality planning grant via the Upper Cumberland Development District.

George Darkwah

My name is George Kwabena Darkwah, and I am from Ghana. I moved to the United States in January 2020 to pursue my master's degree in Civil and Environmental Engineering at Tennessee Technological University, TN. I am passionate about helping people to apply my knowledge to improve the quality of life in my community. That passion inspires my current field of study. I obtained my bachelor's degree in Civil Engineering from Kwame Nkrumah University of Science and Technology (KNUST), Ghana, after which I spent two years in the construction industry.

I am currently involved in two research projects. The first project, funded by the USDA, is development of flood models for the Red River basin, near Clarksville, TN. This basin lacks comprehensive streamflow data, so I am developing a more representative flood model that can predict flood impacts on agricultural lands near the river. My second project is development of an operational flood forecasting system for the Window Cliffs State Natural Area, TN, using machine-learning techniques. My goal is a system that can provide timely flood warnings to help save lives and property in the event of unforeseen weather events. This research, if successful, can be scaled up and applied in other state parks and flood-prone areas across Tennessee.

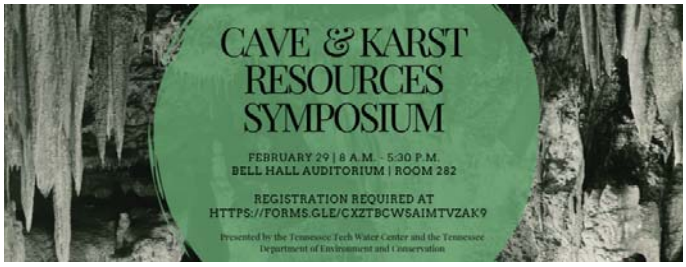
Samantha Allen

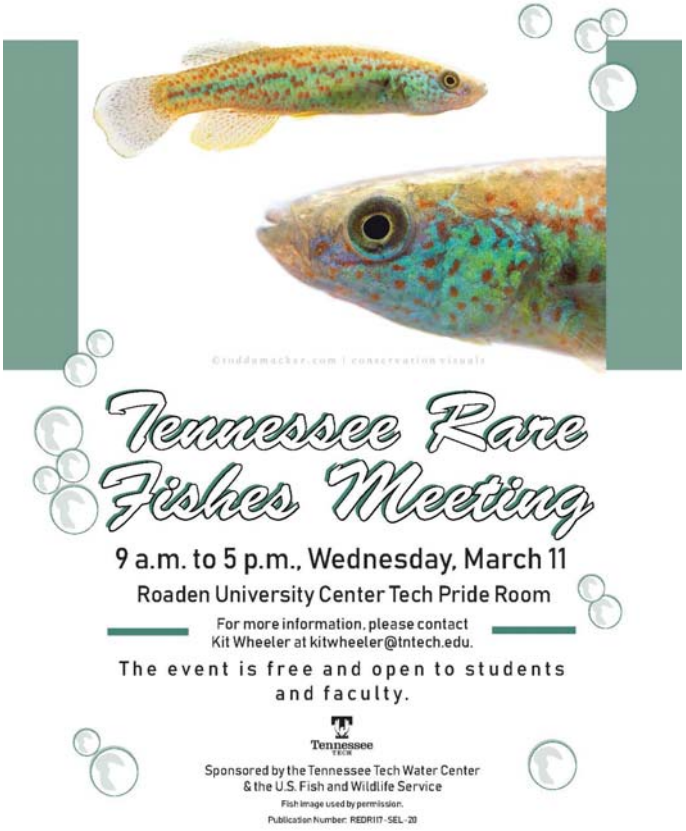
I am enrolled in the Environmental Science Ph.D. program at Tennessee Tech. My past research has focused on using Geographic Information Systems (GIS) technologies to gain insight into species distributions of aquatic species in Tennessee, including the endangered bluemask darter and pygmy madtom. Additionally, I assisted in creating a web-based geodatabase for the Falling Water River Watershed to facilitate data sharing and collaboration among watershed stakeholders. My current doctoral research is based in the Arnold Air Force Base in Tullahoma, TN. My goals are to apply remote sensing and GIS techniques to better understand karst groundwater systems, create a human threat index to highlight areas at risk to human effects, and to model the aquatic species distributions for the area.

Cory Highway

My name is Cory Highway, and I study the ecology and habitat availability of wintering waterfowl in western Tennessee under the Supervision of Dr. Brad Cohen and Dr. Dan Combs. I was fortunate to grow up in a family that introduced me to the outdoors at an early age, and my passion for understanding wildlife led me to seek an education and career in natural resources management and wildlife biology. My research focuses on wintering mallard ecology in western Tennessee and is designed to support decision-making by the Tennessee Wildlife Resources Agency. Waterfowl managers must provide both food and hunting opportunities. Flooding unharvested corn is a popular management tool, but, does corn flooding benefit waterfowl? My goal is to identify depletion rates of unharvested corn in western Tennessee and identify factors influencing depletion. I also want to understand how waterfowl perceive their environment and shift their activity patterns to avoid hunters. We are attaching GPS/GSM transmitters to over 120 mallards annually over three years and using real-time locations to learn how mallards respond to weather, forage availability, and hunting pressure across space and time. We hope to provide information that will help resource managers better understand mallard movements in western Tennessee, and inform them about ways to balance providing food resources and hunting opportunities.

The photo was taken at Hatchie National Wildlife Refuge (NWR) in western Tennessee. Elementary students from Shelby County Public Schools visited the refuge on January 27 to learn about bottomland hardwood ecosystems and observe local wildlife. Abbey Blake-Bradshaw and I captured ducks immediately prior to their arrival. We presented a brief explanation of our project and an overview of waterfowl migration. In the picture, I am explaining why we are putting GPS “backpacks” on ducks and the information we hope to gain from the project. Many of the students had never seen a duck prior to our presentation, but they all got to touch a duck, and two students released ducks afterward. We kept the presentation short to minimize stress on the birds, and we fielded questions after the ducks were released. I believe that the impact of this experience left a lasting impression about the importance of conserving wildlife and natural resources.





Communication Students Join in the Action

Tennessee Tech Communication students enrolled in an Event Promotions and Management course acquired the Water Center as its client for the Spring 2020 semester. This field experience class allowed the students to work closely with the Water Center to plan and execute three events, which were all held on Tennessee Tech campus: The Cave & Karst Symposium and Expedition, which was held on February 29 & March 1, 2020; a Distinguished Speaker Presentation, which was held on March 5, 2020; and the annual Rare Fishes Conference, which was held on March 11, 2020.

For each event, the Communication students were the event planners and executors; teams worked on publicity and promotions, parking and security, registration, and refreshments for participants. On conference day, they registered participants, assisted with audio-visual technology, and ensured that all needed support for seating, refreshments, and poster presentations were in the right place at the right time.

The Cave and Karst Symposium brought together researchers, resource managers, and stakeholders to share information about Tennessee caves and the karst landscape in which they are found, with the goal of supporting better understanding and conservation of Tennessee's cave resources. The following day, Tech hosted a caving expedition designed for Tech students that explored two area caves, and the event planning students were even able to attend.

The second event was a seminar by Dr. Franklin Percival, whose research on American Alligators removed them from the Federal Endangered Species List. His conservation guidance led them to become quite abundant Statewide, and led to their reclassification as a game species. His talk was a historical retrospective on the natural history of Alligators, and how they transitioned from being endangered, to everywhere.

Our third and final event was the Annual Tennessee Rare Fishes Conference. That meeting was held at Tennessee Tech, and transitioned from a small informal gathering into a full fledged conference with a broad range of agency professionals who gathered to celebrate conservation successes and coordinate conservation actions for 2020. Student attendance was enhanced by having it occur on campus, and a number of Tech students did poster presentations.

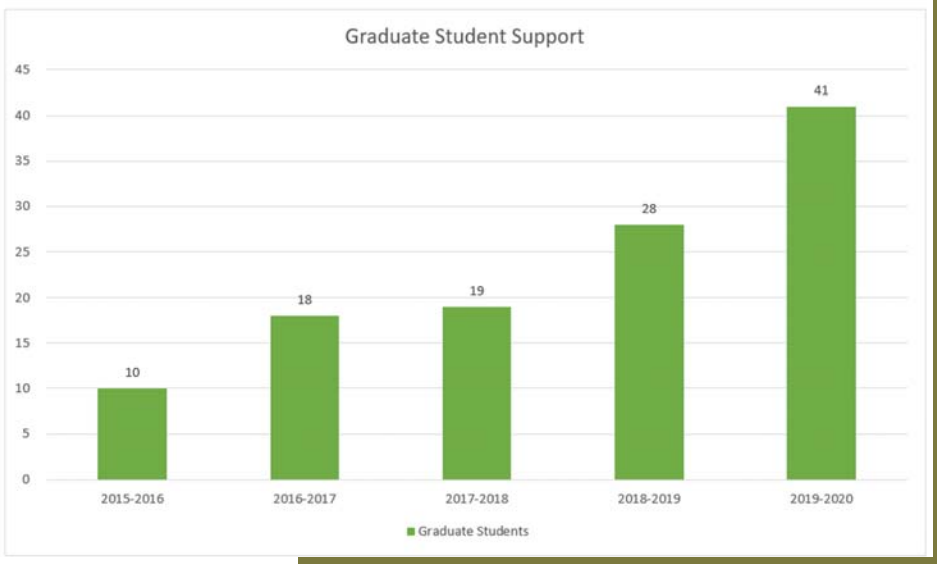
Sadly, two additional events had to be cancelled due to the Covid pandemic, but the students gained real world experience and established a model for undergraduate engagement that will be used in the future by the Water Center to facilitate science communication. Hosting campus events makes them far more accessible to students, and the event planners make it happen.

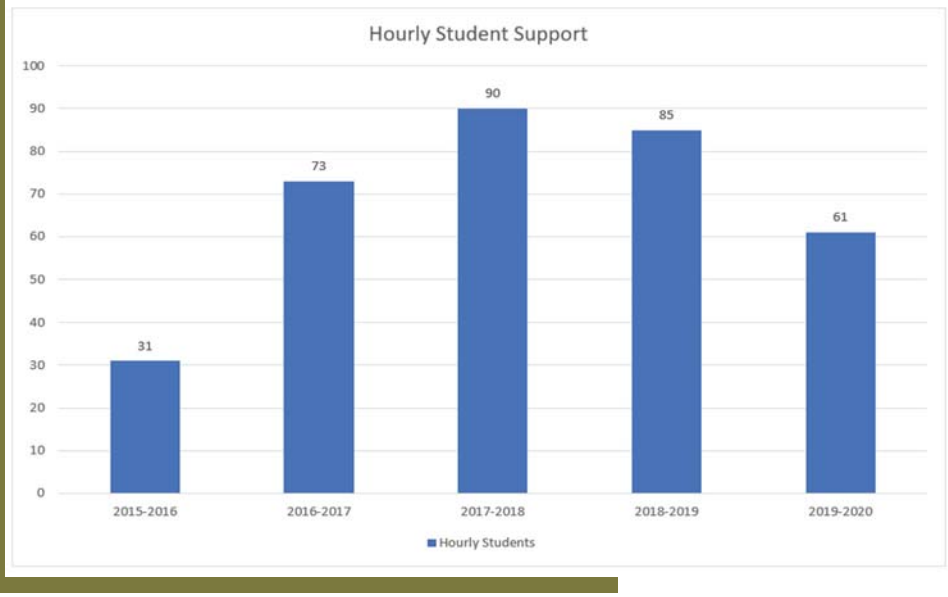
Overall, the students were able to obtain first-hand experience in event planning, promotions, and management – the goal of the class. "It was an honor to have my students work with the Water Center staff to effectively and efficiently plan, promote, and manage their events. This is exactly the type of work they will encounter when they graduate, and I am forever grateful to Jeff Schaeffer and the Water Center staff for allowing my students to gain these valuable skills," said Colleen Mestayer, professor for the class.

ENHANCING EDUCATION & RESEARCH

Students Supported

Without students, the Water Center could not continue to engage in its research initiatives. Therefore, offering our students the most cutting-edge opportunities in environmental research is important. This fiscal year, the Center supported 41 graduate research assistants. The Center also supported 61 students on an hourly basis to work on research and service projects in the field, in laboratories and in the office.





Graduate Students Supported

Ph.D.

Name	Major
John Brackins	ENGR
Robert Brown	EVS
Tigstu Dullo	ENGR
Shrijana Duwadi	ENV
Eric Koehler	ENV
Nicholas Masto	ENV
Grace McClellan	ENGR
Collins Owusu	ENGR
Srinivas Ravinutala	ENGR
Md Bulbul Sharif	ENGR
Prince Turkson	ENGR
Haley White	ENGR
Spencer Womble	EVS

Master's

Name	Major
Godson Adjovu	CEE
Maci Arms	CEE
Brittany Bajo	BIOL
Joseph Brockwell	CE
Joshua Cary	BIOL
Jennifer Caudle	BIOL
Aaron Coons	BIOL
George Darkwah	CEE
Samuel Day	BIOL
Vinay Dhanvada	CE
Thomas Flanagan	BIOL
Wesley Giddens	PSM
Cory Highway	BIOL
Abbey Holsopple	BIOL
Frederick Hoogakker	BIOL
Minhazul Islam	CE
Christopher Kaczmarek	CEE
A. Danielle Kirkpatrick	CEE
Maria Kuchla	CHE
Mackenzie Martin	CEE
Morgan Michael	BIOL
Zishan Onik	CSC
Ashley Padgett	BIOL
Anchita Sanan	BIOL
Nusrat Jannah Snigdha	CE
Victor Wesley	BIOL
William T. Wood	BIOL
Tyler Wright	CEE

Recent Graduates

Ph.D.

Name	Major	Dissertation Title
Grace McClellan	ENGR	Microbial Community Structural and Functional Response to Optimization of a Water Resource Recovery Facility for Biological Nutrient Removal (Advisor: Associate Professor Tania Datta)
Juliet Ohemeng-Ntiamoah	ENGR	Anaerobic Co-Digestion of Waste Activated Sludge with Food Waste and Fats, Oils and Grease: Effects on Digester Performance, Microbial Community Structure and Activity (Advisor: Associate Professor Tania Datta)
Robert Paine	BIOL	Environmental DNA: A Molecular Approach to Delineating the Distribution and Community Composition of Fishes in the Duck and Clinch Rivers, Tennessee (Advisor: Associate Professor Carla Hurt)
W. Grady Wells	ENV	Aspects of Life History, Species-Habitat Associations, Species-Community Associations, and Distribution of the Pygmy Madtom, *Noturus stanauli* (Advisor: Professor Hayden Mattingly)

Master's

Name	Major	Thesis Title
Godson Ebenezer Adjovu	CEE	Evaluating the Performance of a GIS-Based Tool for Delineating Swales along Two Highways in Tennessee (Advisor: Associate Professor Alfred Kalyanapu)
Austin Auld	CEE	Investigating a Methodology for Dam Gate Optimization for Extreme Events Using Existing Physical Data (Advisor: Associate Professor Alfred Kalyanapu)
Sam Day	BIOL	Water Chemistry Effects on *Didymosphenia geminata* Physiology and Distribution (Advisor: Associate Professor Justin Murdock)
Ryan Hanscom	BIOL	Snapping Shrimp Species Diversification: The Role of Genome Size, Geography, and Ecology in Two Genera (Alpheus and Synalpheus) (Advisor: Associate Professor Carla Hurt)
Jordan Holtswarth	BIOL	Transferability of Fundamental Niche Models for Mussel Assemblages in Missouri Ozark Rivers (Advisor: Professor Amanda Rosenberger)
Kayla Key	BIOL	Identification of Risks and Threats to Mussel Assemblages in the Meramec Drainage Through Spatially Explicit Niche Modeling (Advisor: Professor Amanda Rosenberger)
Alisha Danielle Kirkpatrick	CEE	Nutrients in Highway Stormwater Runoff in Tennessee: Their Characterization and Correlation with Land Use and Meteorological Factors (Advisor: Associate Professor Tania Datta)
William Wood	BIOL	Predicted Ecosystem Effects and Population Control Needs of Bigheaded Carp in Productive Southeastern Reservoirs (Advisor: Professor Mark Rogers)

PROFESSIONAL SERVICE

Tania Datta, associate professor of civil and environmental engineering, was the chair of the Best Management Practices Working Group of the Tennessee Nutrient Reduction Strategy Work Group. She was also a board member of the Tennessee Caves and Karst Advisory Group. She is a reviewer for the *Science of the Total Environment*, *Water Science and Technology*, and *Bioresources Technology* journals.

Hayden Mattingly, biology professor and director of the School of Environmental Studies, is an editorial board member, manuscript editor, and special issue volume editor for the *Southeastern Naturalist*. He is also a federally appointed member of the Bluemask Darter Technical Team of the U.S. Fish and Wildlife Service and is a member of the American Fisheries Society and Southeastern Fishes Council. Mattingly was also an external reviewer for the Arkansas State University Ph.D. and M.S. graduate degree programs in environmental sciences in February 2020.

Justin Murdock, biology associate professor, is a member of the State of Tennessee Harmful Algal Bloom working group and a member of the State of Tennessee Nutrient Reduction Taskforce. He also began a Citizen Science Project with Trout Unlimited and North Carolina Wildlife Resources Division to detect the occurrence and spread of an invasive algae *(Didymo)* across the southeastern U.S. The website is: https://sites.google.com/view/didymocommunityscience/home.

Amanda Rosenberger, assistant unit leader of the Tennessee Cooperative Fishery Research Unit and associate professor of biology, was the 2019 chair of the Student Affairs Committee of the Southern Division of the American Fisheries Society (AFS), and has been the associate editor of the *Transactions of the American Fisheries Society* since 2017. She was also co-chair of the Education Section of the Best Student Presentation Award Committee of the AFS from 2016-2019.

ANALYTICAL CAPABILITIES

The Water Center offers unique analytical capabilities through its state-certified consulting lab including the following services:

- Industrial wastewater treatment process analysis design
- Drinking water and wastewater treatability studies
- Wastewater characterization studies
- Wastewater treatment unit process evaluation using nonstandard analytical techniques including particle size distribution analysis, solids oxygen demand determination, and long-term biochemical oxygen demand
- Aerobic and anaerobic biological wastewater treatment process pilot studies
- Coagulation process optimization using zeta potential measurements
- Activated carbon absorption studies
- Robotic reservoir/stream water quality analysis
- GIS capabilities for field study design

The environmental quality lab continues to support faculty and student research, as well as the surrounding community by offering stand-alone analytical services at a reasonable cost. These include:

- Drinking water regulatory parameters
- Conventional wastewater pollutants
- Metals
- Bacteriological analyses
- Organic analysis, GC and GCMS capabilities to analyze for THMs, HAAs, and semi-volatiles

The Water Center Laboratory also offers field sampling and monitoring capabilities including:

- Composite field sampling for local businesses
- Stream velocity measurements
- Field-dissolved oxygen, pH, temperature, conductivity, and ORP measurements
- GPS position logs of all sampling sites

The lab is managed by Dan Dodson and is staffed by analysts Phillip Burr and David Hobbs.

SUPPORT STAFF

Our staff brings years of expertise in their respective areas of work, and they include Sandy Garrison, office manager, and Karen Warren, financial associate, who work with faculty to prepare budgets for grants and are also integral in administering the financial reporting and details required once a grant is earned. Sandy Dodson, administrative associate 3, provides support in preparing travel claims, administering the Motor Pool, and purchasing supplies. Amy Hill, editor, provides editorial, graphic design and poster-printing assistance to faculty and students and also prepares the Center's annual report and updates the website. The Water Center Analytical Laboratory is managed by Dan Dodson, who oversees all of the lab's functions and has also been a principal investigator on funded research. Phillip Burr is an academic support associate, and David Hobbs provides additional lab support. Center staff are recognized across campus for excellence in their respective duties.

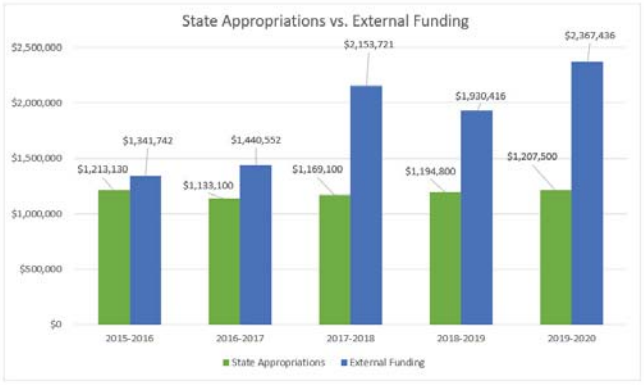
Administration and Faculty

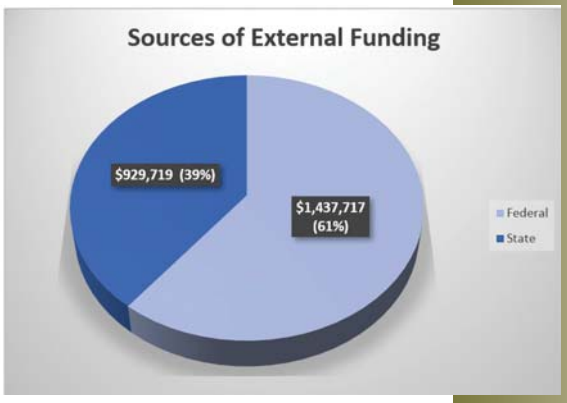
Dr. Jeff Schaeffer	Director
Dr. Tania Datta	Research Focus Area Leader, Associate Professor of Civil and Environmental Engineering
Dr. Alfred Kalyanapu	Research Focus Area Leader, Associate Professor of Civil and Environmental Engineering
Dr. Justin Murdock	Research Focus Area Leader, Associate Professor of Biology

Support Staff

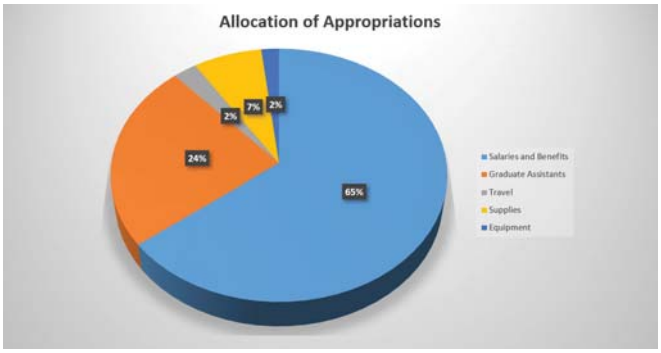
Phillip C. Burr	Laboratory Technician
Daniel P. Dodson	Technical Laboratory Manager
Sandy Dodson	Administrative Associate 3
Sandy Garrison	Office Manager
Amy K. Hill	Editor
David Hobbs	Laboratory Support
Karen Warren	Financial Associate

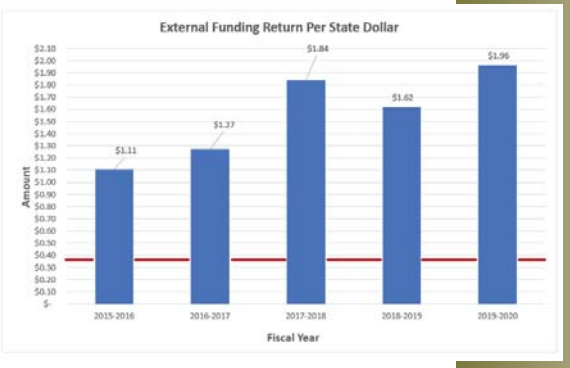
THE NUMBERS

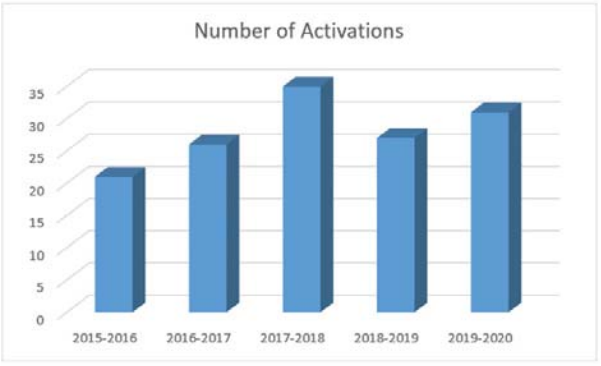




Note: External funding amount includes indirect costs.







Externally Funded Projects
(Projects Activated in Fiscal Year 2019-2020)

Abrams Creek Logperch
Amanda Rosenberger/National Park Service
Activation This Year: $15,400
Project Period: 8/1/2019-11/1/2022

AEDC Bat Aquatic Study
Hayden Mattingly/U.S. Fish and Wildlife Service
Activation This Year: $65,809
Project Period: 7/1/2018-12/31/2020

African Walking Catfish
Mark Rogers/U.S. Fish and Wildlife Service
Activation This Year: $19,304
Project Period: 4/1/2020-3/31/2021

Aquatic Argoecosystems
Justin Murdock/U.S. Department of Agriculture/ Agricultural Research Service
Activation This Year: $10,000
Project Period: 9/1/2017-8/31/2022

Assessing Water Quality of River Feeding Riparian Wetlands
Justin Murdock/University of Tennessee, Tennessee Water Resources Research Center (USGS)
Activation This Year: $4,995
Project Period: 3/1/2020-2/28/2021

Brawley's Fork Crayfish
Hayden Mattingly/Tennessee Wildlife Resources Agency
Activation This Year: $15,000
Project Period: 10/1/2018-6/30/2021

Collection of Biological Data
Steven Hayslette/Tennessee Wildlife Resources Agency
Activation This Year: $2,000
Project Period: 7/1/2016-6/30/2021

CRAC Water Quality
Amanda Rosenberger/Tennessee Wildlife Resources Agency
Activation This Year: $10,000
Project Period: 6/1/2019-5/31/2020

Development of a Low-Cost Real-Time Water Quality Monitoring Network
Alfred Kalyanapu/University of Tennessee, Tennessee Water Resources Research Center (USGS)
Activation This Year: $20,000
Project Period: 3/1/2020-2/28/2021

Duck River Mussel Surveys
Amanda Rosenberger/Tennessee Wildlife Resources Agency
Activation This Year: $31,193
Project Period: 7/25/2019-2/25/2021

Eval. Asian Carp TN & Cumberland River
Mark Rogers/Tennessee Wildlife Resources Agency
Activation This Year: $139,510
Project Period: 7/1/2018-6/30/2021

Evaluating Sport Fisheries
Mark Rogers/Tennessee Wildlife Resources Agency
Activation This Year: $40,000
Project Period: 7/1/2017-6/30/2022

Evaluating Stocked Fisheries
Mark Rogers/Tennessee Wildlife Resources Agency
Activation This Year: $66,000
Project Period: 7/1/2017-6/30/2022

Factors Affecting Sanctuary Use by Mallards
Brad Cohen/U.S. Fish and Wildlife Service
Activation This Year: $27,867
Project Period: 9/1/2019-12/31/2024

Flood 2D-GPU for Titan HPC Env
Alfred Kalyanapu/UT-Oak Ridge National Lab
Activation This Year: $111,072
Project Period: 8/16/2018-8/15/2020

GAVA Tool for HUC-12
Alfred Kalyanapu/USDA/Natural Resources Conservation Service
Activation This Year: $118,213
Project Period: 7/24/2019-8/31/2020

Externally Funded Projects (cont.)
(Projects Activated in Fiscal Year 2019-2020)

Longnose Darter
Amanda Rosenberger/Missouri Department of Conservation
Activation This Year: $39,435
Project Period: 7/1/2018-6/30/2021

Mallard Use TN Wetlands
Brad Cohen/USDA/Tennessee Wildlife Resources Agency
Activation This Year: $425,706
Project Period: 7/20/2019-7/19/2023

Nonlinear Interactions GRFP Brackins
Alice Camuti/National Science Foundation
Activation This Year: $46,000
Project Period: 7/16/2019-7/31/2021

Flood 2D-GPU for Titan HPC Env
Alfred Kalyanapu/UT-Oak Ridge National Lab
Activation This Year: $37,024
Project Period: 8/16/2018-8/15/2020

Ozark Mussel
Amanda Rosenberger/Missouri Department of Conservation
Activation This Year: $36,900
Project Period: 7/1/2018-6/30/2023

Phylogenomics and Diversification...Snapping Shrimp
Carla Hurt/National Science Foundation
Activation This Year: $69,439
Project Period: 9/1/2019-8/31/2022

Project INSPIRE: A STEM Teacher Residency
Jeff Boles/National Science Foundation
Activation This Year: $334,356
Project Period: 8/15/2014-7/31/2021

Pygmy Madtom eDNA
Carla Hurt/Virginia Department of Game and Inland Fisheries
Activation This Year: $15,000
Project Period: 4/6/2020-2/28/2021

Striated Darter
Hayden Mattingly/Tennessee Wildlife Resources Agency
Activation This Year: $21,128
Project Period: 7/1/2019-6/30/2021

Tallassee Blotchside Logperch
Amanda Rosenberger/Tennessee Wildlife Resources Agency
Activation This Year: $19,090
Project Period: 10/1/2019-6/30/2020

TDEC Stormwater Management
Tania Datta/Upper Cumberland Development District
Activation This Year: $68,757
Project Period: 11/15/2019-9/30/2020

Tennessee Heelsplitter Habitat
Amanda Rosenberger/U.S. Geological Survey
Activation This Year: $55,000
Project Period: 12/21/2018-5/31/2021

Wastewater Reclaim GRFP White
Alice Camuti/National Science Foundation
Activation This Year: $46,000
Project Period: 7/19/2018-7/31/2021

Water Quality Tennessee and Kentucky
Justin Murdock/The Nature Conservancy-U.S. Department of Agriculture
Activation This Year: $457,238
Project Period: 10/19/2018-7/31/2022

Refereed Publications and Reports

Bhuyian, Md. N.M., and A. Kalyanapu. (2019). Predicting channel conveyance in the Obion River Watershed using SAMBLE Method. *Journal of Hydrologic Engineering*. doi:10.1061/(ASCE)HE.1943-5584.0001875.

Brackins, J., N. Moragoda, A. Rahman, S. Cohen, and C. Lowry. (2020). The role of realistic channel geometry representation in hydrological model predictions. *Journal of the American Water Resources Association*, 1-19, https://doi.org/10.1111/1752-1688.12865.

Brackins, J.T., and A.J. Kalyanapu. (2019). Evaluation of parametric precipitation models in reproducing tropical cyclone rainfall patterns. *Journal of Hydrology*, doi:10.1016/j.jhydrol.2019.124255.

Chilton, J., A.E. Rosenberger, and R.J. DiStefano. (2020). Habitat associations and distributions of two endemic crayfishes, *Cambarus (Erebicambarus) maculatus* (Hobbs & Pflieger, 1988) and *Faxonius (Billecambarus) barrisonii* (Faxon, 1884) *(Decapoda: Astacoidea: Cambaridae)*, in the Meramec River drainage, Missouri, USA. *Journal of Crustacean Biology*. https://doi.org/10.1093/jcbiol/ruaa033.

DiStefano, R.J., J.T. Westhoff, C.J. Rice, and A.E. Rosenberger. (2019). Life history of the endemic saddleback crayfish *(Faxonius medius)* (Faxon, 1884), *(Decapoda: Cambridae)* in Missouri, USA. *Freshwater Crayfish*, 24, 1-13.

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Morales-Hernandez, M., M.B. Sharif, S. Gangrade, T.T. Dullo, S.-C. Kao, A. Kalyanapu, S.K. Ghafoor, K.J. Evans, E. Madadi-Kandjani, and B.R. Hodges. (2020). High-performance computing in water resources hydrodynamics. *Journal of Hydroinformatics*.

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Presentations

Allen, S.A., W.G. Wells, and H.T. Mattingly. "A Large-Scale MaxEnt Model for the Distribution of the Endangered Pygmy Madtom, *Noturus stanauli*," presented at the Catfish 2020: Third International Symposium, Little Rock, Arkansas, February 2020.

Bajo, B., and A.E. Rosenberger. "Modeling Fundamentally Suitable Freshwater Mussel Habitat in the Duck River Drainage, Tennessee," invited presentation to the Organization of Fisheries and Wildlife Information Managers Annual Meeting, West Virginia, October 2019.

Bouska, K., A.E. Rosenberger, K. Key, J. Holtswarth, G. Linder, and S. McMurray. "Development and Implementation of a Strategic Mussel Conservation Assessment in Missouri," presented at the Midwest Fish and Wildlife Resources Conference, Springfield, Illinois, January 2020.

Brockwell, J., T. Datta, A. Kalyanapu, D. VandenBerge, and P. Turkson. "Performance Evaluation of Existing Vegetated Swales for Highway Runoff Reduction," presented at the KY/TN Water Professionals Conference, Louisville, Kentucky, August 2019.

Castleberry, B., E. Koehler, M.A. Mutschler, and B.M. Leckie. "Ovipositional Preference of Silverleaf Whitefly on Benchmark Acylsugar Tomato Breeding Lines," presented at the Southern Region of the American Horticultural Society 2020 Annual Meeting, Louisville, Kentucky, January 30 - February 5, 2020.

Castleberry, B., E. Koehler, M.A. Mutschler, and B.M. Leckie. "Ovipositional Preference of Silverleaf Whitefly on Benchmark Acylsugar Tomato Breeding Lines," presented at the Tennessee Tech Research and Creative Inquiry Day, Cookeville, Tennessee, April 2020.

Caudle, J., and C. Wheeler. "Temporal Changes in Freshwater Fish Communities: Implications for Management and Conservation," presented at the Southeastern Fishes Council Meeting, Knoxville, Tennessee, November 2019.

Caudle, J., and C. Wheeler. "Temporal Changes in Freshwater Fish Communities: Implications for Management and Conservation," presented at the Southeastern Fishes Council Meeting, Knoxville, Tennessee, November 2019.

Cohen, B.S., A.G. Blake-Bradshaw, N.M. Masto, C.D. Highway, D.L. Combs, H. Hagy, and J.C. Feddersen. "Using GPS Transmitters to Evaluate Influence of Disturbance on Mallard Movements," presented at the Mississippi Flyaway Council Meeting, Paducah, Kentucky, March 2020.

DeLay, G., E. Koehler, and B.M. Leckie. "Squash Bug Ovipositional Preference within *Cucurbita pepo*," presented at the Southern Region of the American Horticultural Society 2020 Annual Meeting, January 30 - February 5, 2020, Louisville, Kentucky.

DeLay, G., E. Koehler, and B.M. Leckie. "Squash Bug Ovipositional Preference within *Cucurbita pepo*," presented at the Tennessee Tech Research and Creative Inquiry Day, Cookeville, Tennessee, April 2020.

Fitzgerald, D.B., D.R. Smith, K.O. Maloney, J.A. Young, M.C. Freeman, A.E. Rosenberger, and D.C. Kazyak. "Multispecies Approaches to Status Assessments to Inform Endangered Species Determination," presented at the Annual Meeting of the American Fisheries Society, Reno, Nevada, October 2019.

Harrington, R., J.W. Simmons, H.T. Mattingly, and T.J. Near. "Family Feud on the Caney Fork: Collection Records and Population Genetic Analyses of Barrens Darter, *Etheostoma forbesi*, and Fringed Darter, *E. crossopterum*, Reveal Displacement and Gene Flow Between Two Closely Related Species," presented at the Southeastern Fishes Council Annual Meeting, Knoxville, Tennessee, November 2019.

Holsopple, A.R., A.L. Walker, K. Wheeler, and C. Hurt. "Distribution, Habitat Use, and Population Status of the Striated Darter, *Etheostoma striatulum*, in the Duck River System, Tennessee," presented at the Tennessee Rare Fishes Meeting, Cookeville, Tennessee, March 2020.

Holtswarth, J.N., A.E. Rosenberger, K.N. Key, and G. Lindner. "Assessing the Transferability of a Freshwater Mussel Fundamental Niche Model within the Ozark Ecoregion, Missouri," presented during the Organization of Fisheries and Wildlife Information Managers Annual Meeting, West Virginia, October 2019.

Jones, V.J., and H.T. Mattingly. "Summer Habitat Use Patterns of the Endangered Bluemask Darter *(Etheostoma akatulo)* at Two Spatial Scales in the Collins River, Tennessee," presented at the Southeastern Fishes Council Annual Meeting, Knoxville, Tennessee, November 2019.

Kirkpatrick, D., R. Wigner, T. Wright, and T. Datta. "Characterization of Highway Stormwater Runoff from Sites with Varying Land Uses in Tennessee," presented at the KY/TN Water Professionals Conference, Louisville, Kentucky, August 2019.

Presentations (cont.)

Koehler, E., and B.M. Leckie. "Small Farm Evaluation of Bush-Type Southern Appalachian Heirloom Snap Beans," presented at the Southern Region of the American Horticultural Society 2020 Annual Meeting, Louisville, Kentucky, January 30 - February 5, 2020.

Leckie, B.M., and M. Best. "Characterization of Southern Appalachian Heirloom Snap Beans Using Genotyping by Sequencing," presented at the Southern Region of the American Horticultural Society 2020 Annual Meeting, Louisville, Kentucky, January 30 - February 5, 2020.

Lindner, G.A., K.N. Key, A.E. Rosenberger, L. Lueckenhoff, and D. Mosby. "A Riverscape Perspective of Physical Habitat for Quantifying Injury of Mussel Populations in the Big River," presented during the NRDAR Freshwater Mussels Workshop II, Columbia, Missouri, September 2019.

Mahan, M.A., and B.M. Leckie. "Selection of Stable Bush-Type Southern Appalachian Heirloom Snap Beans," presented at the Southern Region of the American Horticultural Society 2020 Annual Meeting, Louisville, Kentucky, January 30 - February 5, 2020.

Masto, N.M., A.G. Blake-Bradshaw, C. Highway, and B.S. Cohen. "Mallard Movements and Habitat Use in West Tennessee: Project Summary," invited presentation to the Dyer County Ducks Unlimited Varsity, Dyersburg, Tennessee, 2019.

Mattingly, H.T., V.J. Jones, and W.K. Gibbs. "Interbasin Comparison of Stream Habitat to Inform Reintroduction Strategies for the Endangered Bluemask Darter *(Etheostoma akatulo)*," presented at the Southeastern Fishes Council Annual Meeting, Knoxville, TN, November 2019.

McClellan, G.E., and T. Datta. "Elucidating the Microbial Community and Process Stability of Oxidation Ditches Optimized for Biological Nutrient Removal," presented at the Water Environment Federation Technical Exhibit and Conference, Chicago, Illinois, September 2019.

McClellan, G.E., and T. Datta. "Optimizing Nutrient Removal: A Study on the Microbial Communities of Three Water Resource Recovery Facilities," presented at the KY/TN Water Professionals Conference, Louisville, Kentucky, August 2019.

McClellan, G.E., and T. Datta. "Microbial Community Structure and Stability During Optimization of a Full-Scale Biological Nutrient Removal Process," presented at the KY/TN Water Professionals Conference, Louisville, Kentucky, August 2019.

Morris, S., and J. Murdock. "Wetland Reserve Program Research in Tennessee," invited presentation to the USDA NRCS Tennessee State Technical Committee, Murfreesboro, TN, August 2019.

Murdock, J. "Improving Nutrient Retention in Agricultural Watersheds through Floodplain Wetland Restoration," presented during the Southeastern Water Pollution Biologists Association Annual Meeting, Chattanooga, TN, October 2019.

Ohemeng-Ntiamoah, J., and T. Datta. "Anaerobic Co-Digestion of Wastewater Residuals with Food Waste and FOG: Effects on Digester Performance and Microbial Community Structure," presented at the Water Environment Federation Technical Exhibition and Conference, Chicago, Illinois, September 2019.

Rogers, M.W. "Asian Carp Status and Research Efforts for Informing TVA Environmental Assessment in the Tennessee River," presented at the TVA Environmental Assessment Webinar Series, 2020.

Rogers, M.W., C.R. Harty, and P.W. Bettoli. "Investigation of Channel Catfish and Blue Catfish Population Dynamics in Three Tennessee River Reservoirs," presented at the Southern Division of American Fisheries Society Annual Meeting, Little Rock, Arkansas, 2020.

Rogers, M.W., W.T. Wood, and Y-.C. Koa. "An Ecosystem Model for Population Controls and Ecological Effects of Bigheaded Carp in a Productive Southeastern Reservoir," presented at the Southern Division of American Fisheries Society Annual Meeting, Little Rock, Arkansas, 2020.

Rosenberger, A.E. "Tennessee's Aquatic Life," presented during the Treehouse Seminar Series, Tennessee Tech, Cookeville, Tennessee, September 2019.

Rosenberger, A.E. "Tennessee's Freshwater Life," presented during the Wake Up Wednesday Seminar Series, Tennessee Tech, Cookeville, Tennessee, September 2019.

Stretz, H.A. "Polyelectrolytic Fouling of Membranes and Sensors in Water: Puzzles of a Complex Nanworld," presented to the University of Tennessee, Knoxville, Department of Chemical Engineering, Tennessee, October 2019.

Presentations (cont.)

Wells, W.G., and H.T. Mattingly. "Aspects of Life History and Ecology of the Endangered Pygmy Madtom," presented at the Catfish 2020: Third International Symposium, Little Rock, Arkansas, February 2020.

White, M., and K. Wheeler. "Suckers: Salmon of the South?" presented at the Tennessee Rare Fishes Meeting, March 2020.

White, M., and K. Wheeler. "Abundance Estimates of Spawning Catostomids in a Small, Oligotrophic Stream Using Aerial Imagery," presented at the Southeastern Fishes Council Meeting, Knoxville, Tennessee, November 2019.

Wood, W.T., and M.W. Rogers. "Abundance and Population Controls of Bigheaded Carp in a Productive Southeastern Reservoir," presented at the Southeast Association of Fish and Wildlife Agencies Meeting, 2019.

Wright, T., and T. Datta. "Impacts of Biomethane Potential Test Variability on Specific Methane Yield," presented at the KY/TN Water Professionals Conference, Louisville, Kentucky, August 2019.

Final Reports

Gibbs, W.K., J.N. Murdock, and M.A. Kulp. 2019 Interim Report -- Assessment of Benthic Macroinvertebrate Response to Antimycin During Brook Trout Restoration in Little Cataloochee Creek, Great Smoky Mountains National Park - Study #: GRMS - 02362, Permit #: GRSM-2015-SCI-2362.

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Murdock, J.N. 2019 Duke Energy Final Report. Determining the Current Distribution and Potential Spread of Didymo in North Carolina Streams.

Hourly Student Support

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Maci Arms	CEE	Eric Jackson	CEE
Marshall Avera	CEE	Valerie Jones	BIOL
Ryan Bauer	WFS	Chris Kaczmarek	CEE
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Budget Note: The Center for the Management, Utilization and Protection of Water Resources requests a five percent budget increase for the 2020-2021 fiscal year to accommodate potential increases in salaries and other supplies and equipment expenses.

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