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CENTER FOR THE
MANAGEMENT,
UTILIZATION
AND
PROTECTION
OF WATER
RESOURCES

ANNUAL REPORT

FY2021-22

TENNESSEE TECH

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MESSAGE FROM THE DIRECTOR

The past year has been both sad and joyful. Last September, our beloved and skilled Center Manager passed away unexpectedly, and our loss was both professional and deeply personal. Because nearly every decision within a Center of Excellence involves the Center Manager, we struggled daily. We also saw a reduction in the number of scientists working with the Center as life changes caused several folks to put their research portfolios on hold. It took us months to get back on our feet, but we did. We found a new Center Manager, Ms. Michelle Holm, who is so skilled that she had us up and running again within a few days of her arrival this spring. Our scientists also returned to research, and we are in the process of engaging several new faculty whose interests lie with the realm of applied water research. And in terms of research dollars, our portfolio actually expanded slightly despite the previous setbacks.

Major research accomplishments this year were continued growth of our molecular genetics group and continued growth of our partnership with the Cooperative Fishery Research Unit. A detailed look at both programs appears elsewhere in our report. We also have begun development of what promises to be a large investigation of how to best manage new water withdrawals on the Duck River. That river is the most biodiverse stream in the nation, and it also supports continued economic growth as a water source for Nashville and its growing suburbs. Our goal is to carry out an interdisciplinary study of what happens to fish

and wildlife habitats under various withdrawal scenarios, especially under draught conditions.

But one thing that did not change was our continued dedication to support training of new professionals. The Water Center maintained its traditional focus on M.S. students, but we have made longer-term commitments to engage more Ph.D. students. We also now regularly support capstone engineering teams that provide undergraduates with opportunities to devise solutions to real-world applied problems.

But our greatest accomplishment occurred a few weeks after the end of a challenging year; we received notice that a faculty collaboration that included both the Energy and Water Centers had been awarded a 3-million dollar National Science Foundation grant to evaluate a new model for graduate education. Several cohorts totaling over 20 students will be arriving each fall for the next several years. What will they study? That is the new model: students will work directly with inputs from stakeholders and resource managers to develop and implement their own research projects. The idea is to produce not just traditional problem solvers, but to create a new generation of problem identifiers that can carry out research that can be applied more quickly and directly to scientific and technical problems faced by society. How will this grand experiment work, exactly? Stay tuned!

CENTER AT A GLANCE 2021-2022

- State appropriation of \$1.3 million
- External grants totaling \$2.3 million (total includes direct and indirect costs)
- Return per state dollar: \$1.80
- Six staff members
- Four faculty focus area leaders
- Twelve faculty principal investigators
- 32 graduate students
- 95 hourly student workers
- 17 peer reviewed publications
- 54 professional presentations

ACCOMPLISHMENTS & AWARDS

Nicholas M. Masto, Brad Cohen's student, was awarded "Olin Foundation Wetlands and Waterfowl Research Fellowship" by Ducks Unlimited Inc. and Ducks Unlimited Canada. His other student, Abigail Blake-Bradshaw, was awarded "Best Student Presentation" at 54th Annual Conference of the Tennessee Chapter of the Wildlife Society.



STUDENT HIGHLIGHTS

COLLINS OWUSU

My name is Collins Owusu, and I am from Ghana. I enrolled at Tennessee Tech in Fall 2019 to pursue a Ph.D. degree in Civil and Environmental Engineering. I obtained my bachelor's and master's degrees in Civil Engineering from Kwame Nkrumah University of Science and Technology (KNUST), Ghana. I have eight years of experience as a consultant in the design and construction supervision of water resource engineering projects, which includes irrigation and drainage systems, flood modeling and control, small dams, and water diversion structures for community water supply in Ghana and other African countries. I aspire to develop sustainable systems and solutions that improve livelihoods in a challenging environment using readily available data and advanced information technology.

Wetlands play very important roles in sustaining our ecosystem by performing functions such as cleaning polluted waters, providing flood control, and serving as habitats for various plant and animal species. The seasonal and annual fluctuation in water levels in wetlands is considered one of the main determinants of the effectiveness of wetland processes, but information on these fluctuations is often nonexistent due to

the lack of monitoring systems and difficulty in accessibility in wetland environments. There is, therefore, the need to find an alternate source of information to develop holistic solutions to wetland management. My research work at TTU, supported by the Natural Resources Conservation Service (NRCS) and The Nature Conservancy (TNC), is centered on developing methods and tools that combine satellite imagery, artificial intelligence, hydrologic modeling, and advanced information technologies to generate relevant data on the historical fluctuations in wetland water levels and to be able to predict what will happen in the future to assess the impact of climate change on these wetlands. My research is particularly targeted toward generating the necessary information and developing easy-to-use tools to help water resource managers make informed decisions in managing, restoring, and sustaining wetlands and other water resources. Preliminary outcomes of my research are currently being applied in monitoring the restoration success of some wetlands in West Tennessee and Kentucky, and I hope the outcome of my research can be scaled up to other domains and regions within and outside the United States.



PETER BLUM

My name is Peter Blum, and I am an Environmental Sciences -- Biology Ph.D. student advised by Dr. Justin Murdock in the Department of Biology. I taught as a biology lecturer at the University of North Carolina at Greensboro for two years after completing my M.S. in Biology. My research focuses on freshwater ecotoxicology and specifically how adult freshwater insects transport persistent organic pollutants from aquatic to terrestrial ecosystems. I conduct my research at the Arnold Air Force Base in southern Tennessee on streams and reservoir coves that have received contaminated coolant water from activities on the base.

My research focuses on two persistent organic pollutants, polychlorinated biphenyls (PCBs) and the emerging contaminant, per- and polyfluoroalkyl substances (PFAS). PCBs are banned endocrine-

disrupting compounds implicated in the reduction of reproductive success and immune function of animals. In contrast, PFAS are an understudied diverse family of compounds used in various products (including non-stick surfaces and fire retardants) and implicated in adverse outcomes for aquatic animals. Both compounds increase in concentration for organisms over their lives and increase more in food webs, making them a concern for humans and wildlife. For example, dietary exposure to PCBs from contaminated aquatic insects likely explains the increased concentration of PCBs from deceased endangered gray bats near the Air Force base.

My dissertation aims to quantify the flux of PCBs through emergent adult freshwater insects from contaminated streams and reservoir coves. He

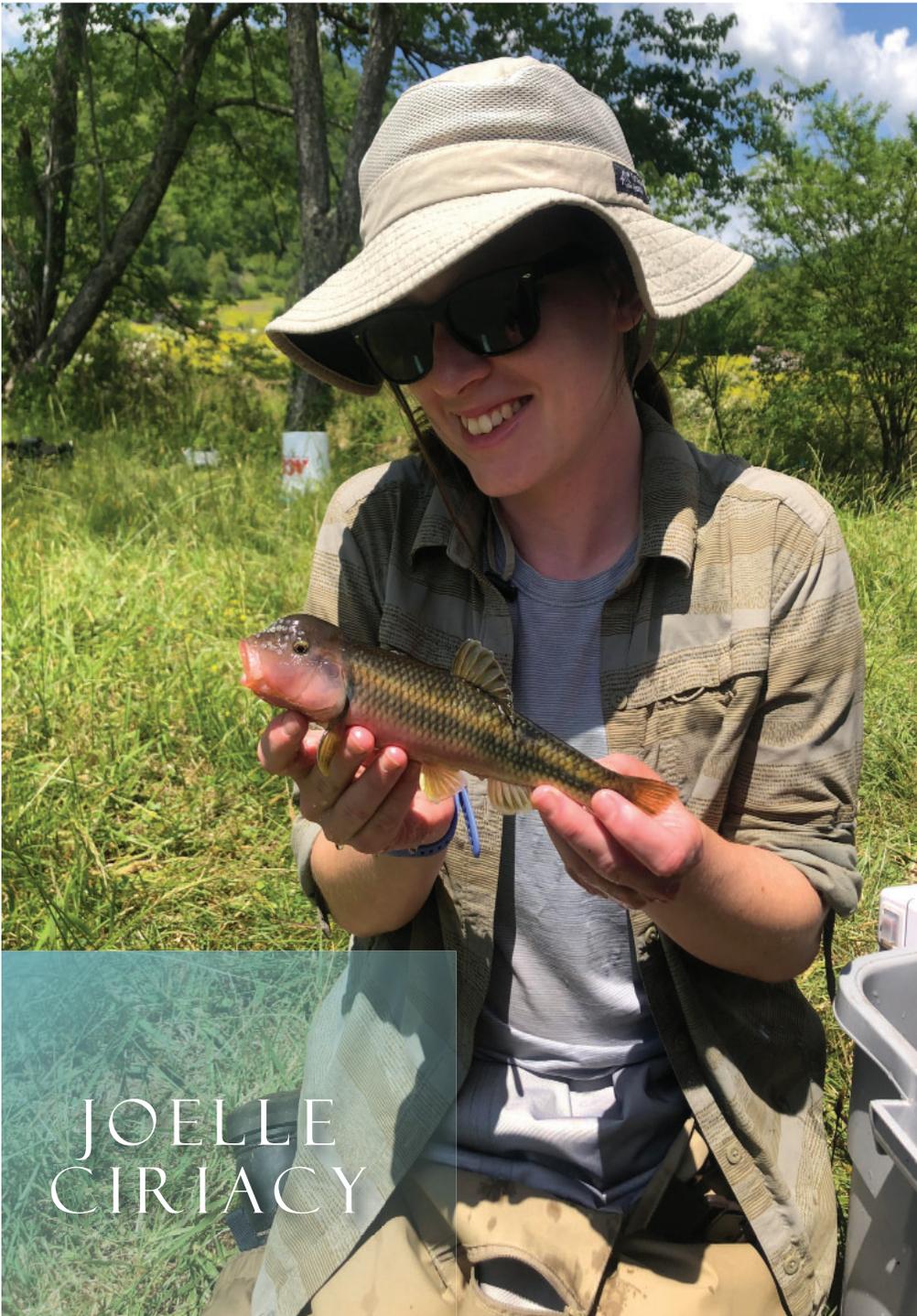


has found that non-biting midges are a major contributor to insect biomass in streams and coves and may be crucial for transporting PCBs to terrestrial consumers. He is also examining the pathway of PCB movement in stream food webs using stable isotopes of carbon and nitrogen to construct trophic relationships between

organisms and their food sources. Similarly, he is examining how the stoichiometry of carbon, nitrogen, and phosphorous influences the accumulation of PCBs in animal tissues. Adult stream insects are also being analyzed for PFAS concentrations, comparing biomagnification of PFAS with select insect groups.

Additionally, I am involved in several research collaborations, including how the aftermath of tornadoes in Tennessee and Kentucky may influence water quality and illuminate the life history of rare caddisflies (*Pycnopsyche rossi*).

I plan to pursue a career in freshwater resources management or teaching at a primarily undergraduate institution.



While snorkeling and tracking the movements of hellbenders as an undergraduate, I saw my first River Chub mound. Although I knew nothing of the phenomenon at the time, I paused daily to watch the swirling colors of fish spawning over a mound of pebbles on the streambed. I remember thinking the tiny fish, with their fiery oranges and reds,

looked like they belonged in the tropics. I later learned these great mounds were built by River Chubs, *Nocomis micropogon*, and the colorful fish I saw were nest associates, enjoying the benefits of the chubs' hard work. In 2020, I graduated from Lee University with a B.S. in Biology and proceeded to work in a variety of plant and wildlife

technician positions across the country. A year later, I found myself back in Tennessee—excited to study the fishes I had found so mesmerizing years ago under Dr. Kit Wheeler, Assistant Professor of Biology.

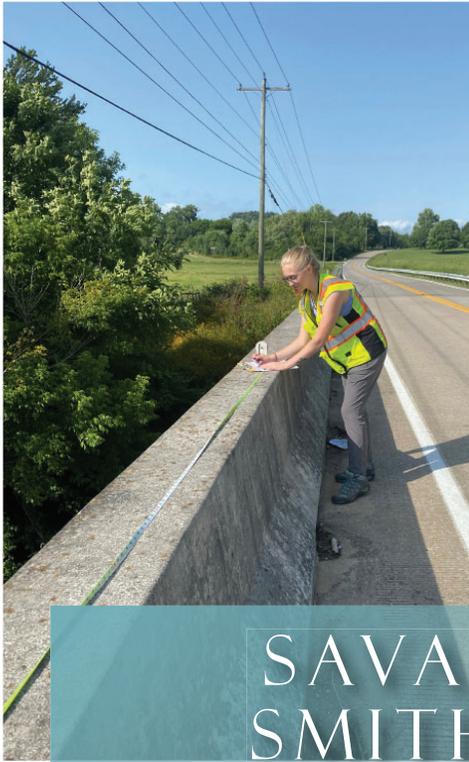
Some organisms may have a greater impact on their biotic community and physical environment than one might expect from their abundance in the community. These organisms have been called “keystone species.” Members of the chub genus *Nocomis* build and spawn over pebble mounds that shelter eggs from predation and may improve egg oxygenation, earning *Nocomis* the title of keystone in many recent publications.

The purpose of my project is to investigate the nature of *N. micropogon*’s impact on other fishes and benthic macroinvertebrates, giving us insight into *N. micropogon*’s potential keystone status. I am working to understand *N. micropogon*’s role in its community by (1) experimentally removing spawning mounds and collecting fish and benthic macroinvertebrate community samples before, during, and after the spawning season and (2) evaluating patterns of co-occurrence between *N. micropogon* and their nest associates across the

Little Tennessee River watershed by analyzing a long-term dataset provided by the Tennessee Valley Authority. As of the summer of 2022, I completed my first field season of removing mounds and collecting community samples.

Although I have just begun data analysis, my time in the field has offered unique opportunities to observe *N. micropogon* behavior, which will guide future work. Namely, we found that repeated removal of spawning mounds did not discourage building; one mound was rebuilt on the same site six times over the time span of several weeks, even after several small boulders were placed over the site that made it an uncharacteristic site for a spawning mound. Although this is an extreme example, most destroyed mounds were rebuilt multiple times, indicating a remarkable commitment to this reproductive behavior and fidelity to specific building sites.

I am excited to continue studying the community impacts of these fascinating creatures for the remainder of my time at Tennessee Tech. After graduation, I hope to use the field sampling techniques, study design, technical writing, and leadership skills I’ve developed during this project as a fisheries or aquatic wildlife biologist in the future.



SAVANNAH SMITH AND NOAH UPTEGRAW

Savannah Smith is from Harriman, TN. She is an Environmental Sustainability and Conservation Studies major with a minor in Biology, projected to graduate in December of 2022. After her academic career, she would like to go on to work for TDEC as an environmental scientist.

Noah Uptegraw is from Cookeville, TN. He is a Wildlife and Fisheries Science Major with a focus in Conservation Biology and is projected to graduate December of 2022. He has aspirations to attend graduate school for a master's degree. Savannah and Noah both worked on a survey of road-stream crossings in the Elk River drainage, where they drove back roads to survey bridges and culverts, and assess their potential

for migratory fish passage and look for problems with sediment erosion. They collected data and photographed hundreds of sites throughout Tennessee and became experts in navigation and measurement. They worked independently as a team and had to engage in decision making and use professional judgement on everything from biological assessments to vehicle breakdowns. Both valued the opportunity to work with the Water Center and learn valuable field skills. Savannah's experience gained her a TDEC internship for Fall 2022, and both are hoping to present their results at an American Fisheries Society conference in Norfolk, Virginia next January.



NICHOLAS MASTO

I have been awarded the Spencer T. and Ann W. Olin Waterfowl and Wetlands Research Fellowship for my doctoral work with the Cohen Wildlife Lab, the Water Center, and the School of Interdisciplinary Studies. This fellowship is generously solicited by the Ducks Unlimited Institute for Waterfowl and Wetlands Research, Manitoba, Canada and is open to graduate students enrolled in any North American University with research dealing with waterfowl or wetland biology that promises to advance sustainability and conservation of these natural resources.

My research focuses on the behavioral and landscape ecology of waterfowl during winter and migration. Food energy, wetland habitat availability, and hunting pressure are thought to drive duck distributions, but datasets have not been available to evaluate this in an integrated framework. I am working collaboratively on a study using hundreds

of state-of-the-art GPS transmitters, which are deployed on mallard ducks. Frequent estimates are made of landscape conditions and food energetics to evaluate relative contributions of landscape energy, hunting, and shifts in wetland availability on wintering waterfowl movement behaviors and distributions. My research will help refine regional conservation planning tools and facilitate wetland restoration efforts for habitat features most limiting to waterfowl during the non-breeding period.

I am also a passionate father, sportsman and conservationist, and Clemson football fan. I plan to defend my dissertation in December 2023. Visit <https://www.facebook.com/cohenwildlab> to see my team's research, including animated maps of duck migration and field-work photographs on social media.

TENNESSEE COOPERATIVE FISHERY RESEARCH UNIT

State and federal fisheries managers are faced with a barrage of questions whose answers can inform them about how well their management efforts are translating into successful fishing trips for Tennessee's 869,000 licensed anglers. A few examples: "We stock trout in many rivers, but in some streams we see more and even larger trout than one would expect from our programs. Could this be due to natural reproduction?" "What is the general trend in Statewide angling effort within our reservoirs, and do individual reservoirs exhibit unique trends, and if so, why?" "Florida has the largest bass in the U.S. Would stocking Florida fish in Tennessee result in anglers catching more and larger bass?" "Tennessee has about 150 freshwater mussel species, but where are they found? That information is vital as we plan development, and there are thousands of species records from all over the State, but those data have never been assembled in a searchable database. Why can't we create one?" The questions are varied, but all have one thing in common: resource managers need answers so they can manage aquatic resources effectively. The Water Center has been helping provide those answers for 37 years through a long-standing partnership with a unique federal program: the Tennessee Cooperative Fishery Research Unit.

Established in 1973, The Tennessee Cooperative Fishery Research Unit is a partnership between the United States Geological Survey (USGS), the Tennessee Wildlife Resources

Agency (TWRA), and Tennessee Tech. USGS provides salaries for a Unit Leader (Dr. Mark Rogers) and an assistant unit leader (Dr. Amanda Rosenberger) who serve as TTU faculty, while TWRA provides an annual operating budget. Tennessee Tech provides an administrator while the Water Center provides administrative support for Unit grants and students. The Cooperative Research Unit (CRU) program was established in 1935, and there are presently 41 CRUs in 39 States. All are located on University campuses where their USGS scientists hold faculty appointments. Most are located at land grant universities, and most have both fisheries and wildlife missions. Tennessee's CRU is somewhat unique because it is a Fisheries Unit only, but all CRUs are similar in that one of their primary missions is to train new scientists by supporting M.S., Ph.D., and post-doctoral students, and they provide training by working on applied fisheries and conservation problems of interest to local, regional, state, or federal resource managers.

The Tennessee CRU has been working closely with the Water Center since we were established in 1985. That partnership has been so successful that Dr. Phillip Bettoli, one of our CRU scientists from 1987 to 2017, mentored 58 graduate students during his tenure. Many of his students are now in senior positions with

RESEARCH HIGHLIGHTS



the State of Tennessee, or with federal agencies throughout the region. Our present CRU scientists are maintaining a similar pace; they currently have a total of six graduate students, four staff scientist/technicians, and one postdoctoral scientist. Annually, the partnership administers about \$800,000 dollars in research grants. This varies annually, but the CRU is consistently one of the largest grant recipients on campus. Currently, the CRU has three focal areas: invasives, management of game species, and biodiversity. Invasives research focuses on Silver, Bighead, and Black carps brought to the U.S. from China during the 1970s. All three species escaped from captivity into the Mississippi River, and Bighead and Silver Carp have proliferated. They now dominate the fish community in some areas, and their escape behavior is a threat to humans. When startled, Silver carp leap out of the water and can strike humans, especially boaters. That risk can be seen in dozens of Youtube™ videos that show hundreds of fish in flight.

Asian Carp have not overtaken Tennessee waterways, but they are abundant in the lower Tennessee and Cumberland rivers and are moving

upstream. While dams impede their progress, they slip upstream through navigation locks. This is a major issue because our reservoir fisheries are renowned, and our rivers support high biodiversity. To maintain our fisheries resources, managers need answers to five important questions: 1) what is their distribution in Tennessee? 2) how are they using locks as migration routes and what can be done to prevent passage? 3) Are the fish we see in Tennessee a result of immigration or spawning within Tennessee waters? 4) If Asian Carp do proliferate, what would be their ecological role and potential impacts in our reservoirs and upper rivers? 5) could management strategies such as commercial harvest limit their abundance? Multiple teams of graduate students led by Dr. Mark Rogers are using a variety of field methods to provide answers. For game species, the CRU just completed a novel analysis of angler fishing effort in Tennessee reservoirs. Dr. Mark Rogers and his student Fritz Hoogaker found that overall angling effort declined in Tennessee over the past two decades, but individual reservoirs deviated from the pattern. In particular, small reservoirs received more attention from anglers, with the underlying explanation that they may be



experiencing less boat traffic. And Chickamauga Reservoir experienced an uptick in fishing trips as anglers responded to a well-publicized effort to introduce faster-growing Florida bass in that reservoir. But perhaps the best part is that angler catches actually increased, showing that a broad range of management strategies can be successful in delivering more fish to each angler!

Tennessee has over 150 freshwater mussels, and many of them are federally listed. That means that development such as bridge repairs or water intake construction needs to be accomplished carefully, and managers need to be cognizant of what mussels may be found in a particular river, or even at specific places. Mussel biologists have been making collections and carrying out surveys for over a century, but the data are scattered among agencies, museums, and even private collections. The outcome is that whenever a construction project is being planned, someone needs to carry out a thorough mussel survey of the area, and this adds to the project's cost. Dr. Amanda Rosenberger and staff scientist Kristen Spencer are pulling together records from all over the state

to create a searchable database such that permitting of new projects can be made easier, and there is scientific value in creation of more comprehensive distribution maps that will facilitate mussel conservation in our rivers.

The list of projects is much longer and far more diverse, but one consistency is a strong partnership with the Water Center to support the research and the students. Not every grant is large enough to provide full support for an individual student, and we take great pride in providing that extra measure of financial support that allows students to produce a well-written thesis or dissertation that can be published in a peer-reviewed scientific journal. That makes students competitive for jobs, and state and federal agencies throughout the region have been populated by Tennessee Tech graduates who have risen to the highest ranks within their professions. It's a time-tested partnership that we hope remains as successful in the future as it has for the past three decades.



The history of science is filled with revolutions driven by new discoveries and technologies. The Water Center is now on the forefront of a revolution in the field of genetics. Most people are familiar with the role of genetics in medicine and agriculture, but these principles are now being applied to biodiversity conservation with increasing urgency in the face of changing climate. Tennessee Tech researchers have created a regional center that uses molecular genetics to support resource managers in their quest to conserve Tennessee's biodiversity.

Within two human generations, scientists have moved from not even knowing the basic chemical structure of DNA to being able to comprehend the entire genome of many organisms. The second change is in technology. Twenty years ago, geneticists spent most of their time at their lab

bench; now, they spend most of their time at computers analyzing huge volumes of data generated by instruments that perform largely automated processes. But the third and most important aspect of the revolution has been the applications to which new knowledge has been put to use. Water Center scientists are now harnessing this knowledge to ask novel questions about novel problems. Biodiversity is much more complex than previously thought

Tennessee has one of the most diverse assemblages of aquatic organisms of any state. We have over 300 species of fish and at least 150 species of freshwater mussels. Many of these are rare and exist as small, isolated populations scattered across the state. Historically, these unique populations have often been lumped together and treated as single species.

WATER CENTER LEADS THE WAY WITH CONSERVATION GENETICS





Dr. Carla Hurt and her students engage in a broad range of research topics on Tennessee's aquatic biodiversity, but her research portfolio is international. She recently traveled to Guam to examine the genetics of marine snapping shrimp. That work is supported by the National Science Foundation. This photo was taken during August 2022.

But new genetics techniques have revealed that while these organisms may look alike, their genetics may differ to the point where they may should in fact be recognized as distinct species. Careful population studies have revealed local adaptation within these sites as a result of long-term differences in water chemistry or thermal regime. This has tremendous implications for conservation: we now understand that safeguarding just a few key populations could result in the loss of important genetic diversity found across the species' ranges. Some of those populations might exhibit key traits needed to help maintain the species in the face of

climate change, poor water quality, or novel disease. Dr. Carla Hurt and our new developmental biologist Dr. Joshua Hall are looking at within-species diversity of the streamside salamander to address these issues. This species is state listed as near threatened, yet some populations seem to persist despite environmental challenges. Drs. Hurt and Hall are working together to determine if there are genetic factors underlying that persistence whether there are specific populations that might be conservation priorities.

Genetic approaches can address past mistakes



The barrens topminnow is one of the rarest fishes in the world. Originally known from ca. 30 isolated springs on the Cumberland Plateau, this species had declined rapidly to just 18 populations by the time the species was even formally described. Biologists brought them into captivity for breeding, but over the years, individuals from different areas were sent all over the world to zoos and private aquariums. These living collections are now thriving in aquaria and breeding successfully, but unfortunately, detailed records about their genetic ancestry has not been maintained. It may now be possible for the barrens topminnow to be reintroduced into restored habitats, but we are now faced with a difficult question: which individuals should be chosen for those reintroductions? A study led by Tennessee Tech University geneticist Dr. Carla Hurt will analyze these captive populations to determine how much of their original genetic diversity remains and which sources of individuals might best be utilized in reestablishment across their native range. This information will help managers recreate populations that retain as much of their original genetic diversity as possible.

Genetics can inform us about rare fish and mussel distributions

Tennessee is home to fish and mussel species that are so rare that they are almost impossible to capture, or they live in habitats almost impossible to sample. The slender chub is a great example. It was never historically common and lives in large rivers that are difficult to access. In fact, this species has not been collected for so many years that some biologists fear they are extinct. A novel genetics application led by Dr. Robert Paine may shed light on their existence. Environmental DNA (eDNA) is based on the principle that organisms constantly shed minute amounts of their DNA via saliva, hairs, or shedding of tissue. That eDNA persists in the water for some time, and it can be collected, concen-

trated, and then amplified via polymerase chain reaction (PCR) and sequenced, thus facilitating the identification of the species that left the eDNA to begin with. This application is still being refined, but eDNA evidence is now a commonly used tool in the search for rare aquatic species. In fact, it can be used to examine entire aquatic communities to identify species assemblages. In a few years, eDNA surveys may replace or at least supplement traditional aquatic surveys that rely on nets, electrofishing, or visual searches by snorkeling teams. If the slender chub still exists, eDNA will be the method that will find it.

Have pollinators declined?



It is very common to hear news stories and social media posts raising concerns about pollinator abundance, especially bees. That concern is real, but how can we actually measure it? Dr. Shawn Krosnick has found a new and creative way to look at the situation using eDNA! Botanists have a long tradition of preserving dried plant specimens in herbaria with detailed information about when and where they were

collected. Most of the time, these specimens have flowers, and if those flowers were visited by pollinators, they may have left traces of eDNA on the flowers during their visit. These eDNA samples may remain on the plant for decades. That DNA can be extracted and amplified to facilitate identification of historical pollinators. Using historical and fresh specimens, she and her students have successfully obtained eDNA evidence of floral visitors including bees, thrips, true bugs, beetles, and even hummingbirds. Historical specimens can be compared with fresh samples to look for temporal changes in pollinator communities. Changes in floral visitors could be associated with declines in plant abundance or genetic factors. Herbarium specimens already provide an invaluable source of data for biodiversity studies, with this new approach provides yet another reason to preserve and further develop natural history collections.

We still do classical genetics!

There is still a need for traditional approaches although we can make them go faster with technology. Tennessee has thousands of small farms that are perfectly suited for specialty crops because they can be grown sustainably due to our abundant water, and there is special interest in heirloom varieties. Dr. Brian Leckie is examining beans and tomatoes to look at their genetic diversity and find cultivars that can be crossed to create the perfect plants for our region's markets. This is still done the old-fashioned way through

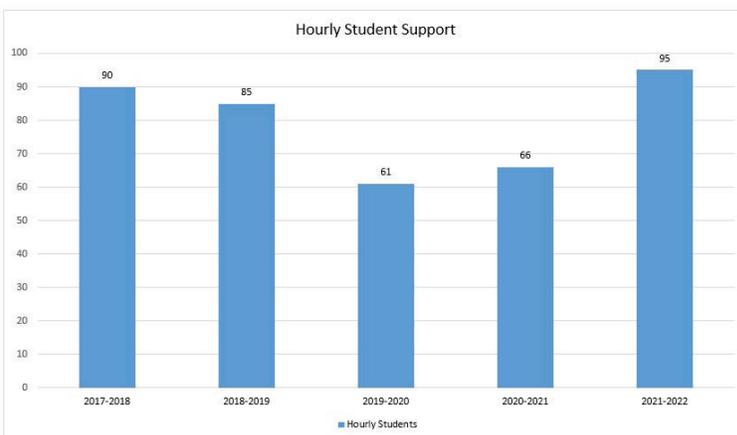
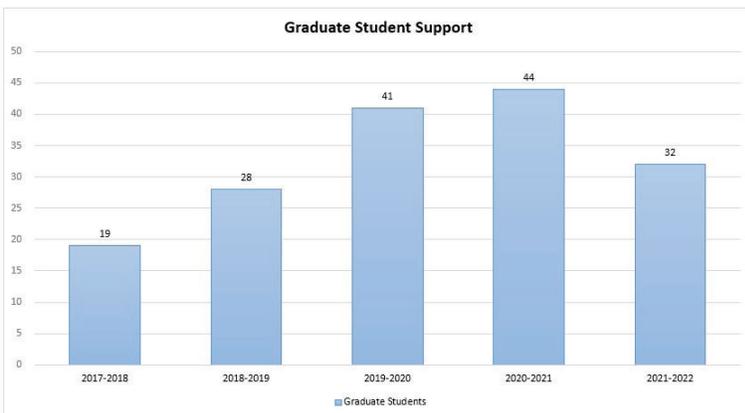
hand pollination, but the laboratory analyses that reveal the underlying genetics go much faster through modern instruments and equipment.

The Challenge

The types of studies we have featured are but a few applications of genetics in conservation, but they all have one thing in common: they require ever-more sophisticated instruments and plenty of computing power. Genetics in the 2020s is similar to the personal computer revolution of the early 1990s: whatever computer you purchased was outdated in six months by a machine that was less expensive, half the size, and twice as fast. It is a constant challenge to keep up with technological changes, but every year the Water Center plans strategically to retire its most outdated technology and replace it with the most cost-effective new instruments. And, there is a concurrent effort by our Information Technology group to ensure that the genetics folks have the computer support they need as new data are generated. The marriage of genetics and computing is manifested in bioinformatics, and Dr. Mostafa Rahnama has joined the Water Center as a principal investigator. He is a new faculty member whose research focus is big data, with an emphasis on analyses of molecular genetics data. His addition to our group will expand a powerful partnership that has allowed Tennessee Tech to establish a reputation as a center for molecular genetics.

ENHANCING EDUCATION & RESEARCH

Numbers of Students Supported





Graduate Students Supported

Ph.D.

Name	Advisor
Peter Blum	Murdock
Robert Brown	Murdock
Shrijana Duwadi	Murdock
Brooke Grubb	Hurt
Agoston Kiss	Stretz
Eric Koehler	Leckie
Nicholas Masto	Cohen
Collins Owusu	Kalyanapu
Md Bulbul Sharif	Ghafoor/Kalyanapu
Spencer Womble	Murdock



Master's

Name	Advisor
Brittany Bajo	Rosenberger
Connor Ballard	Rogers
Joshua Cary	Rosenberger
George Darkwah	Kalyanapu
Vinay Dhanvada	Kalyanapu
Jack Fetters	Rosenberger
Kendell Hamm	Mattingly
Cory Highway	Cohen
Parker Hildreth	Hurt
Abbey Holsopple	Wheeler
Frederick Hoogakker	Rogers
Maria Kuchla	Chavez
Mackenzie Martin	Kalyanapu
Morgan Michael	Murdock
Catherine Murphy	Chavez
Lori Nabors	Li/Schaeffer
Ashley Padgett	Rogers
Sarah Rhoton	Datta
Anchita Sanan	Hurt
Nusrat Jannah Snigdha	Kalyanapu
Adam Walker	Wheeler
Victor Wesley	Rogers

Brad Cohen, assistant professor of wildlife ecology, engaged in several outreach activities including the following publications, presentations and media opportunities:

- Cohen, B.S., and B.A. Collier. 2021. The fantastic four (maybe five) turkey subspecies. National Wild Turkey Federation (Outreach Publication).
- Cohen, B.S. 2022. Deer vision. Wired to Hunt Podcast (Outreach Media).
- Cohen, B.S., Masto N. M, A. G. Blake-Bradshaw, and C. J. Highway. 2022. Is hunting pressure affecting modern duck hunting. Duck Season Somewhere Podcast (Outreach Media).
- Masto N. M, A. G. Blake-Bradshaw, C. J. Highway, and B. S. Cohen. 2022. How the Tennessee Mallard Project helps waterfowl and hunters. Tennessee Outside Radio Show. Bolivar, TN, USA (Outreach Media).
- Managed "Cohen Wildlife Lab" webpage on Facebook: 100,000+ weekly engagements every week during fiscal year (Outreach Media).
- Cohen, B.S. 2022. Duck behavior in Tennessee and the Mississippi Flyway. Ducks Unlimited Sponsor Banquet, Clarksville, TN, USA.
- Highway, C. J., N. M. Masto, A. G. Blake-Bradshaw, and B. S. Cohen. 2022. Using GPS transmitters to research wintering ecology of mallards in western Tennessee. Tennessee Tech Ducks Unlimited Banquet, Livingston, TN (Outreach Presentation).
- Highway, C. J., N. M. Masto, A. G. Blake-Bradshaw, and B. S. Cohen. 2022. Depletion of unharvested flooded corn and drivers of mallard activity patterns during winter. Invited Presentation. Union City Rotary Club, Union City, TN, USA (Outreach Presentation).
- Blake-Bradshaw, A. G., N. M. Masto, C. J. Highway, and B. S. Cohen. 2022. Refuge use of wintering mallards. Invited Presentation. Union City Rotary Club, Union City, TN, USA (Outreach Presentation).

Alfred Kalyanapu, associate professor of environmental engineering, serves as the Executive Committee member of the American Society for Civil Engineering's Computational Hydraulics Committee and a member of the Tennessee American Water Resources Association Executive Committee. He is also an advisory member of the Water Education and Training Center led by the University of Tennessee Institute of Agriculture.

Hayden Mattingly, professor of biology, has a professional society membership in American Fisheries Society and Southeastern Fishes Council. He is also a federally appointed member of Bluemask Darter Technical Team, U.S. Fish & Wildlife Service. As a manuscript reviewer, he provided peer reviews for *Southeastern Naturalist* and Proceedings of the Southeastern Fishes Council. He is also an Editorial Board Member, Manuscript Editor, and Special Issue Volume Co-Editor with Jeffrey W. Simmons for the *Southeastern Naturalist*.



PROFESSIONAL
SERVICE



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 non-standard 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
- 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
- GC for THMs and HAAs

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.

ANALYTICAL CAPABILITIES

Our staff brings years of expertise in their respective areas of work, and they include Michelle Holm, office manager, who administers the financial reporting for the Center. 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 leads commercial testing. David Hobbs provides lab support, coordinates student research, and maintains lab safety. Center staff are recognized across campus for excellence in their respective duties.



ADMINISTRATION AND FACULTY

Dr. Jeff Schaeffer
Dr. Tania Datta

Director
Research Focus Area Leader,
Associate Professor of Civil and
Environmental Engineering
Research Focus Area Leader,
Associate Professor of
Environmental Engineering
Research Focus Area Leader,
Associate Professor of Biology

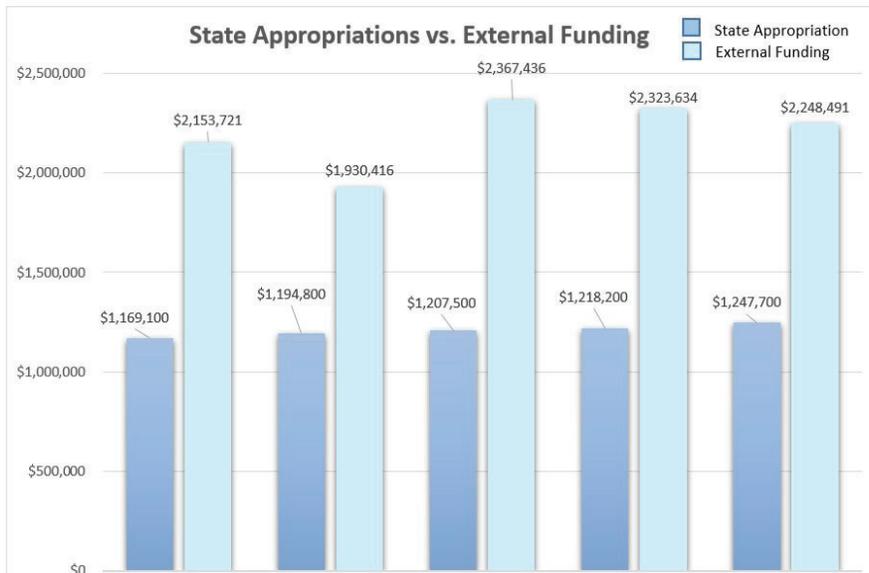
Dr. Alfred Kalyanapu

Dr. Justin Murdock

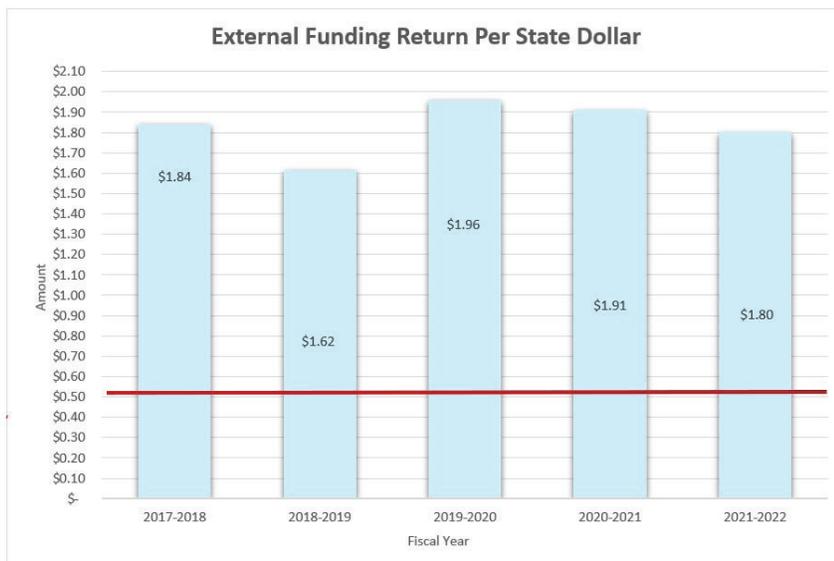
SUPPORT STAFF

Michelle Holm
Phillip C. Burr
Daniel P. Dodson
Sandy Dodson
Amy K. Hill
David Hobbs

Manager
Academic Support Associate
Technical Laboratory Manager
Administrative Associate 3
Editor
Laboratory Support

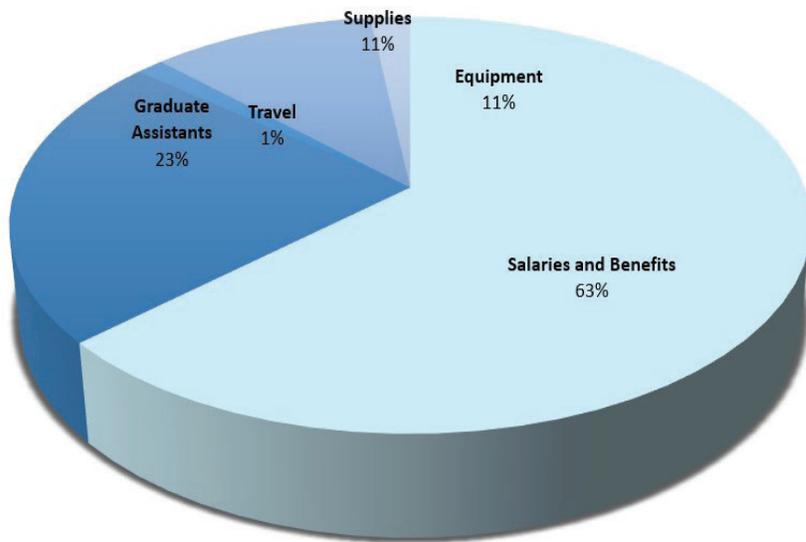


**The total external funding includes both direct and indirect costs awarded.*



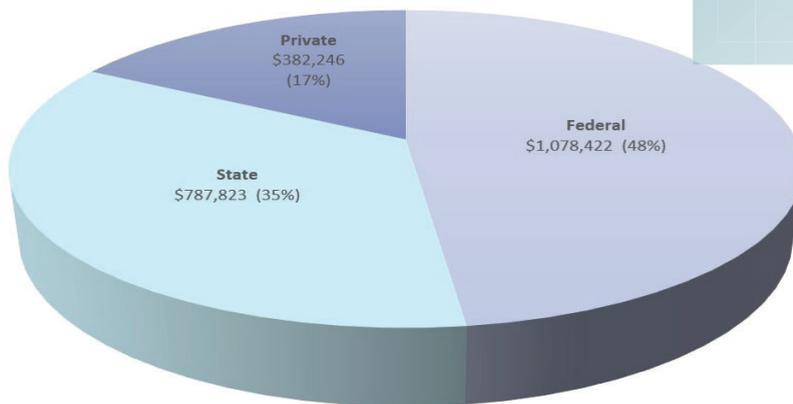
STATE APPROPRIATIONS VS. EXTERNAL FUNDING

Allocation of Appropriations

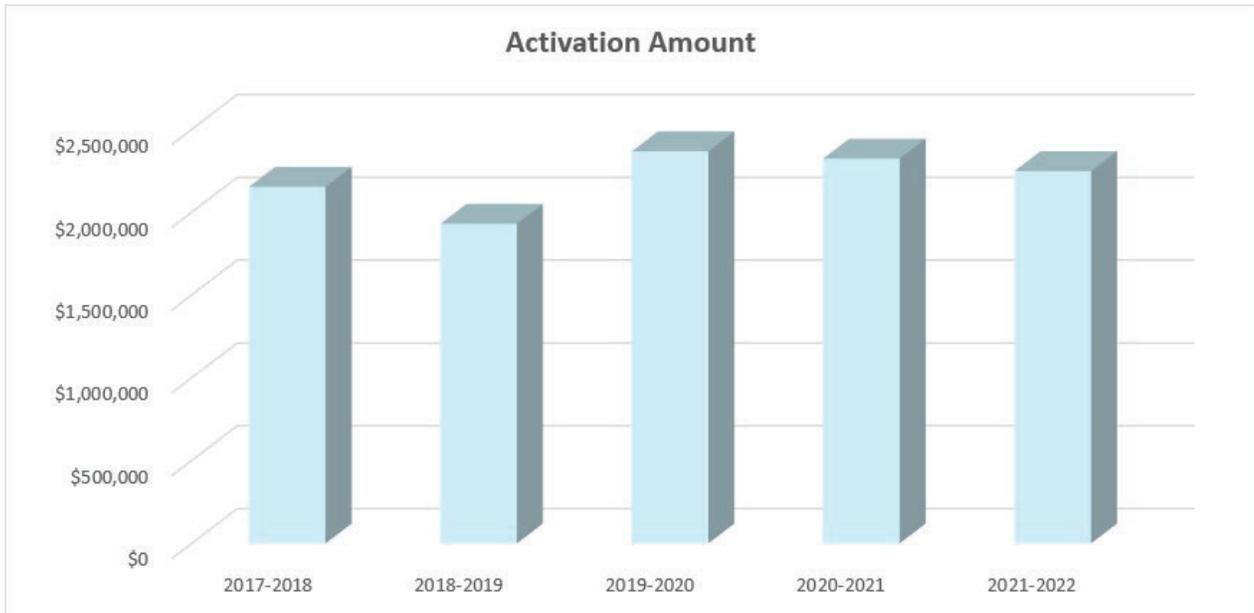


ALLOCATION OF APPROPRIATIONS AND SOURCES OF EXTERNAL FUNDING

Sources of External Funding



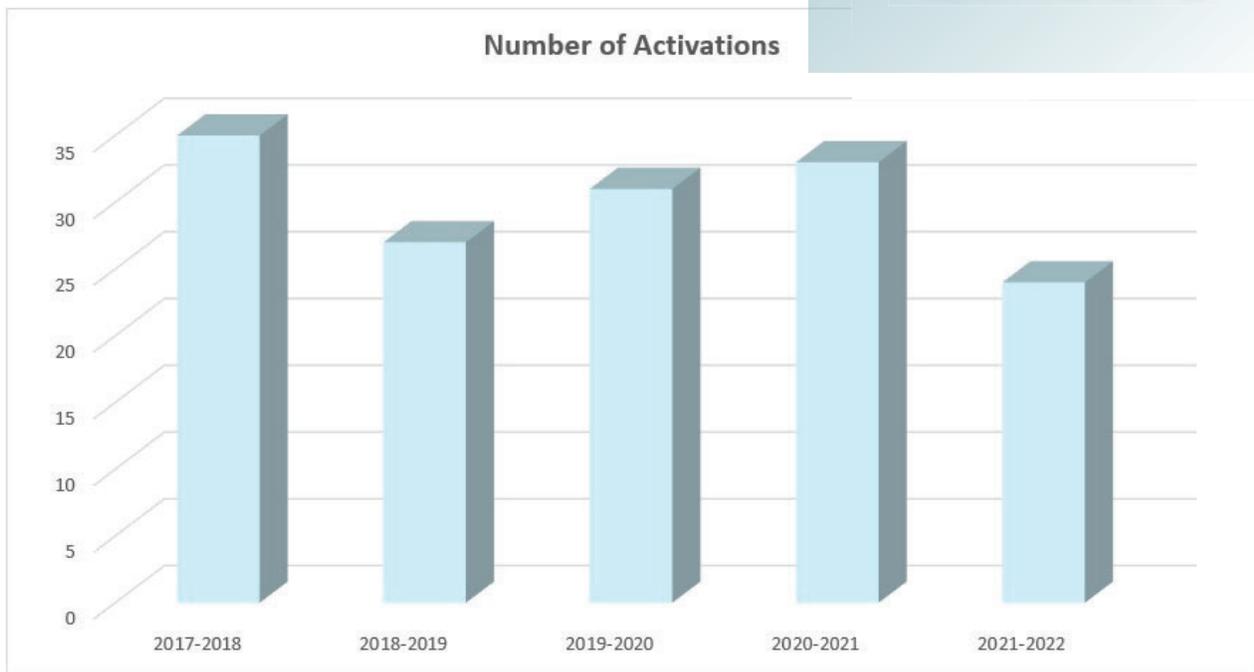
**The total activations includes both direct and indirect costs awarded.*



**The total activations includes both direct and indirect costs awarded.*



ACTIVATION AMOUNT AND NUMBERS OF ACTIVATIONS



Abrams Creek Logperch
Amanda Rosenberger/NPS
Activation This Year: \$24,975

ARB in Urban Groundwater
Systems
Tania Datta/USGS via UT-TWRRC
Activation This Year: \$5,000

Asian Carp Controls
Mark Rogers/USGS
Activation This Year: \$80,000

Assessing the Restoration
Success
Justin Murdock/The Nature
Conservancy
Activation This Year: \$382,246

Bighead and Silver Carp
Mark Rogers/USGS
Activation This Year: \$80,000

Evaluating Asian Carp TN and
Cumberland River
Mark Rogers/TWRA
Activation This Year: \$445,500

Evaluating Sport Fisheries
Mark Rogers/TWRA
Activation This Year: \$40,000

Evaluating Stocked Fisheries
Mark Rogers/TWRA
Activation This Year: \$66,000

Flood 2D-GPU for Titan HPC
Env
Alfred Kalyanapu/UT Battelle/
ORNL
Activation This Year: \$75,000

Hardin Pristine Crayfish
Hayden Mattingly/USFWS
Activation This Year: \$66,065

Hardin Pristine Crayfish
Hayden Mattingly/USFWS
Activation This Year: \$13,929

High-Quality Pod-Types in
Heirloom Green Beans
Brian Leckie/TDOA
Activation This Year: \$25,000

Long-Term Nitrogen and
Phosphorus
Tania Datta/TDEC
Activation This Year: \$2,450

Mallard Use TN Wetlands
Brad Cohen/TWRA
Activation This Year: \$434,282

Mallards Sanctuary Use
Brad Cohen/USFWS
Activation This Year: \$27,867

Multi-State Gobbler Harvest
Brad Cohen/KDFWR
Activation This Year: \$36,660

Mussel Database
Amanda Rosenberger/USGS
Activation This Year: \$87,272

Nonlinear Intrcts GRFP Brackins2
Alice Camuti/NSF
Activation This Year: \$46,000

Road Streams Elk River WS
Jeff Schaeffer/USFWS
Activation This Year: \$53,105

Slender Chub eDNA
Mark Rogers/USGS
Activation This Year: \$28,674

Snapping Shrimp (Supplemental
Funding)
Carla Hurt/NSF
Activation This Year: \$63,725

Striated Darter Duck River
Kit Wheeler/TWRA
Activation This Year: \$53,530

Waterfowl Monitoring Protocols
Brad Cohen/USFWS
Activation This Year: \$21,067

Wolf River Mussel Fauna
Amanda Rosenberger/USGS
Activation This Year:
\$90,144

EXTERNALLY
FUNDED
PROJECTS
ACTIVATED
IN FISCAL YEAR
2021-2022

Anker, A., Lemmon, A., Lemmon, E., and Bracken-Grissom, H. 2021. First worldwide molecular phylogeny of the morphologically and ecologically hyperdiversified snapping shrimp genus *alpheus* (*Malacostraca: decapoda*). *Molecular Phylogenetics and Evolution*. 158, 107080.

Bakner, N.W., Cohen, B.S., Collier, B.A., and Chamberlain, M.J. 2022. Recursive movements of eastern wild turkey broods in the southeastern United States. *Wildlife Society Bulletin*. 46:e1274.

Byrne, M.E., Cohen, B.S., Collier, B.A., and Chamberlain, M.J. 2022. Nest site fidelity and nesting success of female wild turkeys. *Wildlife Society Bulletin*. 46:e1279.

Chamberlain, M.J., Cohen, B.S., Wightman, P.H., Rushton, E., and Hinton, J.W. 2021. Fine-scale movements and behaviors of eastern coyotes (*Canis latrans*) during the reproductive period. *Ecology and Evolution*. 11:9575-9588.

Cohen, B.S., Oleson, B., Fyffe, N., Smallwood, A., Bakner, N., Nelson, S.D., Heffelfinger, J.R., Chamberlain, M.J., and Collier, B.A. 2022. Movement, spatial ecology, and habitat selection of translocated Gould's wild turkeys. *Wildlife Society Bulletin*. 46:e1270.

Dullo, T.T., Darkwah, G.K., Gangrade, S., Morales-Hernandez, M., Sharif, M.B., Kalyanapu, A.J., Kao, S.-C., Ghafoor, S., and Ashfaq, M. 2021. Assessing climate-change-induced flood risk in the Conasauga River watershed: An application of ensemble hydrodynamic inundation modeling. *Natural Hazards Earth Systems Science*. 21: 1739-1757. <https://doi.org/10.5194/nhess-21-1739-2021>.

Ennen, J.R., Kuhajda, B.R., Mitchell, S., Sweat, S.C., Zuber, B.C., Watts, A.V., Mattingly, H.T., Cecala K.K. 2021. Assessing the success of conservation efforts for a North American topminnow at risk of extinction from spatially variable mosquitofish invasions. *Freshwater Biology*. 66(3): 458-467. <https://doi.org/10.1111/fwb.13652>.

Evans, J.L., Murdock, J.N., Taylor, J.M., and Lizotte, R.E., Jr. 2021. Sediment nutrient flux rates in a shallow, turbid lake are more dependent on water quality than lake depth. *Water*. 13(10): 1344.

Henderson, K.A, Murdock, J.N., and Lizotte, R.E., Jr. 2021. Water depth influences algal distribution and productivity in shallow agricultural lakes. *Ecology*. 14(6), doi.org/10.1002/eco.2319.

Mitchell, K., Barletta, M., Giguere, S., Quandt, J., Osborn, D., Watson, E., Cohen, B., and Miller, K. 2021. Physiologic and blood gas effects of xylazine-ketamine versus xylazine-tiletamine-zolazepam immobilization of white-tailed deer before and after oxygen supplementation: a preliminary study. *Veterinary Anaesthesia and Analgesia*. 48:356-363.

Nelson, S.D., Keever, A.C., Wightman, P.H., Bakner, N.W., Collier, B.A., Chamberlain, M.J., and Cohen, B.S. 2022. Fine-scale resource selection and behavioral tradeoffs of eastern wild turkey broods. *Journal of Wildlife Management*. 86:e2222.

Paine, R.T., Hurt, C., and Mattingly, H.T. 2021. Monitoring a minuscule madtom: Environmental DNA surveillance of the endangered pygmy madtom (*Noturus stanauli* Etnier & Jenkins 1980) in the Duck and Clinch rivers, Tennessee. *Environmental DNA*. 2021(3): 745-759.

Paine, R.T., Hurt C., and Mattingly, H. 2021. Monitoring a minuscule madtom: Environmental DNA surveillance of the endangered pygmy madtom (*Noturus stanauli* Etnier & Jenkins 1980) in the Duck and Clinch rivers, Tennessee. *Environmental DNA* 4 745-759.

REFEREED PUBLICATIONS

Peace, A., Frost, P.C., Wagner, N.D., Danger, M., Accolla, C., Antczak, P., Brooks, B.W., Costello, D.M., Everett, R.A., Flores, K.B., Heggerud, C.M., Karimi, R., Kang, Y., Kuang, Y., Larson, J.H., Mathews, T., Mayer, G.D., Murdock, J.N., Murphy, C.A., Nisbet, R.M., Pecquerie, L., Pollesch, N., Rutter, E.M., Schulz, K.L., Scott, J.T., Stevenson, L., and Wang, H. 2021. Stoichiometric ecotoxicology for a multi-substance world. *Bioscience*. 71(2), 132-147.

Silliman, K., Indorf, J., Knowlton, K., Browne, B., and Hurt C. Base-substitution mutation rate across the nuclear genome of *Alpheus* snapping shrimp and the timing of isolation by the Isthmus of Panama. *BMC Ecology and Evolution. Molecular Phylogenetics and Evolution*. 21:1-14.

Sullivan, D.J., Cohen, B.S., Poteet, M., Collier, B.A., and Chamberlain, M.J. 2022. Space-use, movements, and survival of translocated eastern wild turkeys in east Texas. *Wildlife Society Bulletin*. 46:e1283.

Watson, E.M., Cohen, B.S., Osborn, D.A., Brown, J.M., and Miller, K.V. 2022. Estimation of visual discrimination of white-tailed deer by behavioral assay. *American Midland Naturalist*. 187:90-96.

Allen, S.A., Wells, W.G., and Mattingly, H.T. "A large-scale MaxEnt model for the distribution of the endangered Pygmy Madtom, *Noturus stanauli*." Manuscript submitted to *Journal of Fish and Wildlife Management*. Tentatively accepted pending revisions.

Hubbs, Wade, N., Hurt, C.R. Niedzwiecki, J., Leckie, B., and Withers, D. 2022. Conservation Genomics of Urban Populations of Streamside Salamander (*Ambystoma barbouri*). *PLoS ONE*, in press.

Hurt, C., Hultgren K., Hurt, C., Hildreth, P., and Williams, C., 2022. A genomic perspective on the conservation status of the endangered Nashville crayfish (*Faxonius shoupi*). *Conservation Genetics*, in press.

Krosnick, S.E., Thacker, J.H., Mattingly, H.T., Call, G.P., Maynard, S.C., Adams, D.S., and Wheeler, K. "Ecological correlates of reproductive output in a Tennessee population of Short's Bladderpod, *Physaria globosa* (*Brassicaceae*)." Manuscript submitted to *Journal of the Torrey Botanical Society*. Tentatively accepted pending revisions.

Masto, N.M., Robinson, O., Brasher, M., Blake-Bradshaw, A.G., Highway, C.J., Keever, A.C., Feddersen, J.C., Hagy, H.M., Osborne, D.C., and Cohen, B.S. 2022. "Using citizen science to understand avian responses to extreme climactic events." *Global Change Biology*. In press.

Paine, R., Rogers, M., and Hurt, C. 2022. Molecular delineation of silver carp (*Hypophthalmichthys molitrix*) invasion in the Duck River, Tennessee. *The Journal of Fish and Wildlife Management*, in review.

Stickles, J.H., Cohen, B.S., Osborn, D.A., Warren, R.J., D'Angelo, G.J., and Miller, K.V. 2022. "Nighttime traffic volume predicts risk of deer-vehicle collisions." *Human-Wildlife Interactions*. In press.

REFEREED PUBLICATIONS (CONT.)

PUBLICATIONS IN PRESS/ PENDING

FINAL REPORTS

Yeager-Armstead, M., Baker, B., Linhoss, A., Murdock, J.N., and Parajuli, P. 2022. USACE ERDC Technical Report: Identifying Management Needs to Predict, Detect and Manage Harmful Algal Blooms in Flowing Waters Results of Riverine HABS Workshop November 16-17, 2021 Huntington, West Virginia.

Mattingly, H., Murdock, J.N., Wheeler, C., and Gibbs, K. AEDC Bat-Related Aquatic Resources Study – Evaluation of Aquatic Resources to Support Bat Foraging Habitat at Arnold Engineering Development Center, Arnold Air Force Base, with an Emphasis on Rare, Threatened, and Endangered Aquatic Species. Final Report. December 31, 2021.

Alexander, N.R., Baxley, D., Bradley, T., Brown, R., Duwadi, S., Flinn, M., Fore, J., Kalyanapu, A., Michael, M., Morris, S., Murdoc, J., Veum, K., Walker, D., Webb, L., Womble, S., and Whiteman, H. "Patterns of microbial assemblage in wetland ecosystems across habitat type and core incubations." Tennessee Water Resources Symposium, TNAWRA. (Virtual). 2021.

Arms, M., Harris, H., Wright, T., Datta, T., and Kalyanapu, A.J. "Watershed-wide stormwater management in an underserved community of Tennessee through community-university partnership". Kentucky/Tennessee Water Professionals Conference, KY/TN Section of AWWA and CWP-KT, Chattanooga, TN. 2021.

Blake-Bradshaw, A.G., Masto, N.M., Highway, C.J., Keever, A.C., Feddersen, J.C., Hagy, H.M., and Cohen, B.S. "Ruffling feathers: effects of experimental disturbance on mallard space use and movements." 54th Annual Conference of the Tennessee Chapter of the Wildlife Society [virtual]. Awarded "Best Student Presentation." 2022.

Blake-Bradshaw, A.G., Masto, N.M., Highway, C.J., Keever, A.C., Feddersen, J.C., Hagy, H.M., Combs, D.L., and Cohen, B.S. "The influence of experimental disturbance on mallard space use and movements during winter." 28th The Wildlife Society Annual Conference [virtual]. 2021.

Blake-Bradshaw, A.G., Masto, N.M., Highway, C.J., Keever, A.C., Combs, D.L., Feddersen, J.C., Hagy, H.M., and Cohen, B.S. "Ruffling feathers: the influence of experimental disturbance on space-use, movements, and site-fidelity of a wintering waterfowl." 75th Conference of the Southeastern Association of Fish and Wildlife Agencies. Roanoke, Virginia, USA. 2021.

Blum, P.W., Allen, S., Caudle, J., Khan, T., Gibbs, K., Mattingly, H., Murdock, J., Wheeler, K., and Womble, K. "A 20-year comparison of stream ecosystem changes on a military installation in the Tennessee Barrens Plateau." Joint Aquatic Sciences Meeting. Grand Rapids, MI. May 2022.

Brackins, J.T., and Kalyanapu, A.J. "Evaluation of tropical cyclone flood discharges estimated with rainfall from parametric models for flood risk studies." Tennessee Water Resources Symposium, TNAWRA (virtual). 2021.

Brown, R.S., Womble, S.G., and Murdock, J. "The structural design of flow-through core incubations can affect nutrient removal measurements." Joint Aquatic Sciences Meeting. Grand Rapids, MI. May 2022.

Brown, R.S., Blum, P.W., and Murdock, J. "Can tornado damage affect downstream water quality?" Watershed Sustainability Summit. Murray, KY. 2022.

Byrne, M.E., Cohen, B.S., Collier, B.A., and Chamberlain, M.J. "Nest site fidelity and nesting success of female wild turkeys." 12th National Wild Turkey Symposium, Asheville, NC, USA, 2022.

Bakner, N.W., Cohen, B.S., Collier, B.A., and Chamberlain, M.J. "Recursive movements of eastern wild turkey broods in the southeastern United States." 12th National Wild Turkey Symposium, Asheville, NC, USA. 2022.

Casaubon, A., Hurt, C., Hultgren, K., and Murray, C. "Examining snapping shrimp morphology using geometric morphometrics in a phylogenetic framework." 17th Research and Creative Inquiry Day. Tennessee Technological University. April 21, 2022. Cookeville, Tennessee. (First place, Center for Water Center Research Excellence Award - Poster).

Casaubon, A., Hurt, C., and Hultgren, K. "Examining snapping shrimp morphology using geometric morphometrics in a phylogenetic framework." Society of Integrative and Comparative Biology Annual Meeting. January 3-7, 2022. Phoenix, Arizona.

PRESENTATIONS

Casaubon, A., Hurt, C., and Hultgren, K. "Examining snapping shrimp morphology using geometric morphometrics in a phylogenetic framework." Tennessee Academy of Science. November 6, 2021. Cookeville, Tennessee.

Catherine, L., Murphy, X., Zhe, O., and Arias Chavez, L. "Reclamation of resources from industrial wastewater through a hybrid forward osmosis-reverse osmosis system." Association of Environmental Engineering & Science Professors (AEESP) conference in St. Louis. June 28-30, 2022.

Cohen, B.S., Masto, N.M., Blake-Bradshaw, A.G., Highway, C.J., Hagy, H.M., Feddersen, J.C., and Combs, D.L. "Mallard refuge use and survival in western Tennessee." U.S. Fish and Wildlife Service National Refuge System, Reelfoot Lake NWR, TN, USA. Invited Seminar. 2021.

Cohen, B.S., Nelson, S.D., Keever, A.C., Wightman, P.H., Bakner, N., Byrne, M.E., Collier, B.A., and Chamberlain, M.J. "Resource selection of wild turkey broods." 47th Southeast Wild Turkey Working Group Meeting [virtual]. 2021.

Cohen, B.S., Oleson, B., Fyffe, N., Smallwood, A., Bakner, N., Nelson, S.D., Heffelfinger, J.R., Chamberlain, M.J., and Collier, B.A. "Movement, spatial ecology, and habitat selection of translocated Gould's wild turkeys." 12th National Wild Turkey Symposium, Asheville, NC, USA. 2022.

Darkwah, G., and Kalyanapu, A. "Automated flood forecasting system for Window Cliffs State Natural Area, TN." Tennessee Water Resources Symposium, 2021.

Darkwah, G., Kalyanapu, A., Gangrade, S., Kao, S.-C., Sharif, M.B., Ghafoor, S., and Morales-Hernandez, M. "Development of a deep learning surrogate model in the TRITON Inundation Modeling Framework." AGU Fall Meeting 2021. <https://agu2021fallmeeting-agu.ipostersessions.com/?s=69-7B-4B-F2-8D-B4-26-5A-39-4F-83-89-97-9E-EA-CD>. 2021.

Dhanvada*, V., A., Kalyanapu, A., J., Datta, T., and Adkins, J. "Development of a GIS-based watershed vulnerability assessment tool for the Loosahatchie Watershed in Tennessee." Tennessee Water Resources Symposium, TNAWRA. (Virtual). 2021.

Duwadi, S., Womble, S., Brown, R., and Murdock, J. "Relationships between microbial biomass, soil properties, and denitrification potential in restored floodplain wetlands." Joint Aquatic Sciences Meeting. May 2022.

Grubb, B., Mallinger, M., Simmons, J.W., and Hurt, C. "Crayfish diversity within the Tennessee River drainage: A reassessment using molecular phylogenetics." International Association of Astacology 23rd Symposium.

Grubb, B., Mallinger, M., Simmons, J.W., and Hurt, C. "Crayfish diversity within the Tennessee River drainage: A reassessment using molecular phylogenetics." Joint Aquatic Sciences Meeting.

Highway, C.J., Blake-Bradshaw, A.G., Masto, N.M., Keever, A.C., Feddersen, J.C., Hagy, H.M., Combs, D.L., and Cohen, B.S. "Drivers of mallard activity patterns during winter." 28th The Wildlife Society Annual Conference [virtual]. 2021.

Highway, C.J., Masto, N.M., Blake-Bradshaw, A.G., Keever, A.C., Feddersen, J.C., Hagy, H.M., Combs, D.L., and Cohen, B.S. "Abundance and depletion of unharvested flooded corn." Winter Mississippi Flyway Council Meeting, Orange Beach, AL, USA. 2022.

PRESENTATIONS (CONT.)

Highway, C.J., Blake-Bradshaw, A.G., Mastro, N.M., Keever, A.C., Feddersen, J.C., Hagy, H.M., Combs, D.L., and Cohen, B.S. "Ducky days – linking temporal and environmental factors to mallard activity patterns." 54th Annual Conference of the Tennessee Chapter of the Wildlife Society. (Virtual). 2022.

Highway, C.J., Blake-Bradshaw, A.G., Mastro, N.M., Keever, A.C., Feddersen, J.C., Hagy, H.M., Combs, D.L., and Cohen, B.S. "Factors affecting winter activity patterns of mallards." 75th Conference of the Southeastern Association of Fish and Wildlife Agencies. Roanoke, Virginia, USA. 2021.

Kalyanapu, A.J., Kaczmarek, C., Ravinutala, V., and Ngerakuakal, P. "Low-cost, real-time water level monitoring network for Falling Water River Watershed." Tennessee Water Resources Symposium, TNAWRA. (Virtual). 2021.

Keever, A.C., Kelly, J.D., and Cohen, B.S. "Estimating abundance of white-tailed deer using harvest data and integrated population models." 45th Southeast Deer Study Group. (Virtual). 2022.

Mallinger, M., Grubb, B., Simmons, J.W., and Hurt, C. "Assessing phylogenetic placement of an undocumented red-burrowing crayfish in the Tennessee River system." Tennessee Tech Research Day. 2022.

Martin, M.T., Owusu, C., Snigdha, N.J., Kalyanapu, A.J., and Murdock, J. "Development of a 2D model in St. Arbor Wetland for an assessment of levee breaching." Tennessee Water Resources Symposium, TNAWRA. (Virtual). 2021.

Mastro, N.M., Blake-Bradshaw, A.G., Highway, C.J., Keever, A.C., Feddersen, J.C., Link, P.T., Osborne, D.C., Hagy, H.M., Combs, D.L., and Cohen, B.S. "Spring migration of mallards wintering in the Mississippi Alluvial Valley." 75th Conference of the Southeastern Association of Fish and Wildlife Agencies. Roanoke, Virginia, USA. 2021.

Mastro, N.M., Blake-Bradshaw, A.G., Highway, C.J., Keever, A.C., Feddersen, J.C., Link, P.T., Osborne, D.C., Hagy, H.M., Combs, D.L., and Cohen, B.S. "Pre-breeding migration strategies of mallards wintering in the Mississippi Alluvial Valley." 28th The Wildlife Society Annual Conference [virtual]. 2021.

Mastro, N.M., Blake-Bradshaw, A.G., Highway, C.J., Keever, A.C., Feddersen, J.C., Hagy, H.M., Combs, D.L., and Cohen, B.S. "Local winter distributions and fidelity of GPS-marked mallards." Winter Mississippi Flyway Council Meeting, Orange Beach, AL, USA. 2022.

Mastro, N.M., Blake-Bradshaw, A.G., Highway, C.J., Keever, A.C., Feddersen, J.C., Hagy, H.M., Combs, D.L., and Cohen, B.S. "Winter fidelity and distribution of individually marked mallards." 54th Annual Conference of the Tennessee Chapter of the Wildlife Society [virtual]. 2022.

Murdock, J.N. "Designing the future of Mississippi River riparian wetlands: How restoration planning can reduce downstream nutrients." Kent State University. March 2022.

Murdock, J.N. "Nutrient retention recovery in restored floodplain wetlands." Southern Illinois University. February 2022.

Murdock, J., Brown, R., Duwadi, S., and Womble, S. "Nutrient retention recovery across space and time in restored agricultural wetlands." Joint Aquatic Sciences Meeting, Grand Rapids, MI. May 2022.

Murdock, J. "Didymosphenia geminata in Tennessee and North Carolina." Great Lakes Panel on Aquatic Nuisance Species. Virtual. 2021.

Owusu, C., Snigdha, N.J., Martin, M.T., Kalyanapu, A.J., and Murdock, J. "Reconstructing historical wetland surface water hydrographs through remote sensing, machine learning, and cloud computing." Tennessee Water Resources Symposium, TNAWRA, (Virtual). 2021.

PRESENTATIONS (CONT.)

Owusu, C., Snigdha, N.J., Martin, M.T., & Kalyanapu, A. J. (2021). "Hydrologic monitoring and assessment of WRP easements in Tennessee & Kentucky." NRCS-TNC WRP Monitoring Conference, (Virtual). 2021.

Owusu, C., Snigdha, N.J., Martin, M.T., & Kalyanapu, A. J. "Reconstructing historical wetland surface water dynamics through remote sensing and cloud computing." Fall Meeting, AGU, New Orleans, LA & Online Everywhere. 2021.

Rosson, A., and Murdock, J. "Soil nitrate uptake and removal relative to nitrate availability in a restored agricultural wetland." Joint Aquatic Sciences Meeting, Grand Rapids, MI. May 2022.

Snigdha, N.J., Martin, M.T., Owusu, C., Kalyanapu, A.J., and Murdock, J. "RS/GIS-based analyses for wetland restoration evaluation: A case study of St. Arbor Slough Wetland." Tennessee Water Resources Symposium, TNAWRA (virtual). 2021.

Sullivan, D.J., Cohen, B.S., Poteet, M., Collier, B.A., and Chamberlain, M.J. "Space-use, movements, and survival of translocated eastern wild turkeys in east Texas." 12th National Wild Turkey Symposium, Asheville, NC, USA. 2022.

Wall, L., Hurt, C., Grubb, B., and Torrance, K. "The genetics of species boundaries in Tennessee woodrats." Tennessee Technological University Research Day.

Walker, A.L., Wheeler, K., and C.R., Hurt. 2022. "Population status, demographic history, and genetic health of the striated darter (*Etheostoma striatulum*) in the Duck River, Tennessee." Graduate Seminar, Tennessee Tech University, Cookeville, TN.

Walker, A.L., Wheeler, K., and C.R., Hurt. 2022. "Development and application of an environmental DNA (eDNA) assay for the imperiled striated darter (*Etheostoma striatulum*) in the Duck River, Tennessee." 17th Research and Creative Inquiry Day, Tennessee Tech University, Cookeville, TN. (Second Place, Center for Water Research Excellence Award – Poster) .

Walker, A.L., Wheeler, K., and C.R., Hurt. 2022. "Development and application of an environmental DNA (eDNA) assay for the imperiled striated darter (*Etheostoma striatulum*) in the Duck River, Tennessee." Joint Aquatic Sciences Meeting, Grand Rapids, Michigan.

Walker, A.L., Wheeler, K., and C.R. Hurt. 2022. "Development and application of an environmental DNA (eDNA) assay for the imperiled striated darter (*Etheostoma striatulum*) in the Duck River, Tennessee." Tennessee American Fisheries Society, Annual Meeting, Gatlinburg, Tennessee. (2nd Place – Oral).

Walker, A.L., Barnett, E.E., Wheeler, K., and C.R. Hurt. 2021. "Development of an environmental DNA (eDNA) assay to delineate the distribution of the imperiled striated darter (*Etheostoma striatulum*) in the Duck River, Tennessee." Southeastern Fisheries Council, Columbus, Georgia. (Oral).

Walker, A.L., Barnett, E.E., Wheeler, K., and C.R. Hurt. 2021. "Development of an environmental DNA (eDNA) assay to delineate the distribution of the imperiled striated darter (*Etheostoma striatulum*) in the Duck River, Tennessee." American Fisheries Society, National Meeting, Baltimore, Maryland. (Oral).

Womble, S.G., Murdock, J., Duwadi, S., and Brown, R. "Effects of vegetation type and inundation period on nutrient retention in wetland mesocosms." Joint Aquatic Sciences Meeting (JASM). Grand Rapids, MI. May 2022.

PRESENTATIONS (CONT.)

Name	Major
Maci Arms	Civil & Environmental Engineering
Marshall Avera	Civil & Environmental Engineering
Justin Baker	Civil & Environmental Engineering
Ryan Bauer	Biology
Joshua L. Bean	Agriculture
Joshua T. Bean	Biology
Sydney Beltran	Earth Sciences
Abby Blake-Bradshaw	Environmental Sciences
Alec Brenner	Civil & Environmental Engineering
Joanna Brown	Interdisciplinary Studies
Gabrielle Burke	Earth Sciences
Joshua Cary	Biology
Jennifer Caudle	Biology
Billy Clanton	Biology
Aaron Coons	Biology
Nathan Colwell	Chemistry
Trevor Crawford	Biology
Ashley Daniel	Interdisciplinary Studies
Kelly Day	Biology
Daniel Drexler	Civil & Environmental Engineering
Hunter Dyer	Civil & Environmental Engineering
Gary Matthew Dziuk	Biology
Kalei Hair	Civil & Environmental Engineering
Ethan Harper	Civil & Environmental Engineering
Hugh Harris	Civil & Environmental Engineering
Parker Hildreth	Biology
Abbey Holsopple	Biology
Ryan Hudson	Biology
Seth Jones	Interdisciplinary Studies
Nicholas Masto	Biology
Keaton Metcalf	Civil & Environmental Engineering
Lindsey Miller	Civil & Environmental Engineering
Cullen Morrow	Civil & Environmental Engineering
Caleb Moses	Biology
Stefan Nelson	Biology
Isaac Nickels	Agriculture
Kester Nucum	Computer Engineering
Ravi Patel	Civil & Environmental Engineering
Dennis Piercy	Chemical Engineering
Devin Rains	Civil & Environmental Engineering
Jonah M. Ralston	Chemistry
Michael L. Rand	Biology
Rachel Reed	Interdisciplinary Studies
Sarah Rhoton	Civil & Environmental Engineering
Mark Rine	Biology
Andrew Rosson	Biology
Austin Sanders	Agriculture
William Schibig	Biology
Tara Schmidt	Biology
Mary Scott	Biology
Alejandro Segoviano-Carril	Civil & Environmental Engineering

HOURLY STUDENT SUPPORT

Name	Major
Md Bulbul Sharif	Engineering
Isabella Southerland	Chemical Engineering
Jarrett Tallent	Biology
Brandon Tincher	Biology
Katherine Torrance	Biology
Samuel Vesely	Interdisciplinary Studies
Jacob Viamonte	Biology
Emily Vigil	Biology
Adam Walker	Biology
John Micah Westerman	Civil & Environmental Engineering
Effie White	Civil & Environmental Engineering
MacKenzie White	Biology
Kathryn Wilkins	Biology
Alexandra Wilson	Biology
Philip Yankee	Biology

HOURLY
STUDENT
SUPPORT
(CONT.)



CENTERS OF EXCELLENCE/ CENTERS OF EMPHASIS ACTUAL, PROPOSED, AND REQUESTED BUDGET

SCHEDULE 7

Expenditures	FY 2021-22 Actual			FY 2022-23 Proposed			FY 2023-24 Requested		
	Matching	Appopr.	Total	Matching	Appopr.	Total	Matching	Appopr.	Total
Salaries									
Faculty	\$79,095		\$79,095	\$17,427		\$17,427	\$17,863	\$0	\$17,863
Other Professional	\$393,494	\$275,255	\$668,749	\$104,538	\$320,859	\$425,397	\$107,151	\$328,880	\$436,031
Clerical/ Supporting	\$35,350	\$137,828	\$173,178	\$27,500	\$138,085	\$165,585	\$28,188	\$141,537	\$169,725
Assistantships	\$352,872	\$202,382	\$555,254	\$171,823	\$105,000	\$276,823	\$176,119	\$242,067	\$418,186
Total Salaries	\$860,811	\$615,465	\$1,476,276	\$321,288	\$563,944	\$885,232	\$329,321	\$712,484	\$1,041,805
Fringe Benefits	\$376,009	\$226,468	\$602,477	\$113,796	\$275,000	\$388,796	\$116,641	\$281,875	\$398,516
Total Personnel	\$1,236,820	\$841,933	\$2,078,753	\$435,084	\$838,944	\$1,274,028	\$445,962	\$994,359	\$1,440,321
Non-Personnel									
Travel	\$155,509	\$13,682	\$169,191	\$91,173	\$15,000	\$106,173	\$93,452	\$15,375	\$108,827
Software		\$1,525	\$1,525			\$0			\$0
Books & Journals		\$7,474	\$7,474			\$0			\$0
Other Supplies	\$524,364	\$103,887	\$628,251	\$396,405	\$263,156	\$659,561	\$406,315	\$237,579	\$643,894
Equipment	\$20,000	\$17,293	\$37,293	\$15,000	\$170,000	\$185,000	\$15,375	\$71,987	\$87,362
Maintenance		\$3,731	\$3,731			\$0			\$0
Scholarships	\$46,000		\$46,000			\$0			\$0
Consultants	\$56,612		\$56,612			\$0			\$0
Renovation			\$0			\$0			\$0
Other (Specify): Seminars/Conferences		\$345	\$345			\$0			\$0
			\$0			\$0			\$0
			\$0			\$0			\$0
			\$0			\$0			\$0
Total Non-Personnel	\$802,485	\$147,937	\$950,422	\$502,578	\$448,156	\$950,734	\$515,142	\$324,941	\$840,083
GRAND TOTAL	\$2,039,305	\$989,870	\$3,029,175	\$937,662	\$1,287,100	\$2,224,762	\$961,104	\$1,319,300	\$2,280,404
Revenue									
New State Appropriation		\$1,247,700	\$1,247,700		\$1,287,100	\$1,287,100		\$1,319,300	\$1,319,300
Carryover State Appropriation		\$245,956	\$245,956		\$503,786	\$503,786			\$0
New Matching Funds	\$2,039,305		\$2,039,305	\$937,662		\$937,662	\$961,104		\$961,104
Carryover from Previous Matching Funds			\$0			\$0			\$0
Total Revenue	\$2,039,305	\$1,493,656	\$3,532,961	\$937,662	\$1,790,886	\$2,728,548	\$961,104	\$1,319,300	\$2,280,404



Budget Note: The Center for the Management, Utilization and Protection of Water Resources requests a five percent budget increase for the 2022-2023 fiscal year to accommodate potential increases in salaries and other supplies and equipment expenses.

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Designer: Dr. Amy Hill

Center for the Management, Utilization and Protection of Water Resources

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IN MEMORY

