Fiscal Year July 1, 2016 through June 30, 2017

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Center for the Management, Utilization & Protection of Water Resources

Annual Report

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Introduction

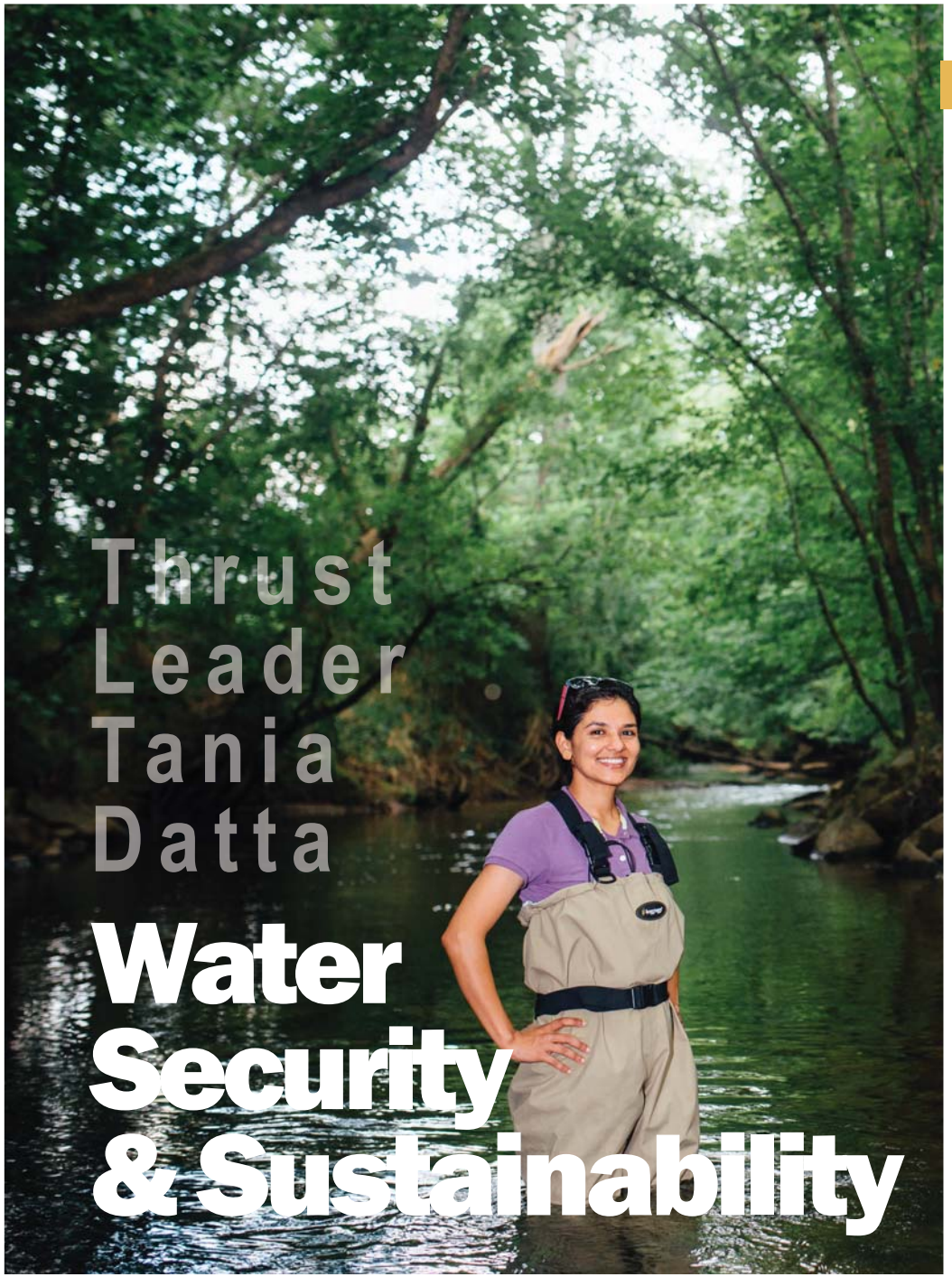
The Center for the Management, Utilization and Protection of Water Resources (Water Center) at Tennessee Tech University (TTU) is an interdisciplinary research center that facilitates and supports faculty members across departments working primarily in four areas:

- Water Security and Sustainability
- Biodiversity
- Water-Energy-Food Nexus
- Enabling Technologies and Tools

The Water Center's work encompasses projects ranging from threatened species protection to watershed management that are vital to supporting the environmental health of the state, nation and world. The Center's mission is to"

- Research and develop solutions to current knowledge and technology barriers associated with safe and sufficient water resources and biological diversity and sustainability
- Develop technologies and tools that encompass water-energy-food interactions
- Through global outreach, support industry and state/federal agencies and communities in water security, biological diversity and associated sustainability programs
- Support academic programs through student and faculty development and laboratory infrastructure access
- Promote regional economic and rural community development

A brief description of each thrust area and some current ongoing projects are presented in the following pages.



Water Security and Sustainability

The overarching objective of this thrust area is to enable fundamental and applied research on topics aimed toward conserving the quantity and enhancing the quality of our water resources. This is being done through the assessment and development of innovative water and wastewater treatment technologies; understanding the impact of stormwater runoff on watershed health; the use of an integrated watershed management approach; and groundwater quality assessment. The thrust also supports and participates in outreach projects.

Current projects in this area include:

- Understanding microbial metabolism and inhibition mechanisms during an anaerobic codigestion process (Tania Datta, Asst. Prof. Water Center): This project evaluates the effects of various high-strength organic waste characteristics on metabolic pathways of key microbial communities involved in anaerobic codigesters, with an ultimate goal of enhancing biogas production from waste.

- Implementing simultaneous nitrification, denitrification and biological phosphorus removal in full-scale municipal wastewater treatment plants (Tania Datta, Asst. Prof. Water Center; Donald Walker, Asst. Prof. Biology): This project investigates the process, operational and microbial community structure-function requirements for enabling existing treatment plants to implement simultaneous biological nutrient removal.

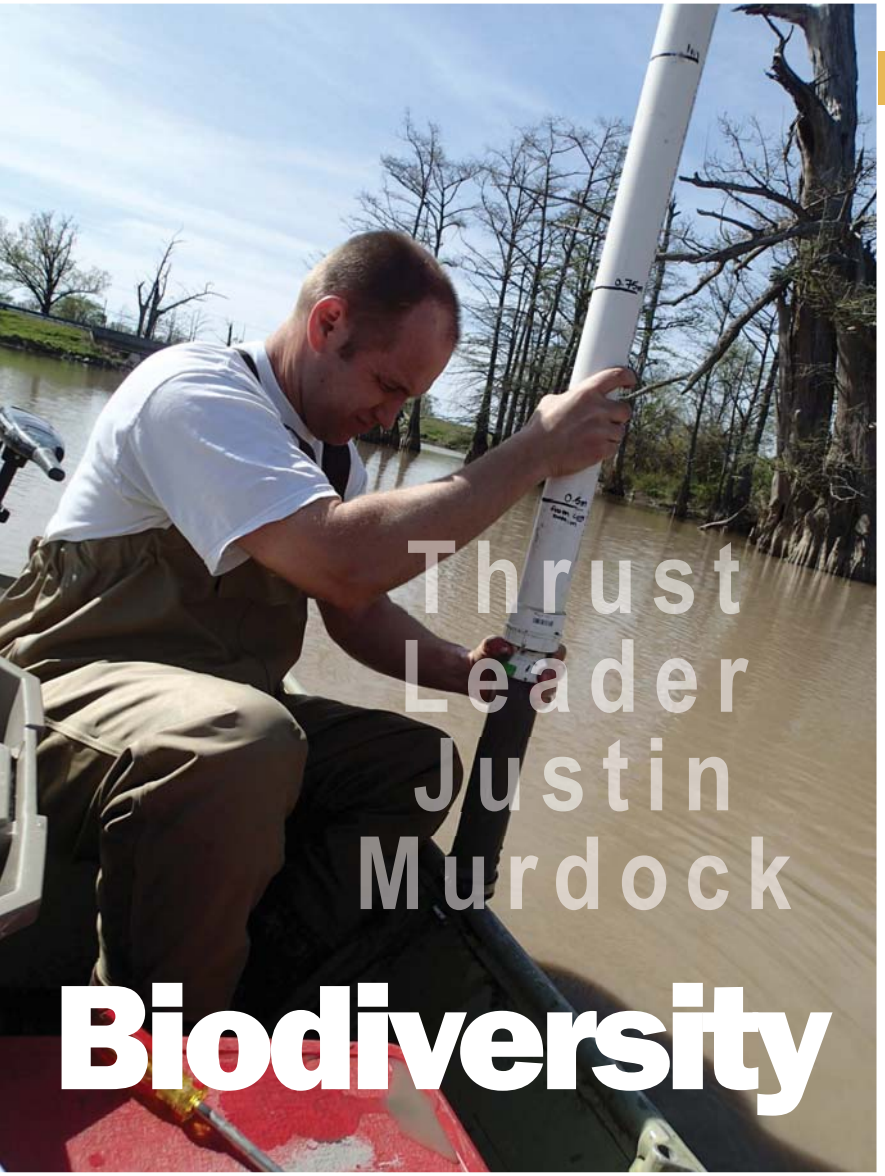
- Tracking sources of nitrogen pollution from highway stormwater runoff (Tania Datta and Alfred Kalyanapu, Assoc. Prof. Water Center): Working in collaboration with the Tennessee Department of Transportation, this project investigates the contributions of atmospheric deposition and decaying vegetation on increased nitrate and organic nitrogen loads in stormwater runoff.

- Managing water quality of the Falling Water River watershed using a watershed approach (Tania Datta and Alfred Kalyanapu):
  This stakeholder-driven undertaking attempts to solve water quality impairment issues in a local watershed by integrating science into regulatory decision-making.

- Determining anthorpogenic impacts on karst aquifer water quality of City Lake Springs, Cookeville using a geochemical approach (Joseph Asante, Asst. Prof. Earth Sciences):
  This project involves collecting spring water samples from the City Lake of Cookeville, TN, to compare the natural aqueous geochemistry of the rock-water interactions in the karst aquifer to the chemistry of water samples from springs at the site. It was determined that the water quality is derived from weathering calcite, dolomite, and gypsum in the karst system, but elevated levels of sodium and chlorine suggest impact from anthropogenic activities or atmospheric deposition on soil.

Faculty in Water Security and Sustainability

- Dr. Laura Arias-Chavez, Chemical Engineering
- Dr. Joseph Asante, Earth Sciences
- Dr. Tania Datta, Water Center
- Mr. Dan Dodson, Water Center
- Dr. Alfred Kalyanapu, Civil and Environmental Engineering
- Dr. Justin Murdock, Biology



Biodiversity

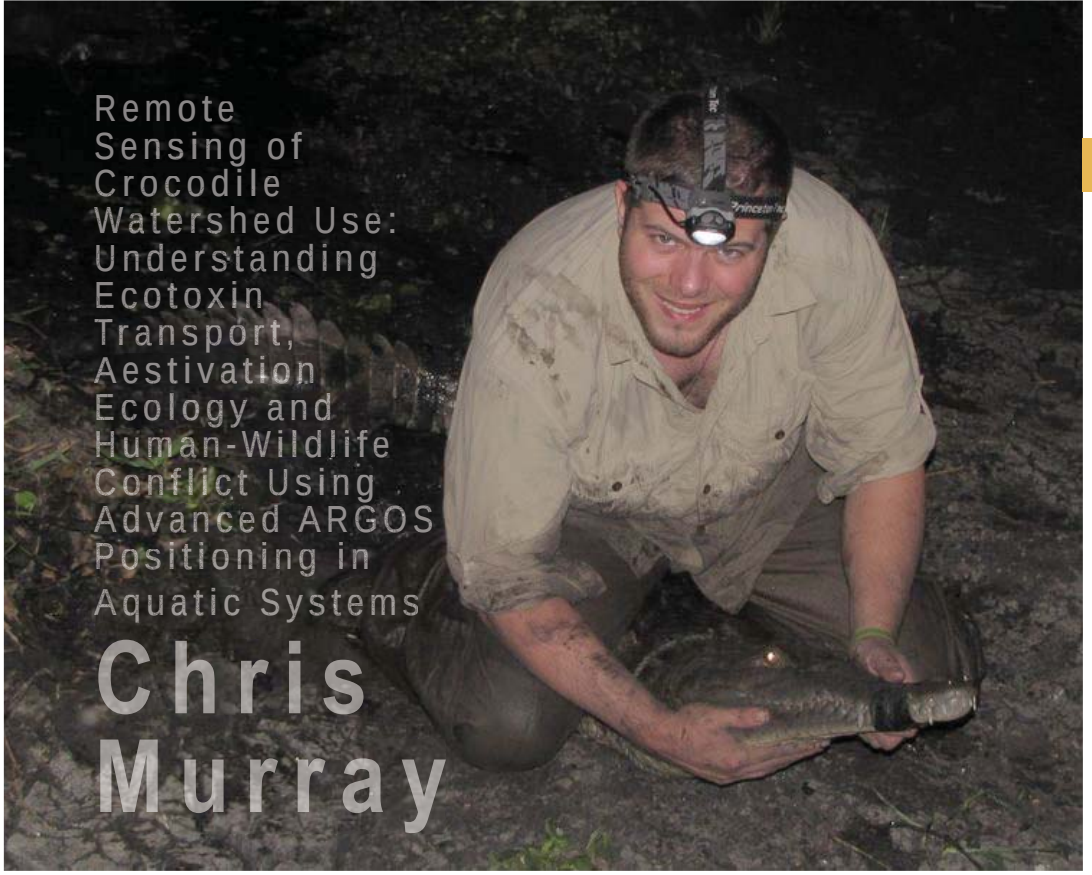
The overarching objective of this area is to enable basic and applied research related to aquatic ecosystem conservation and management. Current research interests among faculty members in this area are diverse, mainly covering endangered, invasive, and game species management, food webs, biogeochemistry, climate change impacts, and ecosystem services. The biological groups of interest include bacteria, algae, macroinvertebrates, fishes, amphibians, reptiles, waterfowl, and bats, as well as genetic-based detection and conservation strategies for many of these groups. Fourteen faculty in the Department of Biology and USGS Cooperative Fisheries Unit are active in this area.

Some current conservation projects include:

- Genetic-based detection and conservation strategies for Pygmy Madtom, Valley Flame crayfish, and Barrens Topminnow (Carla Hurt, Asst. Prof. Biology, and Hayden Mattingly, Prof. Biology)
- The influence of water quality and microhabitat variation on physiological stress in the Eastern Hellbender (Chris Murray, Asst. Prof. Biology)
- Reintroduction of native fishes to Great Smoky Mountains National Park (Josh Perkin, Carla Hurt, Don Walker, Asst. Profs. Biology; and Brian Leckie Asst. Prof. Agriculture)

Faculty in Biodiversity

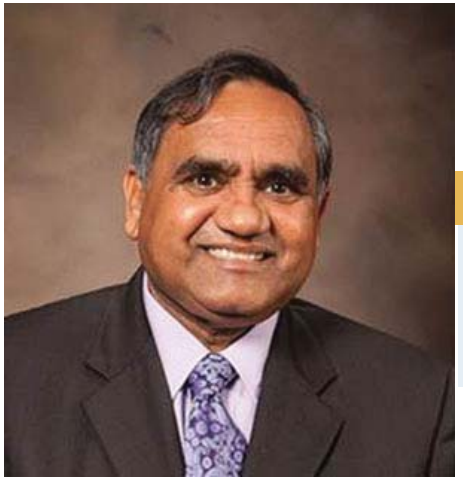
- Dr. Brian Carver, Biology
- Dr. Dan Combs, Biology
- Dr. Brad Cook, Biology
- Dr. Steve Hayslette, Biology
- Dr. Carla Hurt, Biology
- Dr. Robert Kissell, Biology
- Dr. Hayden Mattingly, Biology
- Dr. Justin Murdock, Biology
- Dr. Chris Murray, Biology
- Dr. Mark Rogers, Biology and TN Cooperative Fishery Unit
- Dr. Amanda Rosenberger, Biology and TN Cooperative Fishery Unit
- Dr. Donald Walker, Biology



Remote Sensing of Crocodile Watershed Use: Understanding Ecotoxin Transport, Aestivation Ecology and Human-Wildlife Conflict Using Advanced ARGOS Positioning in Aquatic Systems

Chris Murray

- The causative agent of snake fungal disease, *Ophidiomyces ophiodiicola* (Don Walker)
- Impact of water fluctuations and intermittency on stream communities structure and function (Don Walker, Josh Perkin, Justin Murdock, Asst. Profs. Biology)
- Effects of Asian Carp invasion on the food web of a mussel biodiversity hotspot (Mark Rogers, USGS Co-op, Justin Murdock)
- Impacts of the nuisance alga Didymosphenia geminata on stream food webs (Justin Murdock)
- Assessing what regulates the distribution of the nuisance alga *Didymosphenia geminata* (Justin Murdock)
- Development of a 3D virtual reality stream biofilm for education and research (Justin Murdock)
- Evaluation of the effects of climate change and land use on fisheries harvests in lakes (Mark Rogers)
- Status and distribution of long-tailed weasels in Arkansas (Robert Kissell, Prof. Biology)
- Culture and performance of introduced southern Appalachian brook trout in Tennessee and colonization of aquatic macroinvertebrates following pesticide treatment (Brad Cook, Prof. Biology)
- Drought influences on hypoxia and nutrient cycling in agricultural aquatic ecosystems (Justin Murdock)



Water Energy Food Nexus

Thrust Leader Bharat Soni

Water-Energy-Food Nexus With the recent emphasis on understanding the interconnections among energy, water and food, this new thrust area is still in its developmental phase.

A few projects consider various aspects of the nexus:

- Membranes at the Water–Energy Nexus (Laura Arias-Chavez, Asst. Prof. Chemical Engineering): this research strengthens and broadens the application of selective membranes to lower the environmental impact, energy cost, and water demand of the water and energy sectors. Membrane technologies are primarily used:
  (i) reverse osmosis, a mature technology that is the most energy-efficient option for desalination; and
  (ii) forward osmosis, an emerging technology that has similar selectivity to reverse osmosis but which is less prone to fouling and can be run with even less energy in select applications.

  Ongoing projects include experimental membrane fabrication work aimed at producing more intrinsically fouling-resistant membranes for both reverse osmosis and forward osmosis, and modeling work to improve understanding of transport in forward osmosis.

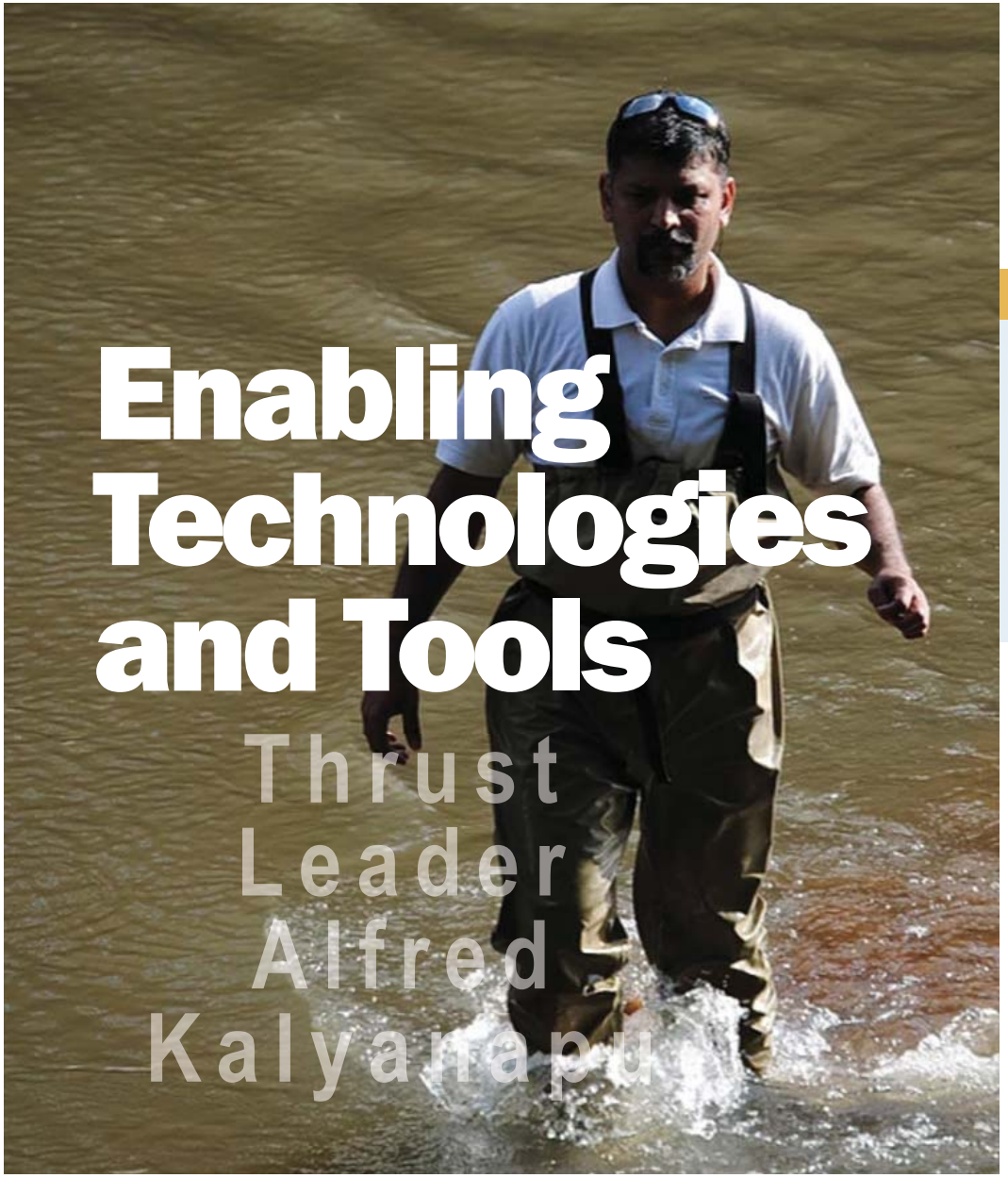
- Water–Food Nexus: Current efforts in this research area (Brian Leckie, Asst. Prof. Agriculture) include genomics applications (e.g., genotyping by sequencing) to evaluate biodiversity in water-related systems. The main project aims to breed drought-tolerant varieties through association mapping of regionally adapted germplasm, but also includes population genetic analysis to improve local fisheries. Additional efforts include evaluating gasifier produced biochar soil amendments for increased crop yields through soil improvements (e.g., water holding capacity).

Faculty in Water-Energy-Food Nexus

- Dr. Tania Datta, Water Center
- Dr. Bharat Soni, Vice President for Research and Economic Development
- Dr. Laura Arias-Chavez, Chemical Engineering
- Dr. Michael Best, Agriculture
- Dr. Brian Leckie, Agriculture
- Dr. Satish Mahajan, Center for Energy Systems Research
- Dr. Holly Stretz, Chemical Engineering

- Sensing of nutrients in surface water bodies using Raman spectroscopy (Satish Mahajan, Prof. Electrical Engineering, and Tania Datta): This project aims to develop a low-cost, easy-to-use sensor for nitrogen and phosphorus in water. Two sensing approaches are proposed. The first approach is based on Raman spectroscopy that involves shining a light on a sample and observing the spectra of bands created from the scattered light that has shifted in frequency due to the phenomena of molecular vibrations in the sample. The spectra provide what is known as the molecular fingerprint that is unique to each molecule in the sample. The second proposed sensing approach is based on Surface Plasmon Resonance (SPR) that occurs when a polarized light hits a surface at the media interface with different refractive indices. SPR techniques excite and detect collective oscillations of free electrons (surface plasmons), and the subsequent reflection is detected. At a certain incident angle (resonance angle), the plasmons are set to resonate with light, resulting in absorption of light at that angle. This creates a dark line in the reflected beam, which could indicate a change in the molecules and the binding kinetics in the sample.

- IR Fluorescent Sensor for Water-Based Agricultural Nutrients (Holly Stretz, Prof. Chemical Engineering, Chabum Lee, Asst. Prof. Mechanical Engineering, Martha Wells, Emeritus Chemistry faculty, Richard Mu, Tennessee State University): Faculty are collaborating to identify and characterize an IR fluorescent dye and nanoparticle enhancer as a report for typical agricultural nutrients in water such as phosphastes, nitrates, etc. A reporter is a nanoparticle/dye pair that can sense the nutrient and produce a fluorescent emission in the IR range compatible with a silicon-based platform.



Enabling Technologies and Tools

Thrust Leader Alfred Kalyanapu

Enabling Technologies and Tools Current research in this area is focused on Geographic Information Systems (GIS) and Remote Sensing (RS) applications, Virtual Reality (VR), modeling and simulation in watershed sciences and computational hydrology and water resources engineering. Currently, researchers from various disciplines including water resources and environmental engineering, biology, agriculture and computer sciences are active in the research focus area of enabling technologies and tools.

Current projects in VR, GIS & RS applications include:

- Implementing web-based ArcGIS application for the Falling Water River Watershed (Tania Datta and Alfred Kalyanapu)
- Remote sensing of crocodile watershed use: Understanding ecotoxin transport, aestivation ecology and human-wildlife conflict using advanced ARGOS positioning in aquatic systems (Chris Murray, Asst. Prof. Biology)
- Virtual reality applications: TTU's iCube (www.ttuicube.com) has provided virtual reality applications that can lead to improved retention and recall, simplification of complex problems and situations, and facilitation of different learning styles through multimedia education and training apps.

Current projects in modeling and simulation in watershed sciences include:

- Development of Watershed Quality Index for the Falling Water River Watershed (Tania Datta and Alfred Kalyanapu)

- Increasing the resilience of agricultural production in the Tennessee and Cumberland River basins through more efficient water resource use (USDA-funded project with Alfred Kalyanapu)

Current projects in computational hydrology and water resources engineering include:

- Development of integrated DHSVM-Flood2D-GPU modeling framework for regional-scale modeling for high-resolution rapid flood risk assessment (ORNL-funded project with Alfred Kalyanapu and Sheikh Ghafoor, Assoc. Prof. Computer Science)

- The iCUBE developed the Tennessee Aquarium's free App for experiencing virtual aquatic adventures and e-sharing highlights with family and friends. The iCUBE has also developed an interactive VR tool that promotes critical thinking associated with river ecosystems. At present, this project is being expanded to include environmental ecosystems involving water-energy-food nexus.

Faculty in Enabling Technologies and Tools

- Dr. Tania Datta, Water Center and Civil and Environmental Engineering
- Dr. Sheikh Ghafoor, Computer Science
- Dr. Alfred Kalyanapu, Civil and Envrionmental Engineering
- Dr. Justin Murdock, Biology
- Dr. Chris Murray, Biology
- Mr. Kevin Liska and the iCube Staff
- Dr. Don Walker, Biology

OUTREACH

Laura Arias Chavez, assistant professor of Chemical Engineering, and her research team built a biosand filter and installed it at Monterey High School, where two biology classes (taught by Jeff Slagle) used it every day for approximately two weeks. Arias-Chavez and her team tested its performance in coliform removal alone and in combination with disinfection. About 20 students, mostly juniors, were involved.

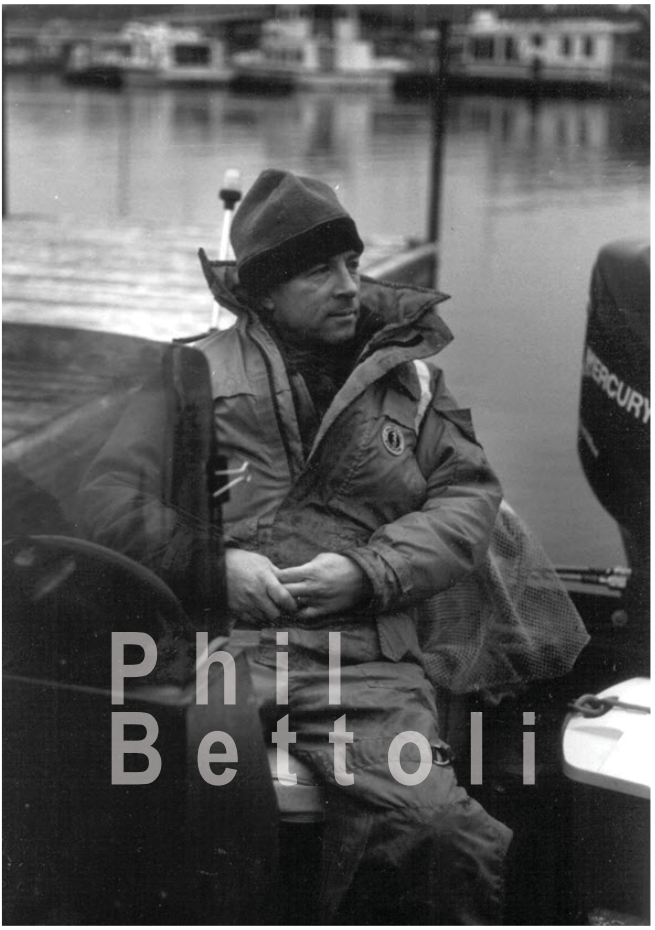
Tania Datta, assistant professor of Civil and Environmental Engineering, was the lead faculty on a urine-diverted composting latrine build project in San Benito Poite, Belize. This project was conducted in close collaboration with the School of Nursing, where three engineering students; three nursing students; Melissa Geist, nursing professor; and Datta travelled to a remote Mayan village in Southern Belize to train the local community on designing and building a model composting latrine.

Datta also volunteered in leading an activity at the 2016 Engineering a Future event, which is organized at TTU and is designed to inspire middle school girls to pursue STEM-related career paths. To give the students a sample of water engineering, Datta organized an introductory presentation, highlighting the importance of water conservation and treatment and the “power” of water. This presentation was followed by a hands-on activity where students learned about water quality.

As further efforts toward community outreach, Datta participated in Trogg Sinkhole cleanup in Cookeville, TN, and assisted the City of Cookeville in collecting and assessing water samples from the City Lake.

Alfred Kalyanapu, assistant professor of Civil and Environmental Engineering, is a co-faculty advisor for the TTU Water Professionals Student Chapter and is an activity coordinator for the Engineering a Future event that promotes the pursuit of engineering careers in high school girls.

faculty SPOTLIGHT



After more than three decades of work dedicated to the wise use, conservation and management of fisheries resources, Dr. Phil Bettoli, biology professor and assistant unit leader of the U.S. Geological Survey's Tennessee Cooperative Fishery Research Unit (TCFRU), has retired. His fisheries career has produced a remarkable $5.1 million in externally funded research projects designed to help conserve sport fish, threatened and endangered species and ensure that the state's thriving fish industry is healthy and sustainable.

Bettoli has handed over all of his research projects, including work on Asian carp, to the new TCFRU leader, Dr. Mark Rogers, who came to Tennessee Tech from the Great Lakes Science Center. Dr. Amanda Rosenberg—with a background in malacology, which is the study of mollusks—is taking over the work of former TCFRU Unit Leader Dr. Jim Layzer, who retired around three years ago and worked closely with Bettoli to preserve the state's aquatic populations for almost 15 years.

Even though he's officially retired, Bettoli says he's still been very busy since his official retirement in 2016, as he remains a part-time employee with the university. "I've submitted two papers that were accepted this year and am working on two book chapters. I'm also helping train the new Unit leaders and their students."

Throughout his career, Bettoli mentored 59 master's students, which is a figure well above the average numbers of students advised by most faculty. He attributes this to the Water Center's support for graduate students when he first came on board.

"I took full advantage of the opportunities I had at that time to work with many students," Bettoli said. A thriving fisheries research program that graduated students ready to work in the field was the result of these opportunities.

Bettoli is proud that a majority of the students produced by the TCFRU and the Water Center have gone on to be managers of wildlife areas like the Smoky Mountain streams and other aquatic habitats throughout the state and nation.

"I can write thousands of papers," Bettoli said, "but to produce that many people who can go on to carry out our work in the real world is the main way to promote fisheries research."

Frank Fiss, a former staff member of the TCFRU, is now Chief of Fisheries at the Tennessee Wildlife Resources Agency. Bobby Wilson is the Assistant Director of TWRA. Jason Henegar is the Assistant Fisheries Chief of TWRA, and Tim Churchill is the Chief of the Real Estate Division at TWRA. Wilson, Henegar, and Churchill are also all products of the TCFRU and/or Water Center.

faculty SPOTLIGHT

Dr. Phil Bettoli earned the Lifetime Achievement Award during the U.S. Geological Survey Tennessee Cooperative Fishery Research Unit meeting held at TTU in September 2016.

Map of locations where Bettoli's former students now work.

"I'm the luckiest guy in the world to have gotten to work with this quality of students just starting out with the TCFRU and Water Center," Bettoli said. "I have been so supported by TTU and the Water Center, and without the Center and the Department of Biology, I couldn't have achieved half of what I've done. I've gotten to experience some of the most collegial relationships in the country while working at TTU."

But Bettoli also says that his work has not been without its challenges. "It's always hard trying to juggle people and budgets, especially when you have to ensure that students maintain funding for the two to three years required to earn their degrees."

And managing federal, state and university obligations was also challenging. Bettoli was an employee of the federal TCFRU but also maintained status as a Tennessee Tech faculty.

Bettoli says that there are 42 other cooperatives like the TCFRU around the country. Missouri was the first to be developed. The co-ops bring federal resources and expertise to help universities and states meet challenges. All the staff in the co-ops are composed of Ph.D. holders who maintain all the rights and privileges of tenured faculty within their respective university.

As a faculty member, Bettoli—who earned his doctorate in wildlife and fisheries science from Texas A&M, his master's in biology from Tennessee Tech, and his bachelor's in wildlife ecology from the University of Maine—published 83 peer-reviewed papers and book chapters and 58 final reports. He was also a co-winner of Tennessee Tech's prestigious Donald Caplenor Outstanding Faculty Research Award in 2007.

But in 2013, Bettoli achieved what he feels was the culmination of his extensive career. He was inducted into the American Fisheries Society's Fisheries Management Section's Hall of Excellence. His plaque is on display in Nebraska.

On winning this honor, Bettoli remarked, "My motto is to surround yourself with people who bring out the best in you and that you bring out the best in them."

Bettoli says that there is still a lot of external funding available in fisheries research.

"The commercial and sport fishing industry in Tennessee is very viable," Bettoli said. "There's a lot of work to be done, and the TCFRU is positioned in good hands to carry on the research we've already established."

student PROJECTS

Student Support

This year, the Water Center supported 18 graduate students in a range of internally and externally funded projects. The following list provides information on those students and their advisors.

o	Thomas Boersig	Advisor: Hayden Mattingly (Environmental Studies/Biology)
o	Nowfel Bhuyian	Advisor: Alfred Kalyanapu (Civil and Environmental Engineering)
o	Samuel Dotson	Advisor: Joseph Asante (Earth Sciences)
o	Tigstu Dullo	Advisor: Alfred Kalyanapu (Civil and Environmental Engineering)
o	Savannah Fernholz	Advisor: Mark Rogers (Tennessee Cooperative Fishery Research Unit)
o	Stanton Hornsby	Advisor: Laura Arias-Chavez (Chemical Engineering)
o	Douglas Huttes	Advisor: Laura Arias-Chavez (Chemical Engineering)
o	Suzanne Johnston	Advisor: Robert Kissell (Biology)
o	Phillip Kacmar	Advisor: Mark Rogers (Tennessee Cooperative Fishery Research Unit)
o	Eric Malone	Advisor: Josh Perkin (Biology)
o	Justin Medley	Advisor: Sheikh Ghafoor (Computer Science)
o	Melissa Moffet	Advisor: Tania Datta (Civil and Environmental Engineering)
o	Juliet Ohemeng-Ntiamoah	Advisor: Tania Datta (Civil and Environmental Engineering)
o	Xi Zhe Ong	Advisor: Laura Arias-Chavez (Chemical Engineering)
o	Robert Paine	Advisor: Carla Hurt (Biology)
o	Piyush Ranjan	Advisor: Laura Arias-Chavez (Chemical Engineering)
o	Corinne Wellemeyer	Advisor: Josh Perkin (Biology)
o	Ryan Wigner	Advisor: Tania Datta (Civil and Environmental Engineering)

student PROJECTS

Linking complex organic feedstock characteristics to microbial metabolic activities in anaerobic codigesters

Juliet Ohemeng-Ntiamoah (Advisor: Tania Datta)

Department of Civil and Environmental Engineering

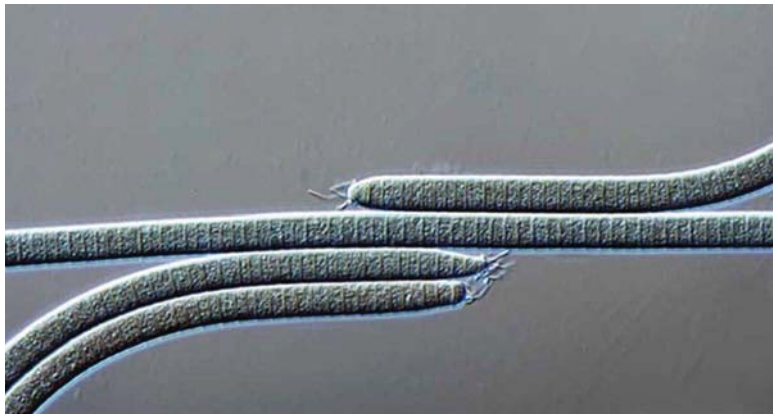
Anaerobic codigestion is the process of adding supplemental feedstocks to an anaerobic digestion system to augment biogas production. Though codigestion results in higher biogas yields, complex and variable feedstock characteristics often inhibit key microbial communities from functioning effectively, resulting in operational problems and decreased biogas production. This is one of the main barriers to this technology. In spite of this, very few studies have delved into investigating the metabolic pathways upon which this biotechnology depends. The overall goal of the study is to understand the effects of feedstock characteristics on "healthy" metabolic pathways of key microbial communities in lab-scale anaerobic codigesters. It is anticipated that at the end of the research, the relationship between feedstock characteristics and microbial metabolic pathways will be well established and the knowledge will enhance the optimum operation of anaerobic digesters.

A look into the microbial communities of three wastewater treatment facilities in Tennessee during different phases of optimization for nutrient removal

Grace McClellan (Advisor: Tania Datta)

Department of Civil and Environmental Engineering

Researchers are investigating the microbial community responsible for nutrient removal of wastewater. They are tracking the changes in microbial community structure as wastewater treatment facilities undergo operational changes.



Algae used for reference in the simulation.

Biofilm Project

Justin Medley (Advisor: Sheikh Ghafoor)

Department of Computer Science

The iCube is working with Dr. Murdock from TTU's Department of Biology and Water Center biodiversity thrust to apply virtual reality technology to stream biofilms. Biofilms consist of bacteria, algae, fungi, and many other microorganisms that grow on most every surface on stream bottoms. This project aims to excite biology students and inform the general public about the importance of these biofilms in maintaining the health of the stream. The iCube is using 2D and 3D images of various algae and other microscopic organisms in stream biofilms provided by Dr. Murdock to create 3D virtual models that allow viewers to examine biofilms with Oculus Rift headsets. Viewers shrink down to the size of algae to explore a biofilm and learn about the organisms that make up this complex microscopic community. The information for the experiential learning component of this simulation is being supplied by Justin Medley, an intern at the iCube with a background in environmental science and a master's degree in professional science, and who is earning his doctorate in computer science at TTU.

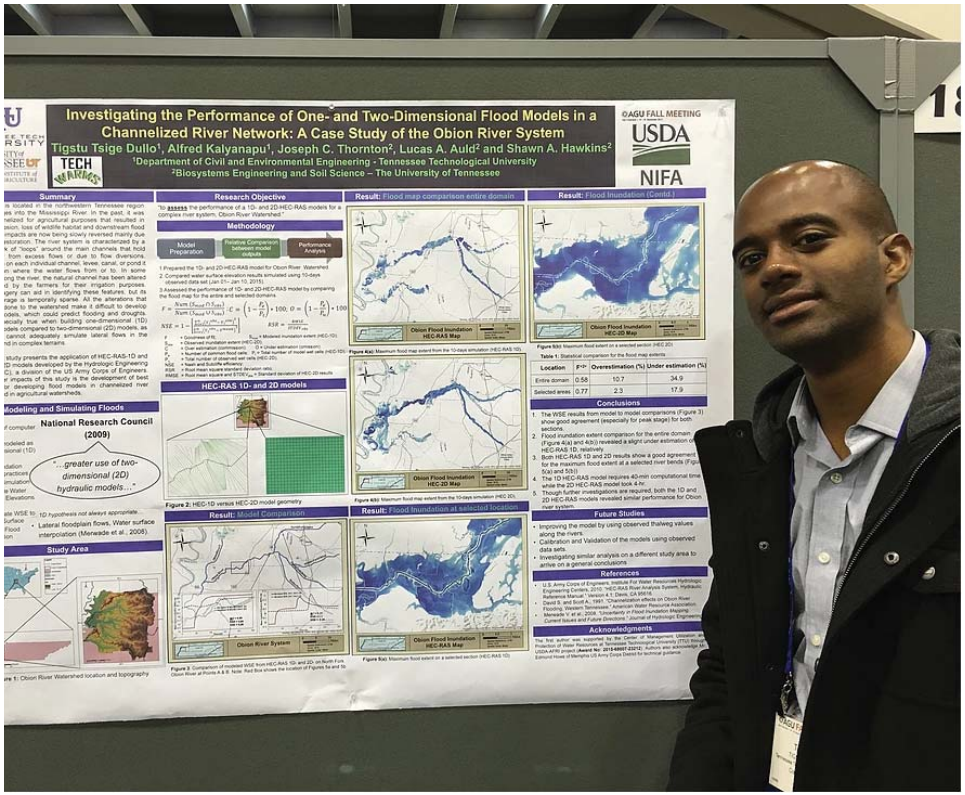
Assessing Florida largemouth bass *(Micropterus floridanus)* genetic introgression by tournament sampling and electrofishing in Chickamauga Lake, Tennessee

Phillip Kacmar (Advisor: Mark Rogers)

Department of Biology

The genus *Micropterus*, or black basses, were one of the most targeted fished species in the United States in 2010 with 10.6 million anglers spending 171 million days fishing for them. Since 1802, black bass have been separated into nine different species and multiple subspecies, including splitting the Florida bass subspecies from the northern largemouth bass. Due to the larger maximum size of Florida bass, they are being released throughout the southern United States. Tennessee began stocking Florida bass into Chickamauga Lake in 2000. Since stocking Florida bass into a Tennessee reservoir is relatively new, constant monitoring is required to determine the success of the stocking program. The objectives of this study are to: (1) determine if the genetics in tournament-caught bass are similar to electrofishing-sampled bass, (2) assess if bass sampled at different times of the year using both sampling techniques are different genetically, (3) observe if Florida bass are longer and heavier than other bass subspecies in the reservoir, and (4) track the summer movement of bass to see if nearshore bass are genetically different than those in deep water.

student PROJECTS



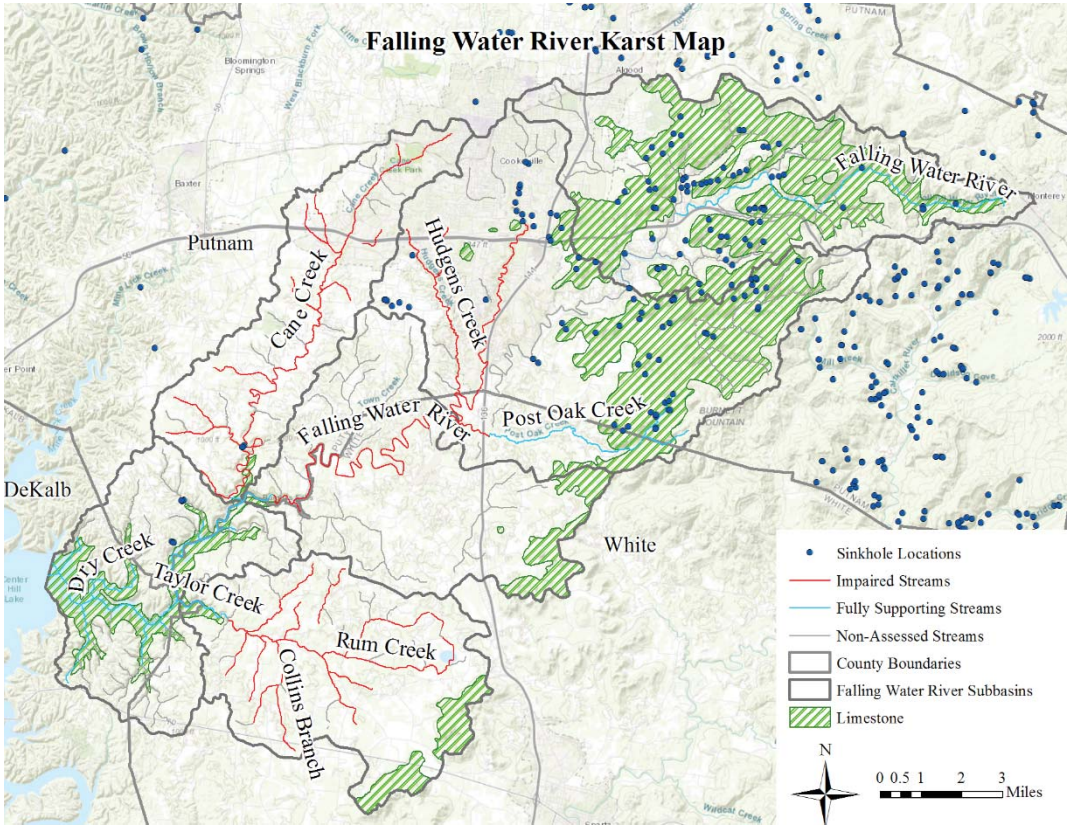
Evaluating the impacts of change in extreme events on design floods, critical energy infrastructures, and floodplain regulation standards

Tigstu Dullo (Advisor: Alfred Kalyanapu)

Department of Civil and Environmental Engineering

Flood magnitudes and frequencies will very likely increase in most regions mainly because of increased precipitation intensity and variability. Consequently, there will be a potential increase in disastrous effects of flooding in terms of loss of life, critical infrastructure damage and economic impacts. Future projections provided by climate models indicate an increase in the magnitude and frequency of rainfall extremes in most regions. Therefore, the researchers are considering non-stationarity of hydrologic records to incorporate the change in extreme events. The objective of the research is to investigate the impacts of change in extreme events from the perspective of design flood estimation, critical energy infrastructure vulnerability, and flood-plain regulation standards. The outcomes of the research will be site-specific design temporal rainfall distributions, improved quantification of the vulnerability of critical energy infrastructure to flood exposure, and a new understanding of floodplain regulation standards set by FFRMS. The proposed study will provide city planners and flood risk managers additional knowledge in understanding floods in a changing climate.

student PROJECTS

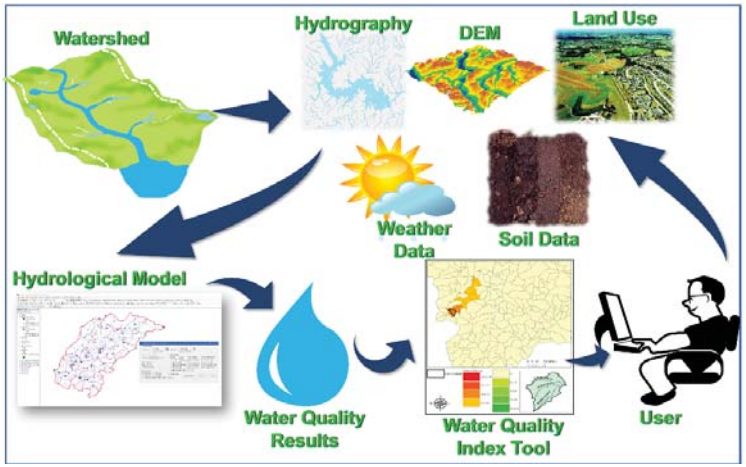


Water Quality Index tool for Falling Water River watershed

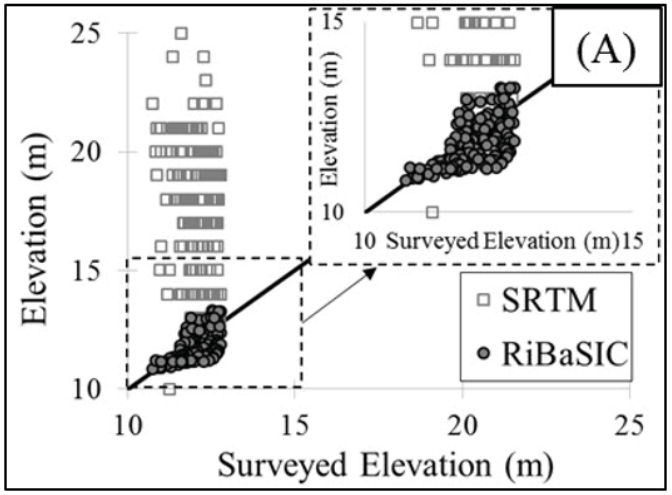
Christine L. Guy-Baker (Advisor: Tania Datta)

Department of Civil and Environmental Engineering

The researchers are developing a Water Quality Index (WQI) tool for Falling Water River watershed. This watershed begins just west of Monterey at the edge of the Cumberland Plateau and traverses the Eastern Highland Rim before joining with the Caney Fork River. Many sinkholes, caves, sinking streams, and springs occur in Falling Water River that will make development of a hydrologic model difficult. After development, this tool will allow city planners to see the impacts of land development on water quality across the Falling Water River watershed.



student PROJECTS

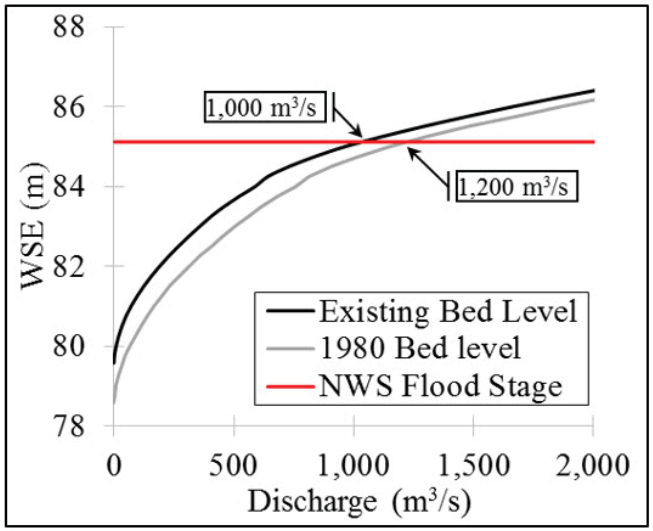


Assessing temporal uncertainty in a Global DEM due to river planform shifting and its impact on flood modeling

Md N M Bhuyian (Advisor: Alfred Kalyanapu)

Department of Civil and Environmental Engineering

DEM used as a source of terrain data plays a key role in flood modeling. They are especially useful for large, remote and data-poor areas. The degree of DEM error varies by source, spatial resolution, and vertical accuracy. Additionally, a DEM is a static data set that represents the topography corresponding to data acquisition time. However, the topography is not static in long-term and it is more dynamic near water bodies such as rivers. It is often exhibited via activity in river morphology. Change in river morphology alters the channel planform and conveyance hence it is of special interest in flood modeling. It is more critical for data-poor areas where users are dependent upon less accurate and aging global DEMs. River planform represented in these DEMs are often outdated and hence may not be appropriate for simulating recent hydrologic events (i.e., floods). Therefore, the objective of this research was to devise an algorithm to produce synthetic bathymetry relevant to planform of a given time for data-poor regions and demonstrate the impact of planform shifting on flood modeling. A proposed algorithm named as River Bathymetry via Satellite Image Compilation (RiBaSIC) could produce synthetic bathymetry via satellite images and observed water surface elevation. It was also found that planform shifting significantly increases flood vulnerability to people living next to river banks at global scale.



Assessing the increase of flood risk in a morphologically active river -- a case study in the Obion River

Md N M Bhuyian (Advisor: Alfred Kalyanapu)

Department of Civil and Environmental Engineering

The Obion River watershed is located in North-West Tennessee. Since 1980, annual lowest water level (LWL) decreased along the upstream forks and increased slong the main stem (from the confluence at Rives to Bogota). This phenomenon could be manifested by bed level erosion on upstream forks and sedimentation on the main stem because no major hydrologic change was reported. It should change the river conveyance in individual reaches and decrease longitudinal slope, causing a change in flood stage for a given discharge. Therefore, the objective of this study was to find the increased flood risk due to bed level changes in the Obion River. An algorithm to predict river bed level (Slope Adjusted Mean Bed Level Elevation) was developed assuming bed level change proportional to LWL change. It was found that the existing discharge corresponding to National Weather Service (NWS) flood stage is 20% less than that of 1980. Additionally, the occurance of flood flow corresponding to existing bed level is 48% higher than that of 1980.

Comparing Assembly Processes for Multimetric Indices of Biotic Integrity

Corinne Wellemeyer (Advisor: Josh Perkin)

Department of Biology

Anthropogenic alterations to global ecosystems necessitate management action to conserve or restore biodiversity and ecosystem services. A major advancement in ecosystem management was the development of multimetric indices of biotic integrity (MMIBI) used to guide development of, and measure progress towards, restoration goals. Despite considerable refinement of MMIBI applications over the past three decades, a central challenge remains concerning the method of selecting ecological indicators for inclusion in MMIBI. The research team quantitatively compared MMIBI metric assembly processes across four sub-regions for fish assemblages in western Tennessee to assess relative performance of three metric selection approaches. Metric selection methods assessed included “filter gradient” using a multi-step approach to filter candidate metrics down to only the most reproducible and responsive, “indirect gradient” using a correlative unconstrained ordination approach, and “direct gradient” involving an automated constrained ordination approach. For each method, the research team calculated MMIBI using the selected metrics and compared their precision (i.e., stability across multiple samples), responsiveness (i.e., discrimination between most- and lest-altered sites), and sensitivity (i.e., ability to detect landscape alterations). The team found metric selection using the filter gradient approach produced MMIBI that were most responsive across all four sub-regions, while the indirect gradient approach produced the most sensitive and precise MMIBI for three of four sub-regions. The direct gradient metric selection approach produced the most sensitive MMIBI only for a single sub-region with a relatively short gradient in landscape alterations. The results reveal a tradeoff between filter and indirect gradient selection methods in which filter gradient metric selection provides high MMIBI responsiveness, but at the cost of increased number of steps and reduced precision and sensitivity. The “middle of the road”, indirect gradient metric selection approach produced precise and sensitive MMIBI, but at the cost of reduced responsiveness. These findings highlight the necessity to pair well-developed ecosystem management goals with MMIBI application, and provide a road map for the most appropriate assembly process for managers developing MMIBI. For example, identification of least- and most-altered sites might best be accomplished with MMIBI developed using the filter gradient approach, but assessing the factors contributing to alteration and precisely measuring progress toward restoration endpoints might best be accomplished with MMIBI developed using the indirect gradient approach. Restoration and management actions guided by MMIBI will become increasingly prevalent with increased future alteration to global ecosystems, and this work provides important insight into how technological and quantitative advances will improve application of ecological indicators.

Tracking the Sources of Nitrogen Pollutants in Tennessee Department of Transportation MS4 Stormwater Discharges

Melissa Moffet and Ryan Wigner (Advisor: Tania Datta)

Department of Civil and Environmental Engineering

Increased stormwater runoff due to rapid urbanization and changing precipitation patterns is a growing concern in the United States. Although stormwater can be a source of pollutants, nutrients (i.e., nitrogen and phosphorus) are of particular interest, because land-use changes, conventional agricultural practices and industrial activities have increased their export from the atmosphere and soils to receiving surface waterbodies.

Tennessee's waterbodies are not immune to nutrient pollution. According to the 2014 303(d) list published by the Tennessee Department of Environment and Conservation, approximately 2,000 miles of streams are impaired due to the presence of excess nutrients. The Tennessee Department of Transportation's (TDOT) stormwater runoff from state roads and interstate highways is often listed as one of the potential sources of nutrients to these streams.

Two potential sources of increased levels of NO2- +NO3- and TKN to TDOT MS4 have been proposed as (1) atmospheric deposition of nitrates and (2) organic nitrogen release from decaying vegetation.

To complete this objective, rainwater and stormwater samples are being collected in three locations with varying land uses throughout the state, and weather data is being collected. Water quality analysis is being completed to determine the contribution of atmospheric deposition of nitrates and vegetation decay to the stormwater runoff concentration of nitrates. This project helps fill the knowledge gap of how atmospheric deposition is contributing to nitrogen pollution in Tennessee's waterways, which will in turn help determine how to treat the issue of nitrogen pollution more effectively.

Robert Paine (Advisor: Carla Hurt)

Department of Biology

Detection and monitoring rare species present unique challenges for researchers. The accuracy and effectiveness of traditional sampling methods, such as seining, electrofishing, and trapping, can be hindered by many biological and environmental factors. Furthermore, these collection methods can harm both target and non-target species. The Pygmy Madtom *(Noturus stanauli)* is a federally endangered, freshwater catfish endemic to Tennessee. The objective of this project is to determine if environmental DNA (eDNA) sampling, the process of identifying organisms from cells or small pieces of tissue floating in the water, is a viable tool for monitoring this rare species. The research team is designing an assay that can detect DNA from filtered water samples to survey multiple sites along the Duck and Clinch rivers. Additionally, a next-generation sequencing (NGS) assay that detects all DNA in a water sample is being designed and compared to the more traditional single species qPCR protocol to assess the sensitivity of the two molecular protocols. Integrity of Biotic Index (IBI) data, obtained from the Tennessee Wildlife Resources Agency, will be examined and compared to molecular protocols to assess the sensitivity and cost-efficiency between traditional and molecular protocols to identify rare species habitat requirements. These objectives will not only develop a protocol that management agencies can add to their arsenal of monitoring tools, but will also potentially eliminate unnecessary costs. The research team's NGS protocol will also provide a community-level monitoring tool that can be used by other state agencies to sample for rare species that co-occur in multiple states.

Pygmy Madtom, Noturus stanauli, captured during an Index of Biotic Integrity (IBI) sampling event with Tennessee Valley Authority at Hite Ford, Duck River, TN. Date: 07/21/2016. Total Length: 34mm.

Relative Densities of Bigheaded Carp in the Tennessee and Cumberland Rivers

Savannah Fernholz (Advisor: Mark Rogers)

Department of Biology

Bighead carp *(Hypophthalmichthys nobilis)* and silver carp *(H. molitrix)* (also referred to collectively as bigheaded carp) are native to eastern Asia and have been introduced across the globe. Since their introduction, bigheaded carp biomass and abundance have rapidly increased across the United States. Bigheaded carp are thought to be a direct competitor of native fish, and their presence has been found to decrease the condition of native planktivores including paddlefish, bigmouth buffalo, and gizzard shad. Bigheaded carp may also be responsible for decreasing food availability to many other species by decreasing zooplankton abundance and shifting plankton communities toward smaller individuals and species. In addition to the threats of bigheaded carp to ecosystems, the jumping response of silver carp to physical stimuli poses a risk to recreational boaters and anglers. The concerns regarding bigheaded carp in the United States continue to grow as their distribution throughout North America expands. The purpose of the project is to assess relative densities of bigheaded carp in reservoirs on the Tennessee and Cumberland rivers, as well as assess population characteristics such as size and age structure, condition, and fecundity.

Determining Anthropogenic Impacts on Karst Aquifer Water Quality of City Lake Springs, Cookeville Using a Geochemical Approach

Drake McDonald and Ben Herrmann (Advisor: Joseph Asante)

Department of Earth Sciences

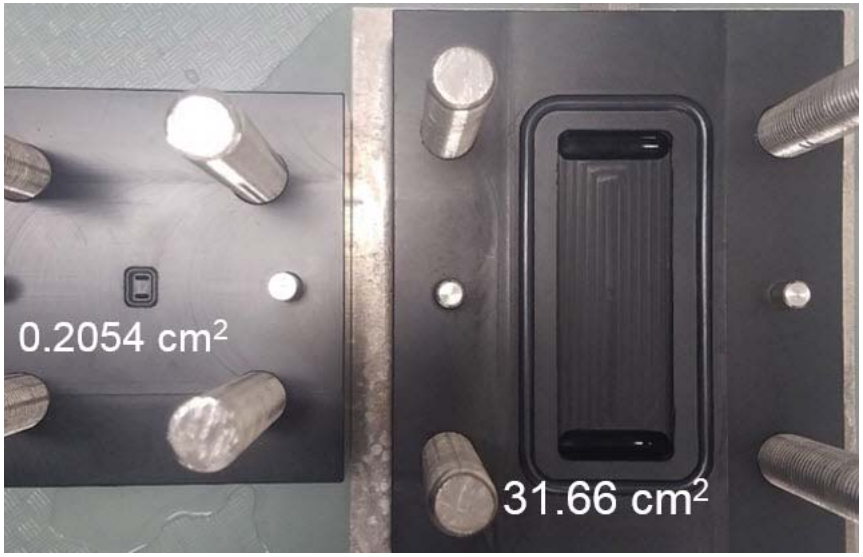
Three springs' water samples were collected between October 25 and November 20 in City Lake Natural Area of Cookeville, TN. Major ion chemistry and trace elements in the water samples collected were measured at the laboratory of the TTU Water Center to infer controlling geochemical processes. A geochemical-oriented approach was used by comparing the natural aqueous geochemistry of rock-water interactions in the karst aquifer to the chemistry of water samples from springs at the site. Concentration ratios were plotted and used to interpret geochemical processes affecting the springs' water quality. Further, the results indicate the water quality is dervied from natural geochemical processes by weathering calcite, dolomite, and gypsum in the karst system, but elevated levels of sodium and chlorine suggest impact from anthropogenic activities or atmospheric deposition on soil. The elevated sodium and chlorine ions need to be further researched. This group of springs are important sources of water to City Lake, a good place for fishing catfish, bass, and bream and for kayaking.

Separation of Inorganic Components from Industrial Wastewater Via a Hybrid Forward Osmosis – Reverse Osmosis System

Douglas Huttes and Xi Zhe Ong (Advisor: Laura Arias-Chavez)

Department of Chemical Engineering

Driven by increasing need for sustainable water and energy, new technologies are being developed to provide these critical resources without waste. Renewable bio-feedstocks can be pyrolyzed to produce energy along with a single waste stream: wastewater containing residual hydrocarbons and inorganics from the energy production step. Here, the research team assesses the potential for a hybrid forward osmosis (FO) - reverse osmosis (RO) system to reclaim all inorganic components of this complex wastewater. FO performs the first separation while RO regenerates the FO draw solution. This dual membrane configuration provides two key advantages. First, the FO membrane protects the more fouling-prone RO membrane. Second, two selective membrane barriers ensure the quality of the RO permeate. Transport through each of these membranes can be customized by independently adjusting the pH of both the feed (wastewater) and the draw solution. By exploiting the pH-dependency of speciation for different contaminants (e.g., ammonia and cyanide), wastewater components can be sequestered in different parts of the hybrid system to achieve optimal fractionation. The data from this project support the potential feasibility of fractionating inorganic species at different membrane stages through adjustment of pH. Preliminary results suggest that the FO-RO hybrid system could be an effective process for reclamation of industrial wastewater.



Variability in Morphology of Polyamide Active Layers for Thin Film Composite Membranes

Stanton Hornsby (Advisor: Laura Arias-Chavez)

Department of Chemical Engineering

The polyamide active layer of thin film composite membranes critically influences performance in reverse osmosis, forward osmosis, and pressure retarded osmosis. Polyamide layer roughness is known to strongly influence fouling propensity, and its thickness has an effect on perm-selectivity. Recent research by several groups has sought to further investigate relationships between polyamide structure and performance. These studies almost exclusively characterize structure using techniques (e.g., scanning electron microscopy (SEM), atomic force microscopy, and water contact angle) that obtain a "representative" figure by averaging a number of data points measured on randomly selected locations. The research team directly quantifies the variability of polyamide morphology across larger areas (~0.1 – 1 cm^2), using SEM to acquire low and high magnification images of the polyamide surface. Low magnification micrographs are stitched together to give a continuous view of entire membrane coupons. ImageJ thresholds these composite images according to shades of gray in order to calculate the area associated with each morphology. High magnification SEM is used to confirm that morphology is consistent across regions that appear as the same shade of gray. In a commercial reverse osmosis polyamide membrane (DOW SW30HR), 5-20% of the total area has a relatively smooth morphology, demonstrating significant variability. With further development, these methods will facilitate a better characterization of polyamide morphology, which can be more powerfully utilized in studies of structure – performance relationships.

Organic Transport and Fouling in Forward Osmosis Separation of Industrial Wastewater

Xi Zhe Ong and Douglas Huttes (Advisor: Laura Arias-Chavez)

Department of Chemical Engineering

Fully reclaiming industrial wastewater instead of sequestering or degrading its components could broadly enhance sustainability across society. These wastewaters can be challenging to separate due to their complex composition and tendency to foul membranes, especially when the wastewater contains high concentrations of hydrocarbons. Forward osmosis (FO) has the potential to avoid severe fouling while also being highly selective, making it a promising candidate for industrial wastewater reclamation. The research team presents a preliminary assessment of a hybrid FO-RO system for reclaiming industrial wastewater. This system reclaims water, hydrocarbons, and inorganics from the wastewater stream of a fast pyrolysis biomass-to-fuel production facility. To better understand the challenges and opportunities associated with separating this complex wastewater, performance was investigated as a function of pH and recovery. Sodium chloride was selected as the draw solute with regeneration provided by RO. The rejection of total organic carbon by the FO membrane exceeded 90% during these tests. These preliminary results indicate that the FO-RO hybrid system has potential for reclamation of complex wastewaters with high foulant concentrations at modest but stable water fluxes.

Water Quality Analytical Lab

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 treability 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 lab also supports the faculty's analytical requirements by testing for drinking water regulatory parameters, conventional wastewater pollutants, metals, bacteriological materials, and organics through gas chromatography and gas chromatrography-mass spectrometry techniques. The lab, managed by Dan Dodson and technician Phillip Burr, also provides analysis in trihalomethanes, haloacetic acids, and semi-volatiles and field sampling and monitoring capabilities, including providing stream velocity measurements and field-dissolved oxygen, pH, temperature, conductivity, and ORP measurements. The lab provides a GPS position log of all sampling sites.

Water Quality Analytical Lab (cont.)

This fiscal year, the lab purchased some sophisticated analytical equipment to further the faculty's research goals, including an Illumina Next-Seq, Illumina MiSeq, and an XRD. Another piece of equipment purchased was the Acoustic Doppler Profiler (ADCP) SonTek M9 RiverSurveyor (www.sontek.com/productsdetail.php?RiverSurveyor-S5-M9-14) used to measure river discharge, 3-dimensional water currents, depths, and bathymetry from a moving or stationary vessel. The system incorporates state-of-the-art instrumentation in a Windows-based software package, providing a high level accuracy without having to change measurement settings for a specific river condition. The M9 RiverSurveyor device is an upgrade to the Water Center lab's existing ADCP equipment and will be used in streams and rivers with depths ranging from 0.5 ft to 98 ft.

The Water Center lab also has access to an Illumina MiSeq and NextSeq, which have been used by both faculty and graduate students in Agriculture, Biology, Environmental Sciences and the Center. Possession and use of the sequencers have allowed faculty and students to present data at 13 conference seminars and submit two publications and four grants. An additional seven publications and one grant are currently in preparation and are expected to be submitted by 2018. The projects that the sequencers have been used for are listed below.

Ongoing Sequencer Projects

Aubree J. Hill: This project studies keystone microbial community members that associate with salamander skin and how they affect pathogenicity of chytrid fungi (*Batrachochytrium* spp.).

Jacob Leys: The project is focused on using high-throughput sequencing to study the host, geographic range, and origin of snake fungal disease in Tennessee. He was recently awarded best student presentation at the Tennessee Herpetological Society meeting for a talk titled "The Host, Geographic Range, and Environmental Corollaries of *Ophidiomyces ophiodiicola*, the Causative Agent of Snake Fungal Disease."

Isabel Papraniku: This work is titled "Spatial and Temporal Changes of Fish Communities, the Fish Microbiome, and Fungal Pathogenicity Under Conditions of Increased Human Water Use." This is a collaborative project with Dr. Josh Perkin at Texas A&M. The sequencer has been used to greatly enhance the quality of the project.

Matt Grisnik: This project is titled "The Probiotic Microbiome of Endangered Tennessee Bats: Implications for Biodiversity Conservation and Development of WNS Biocontrol Agents." The project will use the sequencer approximately nine times over the next four years of Grisnik's Ph.D. work.

Eric Malone: This project is titled "Righting the Wrong: Restoring Ecosystem Services by Prioritizing Reintroduction of Native Fishes to Lower Abrams Creek, Great Smoky Mountains National Park." The sequencer has been successfully used to evaluate several fish populations and make actionable recommendations to the National Park Service.

Water Quality Analytical Lab (cont.)

Jessi West: This project is titled "Range-Wide Population Genetic Structure of Rafinesque's Big-Eared Bat, *Corynorhinus rafinesquii*, and Southeastern Myotis, Myotis austroriparius.'" Two libraries will be sequenced over the next year of West's project.

Brian Leckie: Dr. Leckie's project is titled "Characterization of Southern Appalachian Heirloom Green Beans" and will involve sequencing three libraries over the next six months.

Grace McClellan: This project involves tracking the microbial communities responsible for nutrient removal at wastewater treatment facilities. The sequencer has been utilized in identifying the microbial populatinos from a variety of facilities and will be used multiple times throughout the time earning her Ph.D. Data collected from this project has been presented at both the 2017 Association of Environmental Engineering and Science Professors Conference and the 2017 KY/TN Water Professionals Conference. Results from this project will be used for future publications; two such manuscripts are currently being composed.

Juliet Ohemeng-Ntiamoah: This project focuses on elucidating the microbial community that drives the anaerobic co-digestion process under various operational and feed conditions. Data collected will be used for future publications.

Sequencer-Related Grants Funded and Proposals Submitted

Tennessee Wildlife Resources Agency, State Wildlife Grant. The Probiotic Microbiome of Endangered Tennessee Bats: Implications for Biodiversity Conservation and Development of WNS Biocontrol Agents. $81,000. Funded.

National Science Foundation Graduate Research Fellowship. Linking Diversity of Polyphosphate Accumulating Organisms to Improved Stability of the Enhanced Biological Phosphorus Removal Process. $138,000 for three years. Funded.

National Fish and Wildlife Foundation, Bats for the Future. Biocontrol Testing of Antifungal Bacteria and Development of a Surrogate Animal Model for White Nose Syndrome. $481,214. Pending.

United States Department of Agriculture. Genome Enabled Tools and Germplasm for Insect Pest Resistance in Squash. $300,000. Unfunded.

United States Department of Agriculture. Genetic Basis of Cucurbit Specialist Preference in Plants with Differing Domestication Biogeographies. $396,826. Pending.

United States Department of Agriculture. Building Research Capacity Through the Characterization and Improvement of Insect-Resistant Tomatoes. $300,000. Submitting 9/15/18.

Sequencer-Related Publications

Talbert, D., *Tinker, P., Crowther, T., Walker, D.M. 2017. Using Machine Learning to Understand Top-Down Effects in an Ecosystem: Opportunities, Challenges, and Lessons Learned. *Association for the Advancement of Artificial Intelligence*. Accepted.

Walker, D.M., Albecker, M.A., McCoy, M.W., Camp, C., Kelehear, C., Hill, A.J., Wooten, J.,Rheubert, J., Tionker, P.J., Talbert, D.A., Graham, S.P. Evolution of the Skin and Gut Microbiome of Slimy Salamanders (*Plethodon* spp.). Submitted to *Molecular Ecology.*

External Funding

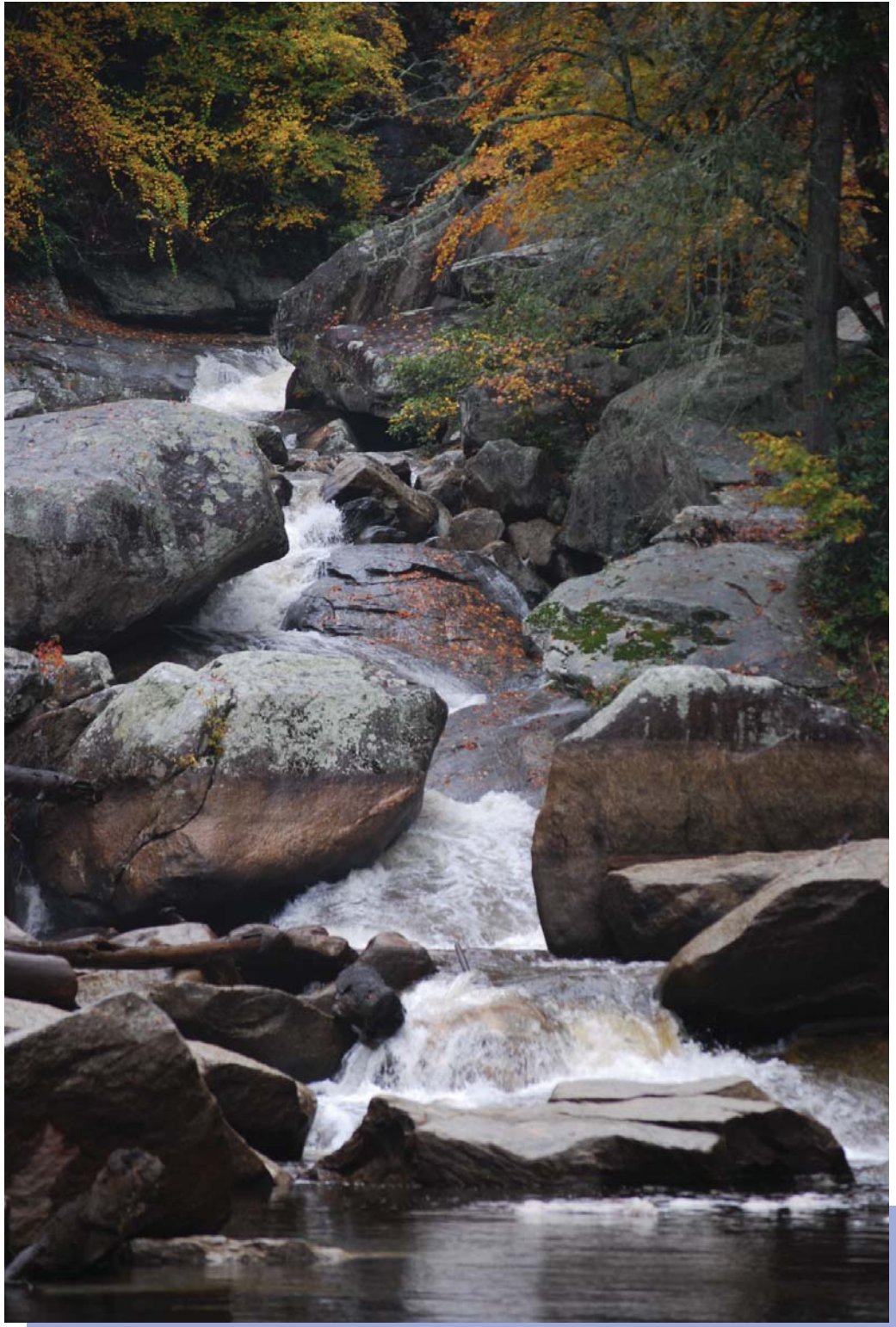
This fiscal year, the following externally funded awards were activated:

TITLE	FUNDING AGENCY	AMOUNT	PI
TN UC Writing Project	NWP	$10,000	Anthony Baker
TN UC Writing Project	TN-UC	$15,000	Anthony Baker
Asian Carp Impacts on Native Sport Fish	TWRA	$35,850	Phil Bettoli/Mark Rogers
Decision Making Models Rivers	USGS	$60,520	Phil Bettoli
Sport Fish Populations	TWRA	$70,000	Phil Bettoli/Mark Rogers
Field Test Camera Small Carnivore	TWRA	$2,996	Brian Carver
Bat Sampling	NAVFAC	$57,420	Brian Carver
EAGER	National Science Foundation (NSF)	$35,000	Laura Arias-Chavez
GOALI: Reclaiming Valuable Resources from Industrial Wastewater	NSF	$140,411	Laura Arias-Chavez
Brook Trout Propagation	TWRA	$28,000	Brad Cook
Developing a Watershed Plan for Falling Water River Watershed	UCDD-TDEC	$22,101	Tania Datta
Falling Water River Watershed	TDEC	$46,307	Tania Datta
Falling Water River Watershed	Upper Cumberland Development District (UCDD)-TDEC	$15,000	Tania Datta
Instream Monitoring (Livingston)	Livingston	$6,617	Tania Datta
Tracking Nitrogen Pollutants	ENSAFE/Tennessee Dept. of Transportation (TDOT)	$60,000	Tania Datta
Collection of Biological Data at Deer Check Stations	TWRA	$2,000	Steven Hayslette
Barrens Topminnow	U.S. Fish and Wildlife Service (USFWS)	$10,517	Carla Hurt
Increasing the Resilience of Agricultural Production/Efficient Water Resource Use	University of Tennessee	$52,685	Alfred Kalyanapu
Integrated DHSVM-Flood2D-GPU	UTB	$60,019	Alfred Kalyanapu
Survey of Long Tailed Weasel	AGFC	$22,620	Robert Kissell
Digitization TCN: Collaborative Research	UTC NSF	$6,572	Shawn Krosnick
Physaria Globosa	USFWS	$10,000	Shawn Krosnick
Pilot Wetland	Tenn. Dept. of Environment and Conservation (TDEC)	$1,000	Shawn Krosnick
Green River Dam	U.S. Geological Survey (USGS)	$20,755	James Layzer
Obey Crayfish	TWRA	$15,000	Hayden Mattingly
Pygmy Madtom	TWRA	$24,000	Hayden Mattingly
Didymo Distribution in the Southern Appalachian Mountains	National Park Service (NPS)	$9,777	Justin Murdock
Detecting Didymo with Environmental DNA (eDNA)	Gulf States Marine Fisheries Commission	$10,804	Justin Murdock
Effects of Didymo on Riverine Food Webs	GSMFC	$19,579	Justin Murdock

External Funding

This fiscal year, the following externally funded awards were activated:

TITLE	FUNDING AGENCY	AMOUNT	PI
Microbial Roles in Water Quality	U.S. Department of Agriculture	$10,000	Justin Murdock
Bio-West Statistical Analysis of the San Marcos and Comal Springs Aquatic Ecosystems	Bio-West, Inc.	$41,393	Josh Perkin
Fish Reintroduction in GSMNP	Tennessee Wildlife Resources Agency (TWRA)	$17,150	Josh Perkin
Increasing Florida's Aquatic Connectivity	SARP	$35,000	Josh Perkin
TNC: Development of Fish Index	The Nature Conservancy	$9,961	Josh Perkin
Deer Check (Federal, $1,500; and State, $500)	TWRA	$2,000	Tom Roberts
Hydrogeomorphic Guidebook	U.S. Army/ERDC	$65,534	Tom Roberts
Effects of Asian Carp Invasion on the Food Web	USFWS	$24,610	Mark Rogers
Evaluating Sport Fisheries	TWRA	$40,000	Mark Rogers
Evaluating Stocked Fisheries	TWRA	$66,000	Mark Rogers
Spawning Success of Asian Carp	TWRA	$153,083	Mark Rogers
Campbell: Inhibition of Chytridiomycosis	Campbell	$5,000	Don Walker
Lewis: Inhibition of Chytridiomycosis	Lewis	$500	Don Walker
Snake Fungal Disease Survey	TWRA	$6,200	Don Walker
TWRA: Endangered TN Bats	TWRA	$60,000	Don Walker



Faculty Awards, Service and Productivity

a. Faculty and Student Recognition and Awards

Associate Professor in Civil and Environmental Engineering Alfred Kalyanapu won the 2016 Kinslow Research Award from the TTU College of Engineering.

Undergraduate students R.A. Varner, K.E. Schubert, and J.H. Himes, advised by Laura Arias Chavez, assistant professor of Chemical Engineering, won first place in the undergraduate poster competition in the category of Chemical Engineering at the 12th Annual Student Research and Creative Inquiry Day at TTU.

Students Amy Stafford and Emily Granstaff and their advisor Biology Professor Hayden Mattingly won the Second Place Award in the Best Spatial Analysis Category for their presentation titled “Southeastern Stream Temperature Monitoring Project (STMP): Prioritizing Future Monitoring Sites in Tennessee,” presented April 2017 at the Tennessee Geographic Information Council’s Annual Conference in Knoxville, TN.

Graduate student Juliet Ohemeng-Ntiamoah, advised by Civil and Environmental Engineering Assistant Professor Tania Datta, received the Best Graduate Poster prize for her presentation at the 2016 Tennessee Water Resources Symposium. Her competitors were from other universities around Tennessee, including the University of Tennessee, Knoxville. Ohemeng-Ntiamoah also received first prize among all other posters from the Department of Civil and Environmental Engineering at TTU’s Research and Creative Inquiry Day and also earned the College of Engineering Eminence Award.

Graduate student Grace McClellan, advised by Tania Datta, won first prize at the Student Poster Competition during the 2016 Kentucky/Tennessee Water Professional Conference and also received the first prize in the graduate poster category at the 2016 Sigma Xi Student Research Conference.

Datta’s student Alexander Davis obtained the TTU Creative Inquiry Summer Experience Grant for summer research in Datta’s lab.

b. Professional and Community Outreach Activities

- Professional Services

  Associate Professor of Civil and Environmental Engineering Alfred Kalyanapu was a reviewer for the United States Geological Survey's Scientific Investigation Report, *Automated Identification of Stream-Channel Geomorphic Features from High-Resolution Digital Elevation Models in West Tennessee Watersheds*. He also served as a reviewer for the *Journal of Hydrologic Engineering*, *Journal of Hydrology*, *Environmental Modelling and Software*, and *Hydrological Processes*. Kalyanapu reviewed conference proceedings for the 2016 EWRI World Water Congress and the 2016 Tennessee American Water Resources Association (AWRA) Conference. He is the president-elect of the Tennessee Section of the AWRA and is secretary and executive committee member of the American Society of Civil Engineers' (ASCE) Computational Hydraulics Committee. Kalyanapu is a member of the Tennessee Infrastructure Report Card Committee and the ASCE Rainwater Harvesting Task Force Committee.

  Assistant Professor of Civil and Environmental Engineering Tania Datta hosted visiting scholar Ken Omori, from Yoshimasa Amano's lab at Chiba University, Japan, for three months in Fall 2016. This effort is part of a long-term research collaboration between Amano and Datta on surface water quality assessment and nutrient pollution. While visiting Datta's lab, students from Amano's research group are trained on the use of advanced instrumentation for the analysis of cyanobacteria and cyanotoxins, and on various aspects of experimental design and technical communications. This collaboration has been very fruitful and is resulting in peer-reviewed publications.

  Datta also initiated a collaborative proposal between TTU and the Technical University of the Philippines (TUP) through the USAID-STRIDE program to investigate biogas production from sugar industry waste. If funded, this project will allow TTU to host a faculty from TUP for six months to assess biomethane production potential of wastewater generated from sugar manufacturing plants. This collaboration will ultimately result in peer-reviewed publications and collaborative research projects.

Datta; Laura Arias-Chavez, assistant professor of Chemical Engineering; and Shihong Li, from Vanderbilt University's Department of Civil and Environmental Engineering, hosted the Association of Environmental Engineering and Science Professors (AEESP) Distinguished Lecturer.

As another part of Datta's scholarly efforts, she organized a workshop titled "Sustainable Wastewater Management: Pathways to Pollution Prevention and Resource Recovery," in Kolkata, India, in December 2016. The objective of the workshop was to initiate collaboration between Datta's research group and local universities on sewage treatment, resource recovery and water quality improvements of streams in India.

c. Professional Activity Summary

This year Water Center faculty published 20 journal articles, two conference proceedings articles, five technical reports and made 57 presentations.

1. Journal Articles Published

- Abegaz, B.W., Datta, T., and Mahajan, S.M. 2017. Sensor technology for the energy-water nexus — A review. *Applied Energy*. Available online www.sciencedirect.com/science/article/pii/S0306261917300429.
- Ahmadisharaf, E., Kalyanapu, A.J., Thomas, B.A., and Lillywhite, J. 2016. Application of a probabilistic framework for comparison of dam breach predication methods. *Environmental Modelling and Software Journal*, 86:248-263.
- Bhuyian, Md.N.M., and Kalyanapu, A.J. Accounting digital elevation uncertainties for flood consequence assessment. *Journal of Flood Risk Management*. DOI: 10.1111/jfr3.12293.
- Dullo, T.T., Kalyanapu, A.J., Teegavarapu, R.S.V. Evaluation of changing characteristics of temporal rainfall distribution within 24-hour duration storms and their influences on peak discharges: A case study of Asheville, North Carolina. *Journal of Hydrologic Engineering*. Accepted for publication.
- Ferrell, H., Hurt, C., and Bettoli, P. 2017. Genetic stock assessment and hatchery contributions of sauger stocked into Old Hickory Lake, Tennessee. *Southeastern Naturalist* (In press).
- Gebhard, A.E., and Perkin, J.S. Assessing riverscape-scale variation in fish life history using Banded sculpin *(Cottus*

carolinae). *Environmental Biology of Fishes* (In press).

- Gebhard, A.E., Paine, R.T.R., Hix, L.A., Johnson, T.C., Wells, W.G., Ferrell, H.N., and Perkin, J.S. 2017. Testing cross-system transferability of fish habitat associations using *Cottus carolina (Banded sculpin)*. *Southeastern Naturalist,* 16:70-86.
- Hibbett, D., Abarenkov, K., Chai, B., Crous, P., Helgason, T., Herr, J.R., Lueschow, S., O'Donnell, K., Nilsson, R.H., Oono, R., Schoch, C., Smyth, C., Walker, D.M., Andrea, P.-A., Taylor, J.W., and Geiser, D.M. 2016. Sequence based classification and identification of fungi. *Mycologia*, 108:16-30.
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- Ridgway, J., and Bettoli, P.W. Distribution, age structure, and growth of bigheaded carps in the lower Tennessee and Cumberland rivers. *Southeastern Naturalist* (Accepted for publication).
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2. Conference Articles
   - Brackins, J., and Kalyanapu, A.J. 2016. Using ADCIRC and HEC-FIA modeling to predict storm surge impact on coastal infrastructure. World Environmental and Water Resources Congress 2016: pp. 203-212. DOI: 10.1061/9780784479841.023.
   - Leys, J.E., Dunham, K.E., Oliver, J., Schiller, E.E., Rush, E.E., Kimrey, J.T., Proctor, M., Reyes, M., Mayberry, D., Alonge, N.M., Elmore, E.R., Rand, V., Stephenson, K., and Walker, D.M. August 7-12, 2016. Sneaky Sally: detection of terrestrial small-body salamander eDNA and implications for biodiversity conservation of non-aquatic amphibians. Ecological Society of America Conference, p. 145.

3. Presentations
   - Ahmadisharaf, E., Kalyanapu, A.K., and Lillywhite, J. April 11-12, 2016. A probabilistic hydrologic model to analyze the uncertainty of the design hydrograph attributes. Twenty-Fifth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Montgomery Bell State Park, Burns, TN.

- Bettoli, P.W., Scholten, G.D., and Ganus, E. 2017. Cryptic mortality in paddlefish. Annual Meeting of the Southern Division of the American Fisheries Society, Oklahoma City, OK.
- Bhuyian, Md.N.M., and Kalyanapu, A.J. April 11-12, 2016. Developing flood consequence correlation using global DEMs. Twenty-Fifth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Montgomery Bell State Park, Burns, TN.
- Brackins, J.T., and Kalyanapu, A.J. 2016. Prediction of storm surge impacts on coastal infrastructure using AD-CIRC and HEC-FIA models. Twenty-Fifth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Montgomery Bell State Park, Burns, TN.
- Curtis, W.J., Gebhard, A.E., and Perkin, J.S. 2017. The river continuum concept predicts prey community structure for an insectivorous fish. TN American Fisheries Society Meeting, Knoxville, TN.
- Dullo, T.T., Kalyanapu, A.J., and Hawkins, S.A. April 11-12, 2016. Investigating the performance of one- and two-dimensional flood models in a channelized river network: A case study of Obion River System. Twenty-Fifth Tennessee Water Resources Symposium, Tennessee Section of the American Water Resources Association, Montgomery Bell State Park, Burns, TN.
- Dullo, T.T., Kalyanapu, A.J., and Teegavarapu, R. May 22-26, 2016. Comparative evaluation of standard NRCS storm and observed rainfall distributions. 2016 World Environmental and Water Resources Congress, West Palm Beach, FL.
- Esfahani, M.R., Languri, E.M., and Arias Chavez, L.H. 2016. Combined effects of hydrodynamics and support layer geometry on internal concentration polarization in forward osmosis: A numerical study. Gordon Research Conference on Membranes: Materials and Processes, New London, NH.
- Gebhard, A.E., Perkin, J.S., Boersig, T.C., Hix, L.A., Johnson, T.C., and Knorp, N.E. 2017. Life history theory predicts long-term fish assemblage response to impoundment construction. Dakota Chapter American Fisheries Society Meeting, Jamestown, ND.
- Goans, B.J., Sealy, K.T., Olawole, W.S., and Arias-Chavez, L.H. 2017. A method for evaluating variability in perm-selectivity of polyamide thin-film composite membranes. Twelfth Annual TTU Research and Creative Inquiry Day, Cookeville, TN.
- Grisnik, M., Munfao, J., Istvanko, D., Campbell, J., Simpson, C., Thames, D., Holliday, C., and Walker, D.M. May 23-25, 2017. Identification of probiotic bacteria with antifungal activity in the cutaneous microbiome of endangered Tennessee bats. White-Nose Syndrome Workshop, Nashville, TN.
- Harmon, A., Ellis, N., and Hurt, C. 2016. Conservation genetics of the endangered Barrens topminnow. Tennessee Academy of Sciences Meeting.
- Hill, A.J., Russell, G.N., Edelbrock, B., Erdman, F., Leys, J., and Walker, D.M. September 29-30, 2016. Inhibition of chytridiomycosis by cutaneous microbiota of Plethodontid salamanders. The 22nd Annual Meeting of the Tennessee Herpetological Society.
- Hill, A.J., Bryan, D., Leys, J.E., Erdman, F.M., Malone, K.S., Russell, G.N., Applegate, R.D., Fenton, H., Niedringhaus, K., and Walker, D.M. 2016. The snake cutaneous microbiome: Using resident probiotic skin bacteria to combat snake fungal disease *(Ophidiomyces ophiodiicola)*.
- Hornsby, S.B., and Arias-Chavez, L.H. 2017. Variability of morphology of polyamide active layers for thin-film composite membranes. Twelfth Annual TTU Research and Creative Inquiry Day, Tennessee Tech University, Cookeville, TN.
- Hornsby, S.B., and Arias-Chavez, L.H. 2016. Variability in morphology of polyamide active layers on a reverse osmosis membrane. Gordon Research Conference on Membranes: Materials and Processes, New London, NH.
- Huttes, D.A., Ong, X.-Z., and Arias-Chavez, L.H. 2017. Separation of inorganic components from industrial wastewater via a hybrid FO/RO system. Twelfth Annual TTU Research and Creative Inquiry Day, Cookeville, TN.
- Ivey, A., Paine, R.T.R., and Hurt, C. November 2016. Environmental monitoring of rare freshwater fishes using next-generation sequencing. Tennessee Academy of Sciences Annual Meeting, Austin Peay State University.
- Kalyanapu, A.J. September 29, 2016. Dealing with floods: Modeling solutions in the 21st Century. Department of Civil and Environmental Engineering (Invited seminar).
- Kalyanapu, A.J. September 22, 2016. Challenges and advances of modeling floods in the 21st Century: Use of gaming technology, Monte Carlo methods and geo-spatial analysis for realistic predictions. Graduate Research Seminar, University of Tennessee, Knoxville (Invited seminar).
- Kalyanapu, A.J. September 13, 2016. Tennessee Tech's water resources modeling and simulations. American Society of Civil Engineers Student Chapter, Department of Civil and Environmental Engineering (Invited seminar).
- Kenny, S., Wells, W., H.T. Mattingly, and Wolak, J. November 2016. Evaluation of Madtom diurnal substrate use in the Clinch River, Tennessee. Tennessee Academy of Science Annual Meeting, Clarksville, Tennessee.
- Knorp, N., and Murdock, J. June 2017. Effects of the nuisance alga *Didymosphenia geminata* on benthic community resources use. Society for Freshwater Science National Meeting, Raleigh, NC.
- Leys, J.E., Cobb, V.A., Bryan, D.L., Leys, M., Hall, C., Peters, D., Kimrey, J.T., Buck, R., and Walker, D.M. September 29-30, 2016. The host, geographic range, and environmental corollaries of *Ophidiomyces ophiodiicola*

the causative agent of snake fungal disease. The 22nd Annual Meeting of the Tennessee Herpetological Society.

- Leys, J.E., Dunham, K.E., Oliver, J., Schiller, E.E., Rush, E.E., Kimrey, J.T., Proctor, M., Reyes, M. Mayberry, D., Alonge, N.M., Elmore, E.R., Rand, V., Stephenson, K., and Walker, D.M. August 7-12, 2016. Senaky Sally: Detection of terrestrial small-body salamander eDNA and implications for biodiversity conservation of non-aquatic amphibians. Ecological Society of America Conference, p. 145.
- Malone, E., Perkin, J.S., Hurt, C., Kulp, M., Leckie, B., and Walker, D. 2017. Restoring ecosystem function to Abrams Creek by reintroducing three native fishes. TN American Fisheries Society Meeting, Knoxville, TN.
- Mattingly, H., Johansen, J., Padgett, M., and Boersig, T. March 2017. Preliminary ecological information for a new species of *Orconectes* from the Barrens Plateau region of Tennessee. American Fisheries Society Tennesse Chapter Annual Meeting, Knoxville, Tennessee.
- McClellan, G.E., Stewart, R., Datta, T., and Young, K. April 2016. An investigation of microbial communities in wastewater treatment facilities undergoing optimization for nutrient removal. Tennessee American Water Resources Association, Montgomery Bell State, Park, TN.
- Murdock, J. June 2017. Flow and large consumer alterations can have limited impacts on benthic colonization in productive agricultural streams. Society for Freshwater Science National Meeting, Raleigh, NC.
- Murdock, J. April 2017. Dissolved oxygen dynamics in turbid, high-nutrient agricultural lakes. West Tennessee Water Resources Meeting.
- Murdock, J. March 2017. The impact of *Didymosphenia geminata* mats varies across trophic levels in Southern Appalachian streams. Southern Appalachian Cooperative Ecosystem Studies Unit (SA-CESU) Annual Meeting. (Invited presentation).
- Murdock, J. February 2017. The impact of *Didymosphenia geminata* mats varies across trophic levels in Southern Appalachian streams. Austin Peay State University. (Invited presentation).
- Murdock, J. November 2016. Highlighting the importance of algal biodiversity through cellular level nutrient measurements. Middle Tennessee State University. (Invited presentation).
- Murdock, J. October 2016. *Didymosphenia geminata* effects on stream food webs. Gulf and South Atlantic Regional Panel on Aquatic Invasive Species. (Invited presentation).
- Murphy, S.P., Curtis, W.J., Gebhard, A.E., Wellemeyer, J.C., and Perkin, J.S. 2017. Testing diel fish migrations between riffle-pool habitats. Twelfth Annual TTU Research and Creative Inquiry Day, Cookeville, TN.
- Murphy, S.P., Curtis, W.J., Gebhard, A.E., Wellemeyer, J.C., and Perkin, J.S. 2017. Testing diel fish migrations between riffle-pool habitats. TN American Fisheries Society Meeting, Knoxville, TN.
- Ong, X.-Z., Huttes, D.A., and Arias-Chavez, L.H. 2017. Organic transport and fouling in forward osmosis separation of industrial wastewater. Twelfth Annual TTU Research and Creative Inquiry Day, Cookeville, TN.
- Padgett, M., Mattingly, H.T. Johansen, J., and Sutherland, C. March 2017. Distribution and threat analysis of the Obey crayfish, *Cambarus obeyensis*. American Fisheries Society Tennessee Chapter Annual Meeting, Knoxville, Tennessee.
- Paine, R.T.R. 2017. Environmental DNA: A molecular approach to delineating the distribution of the endangered Pygmy Madtom, *Noturus stanauli*. Tennessee Technological University Earth Day.
- Papraniku, I.F., Perkin, J.S., Gibbs, K., Slagle, T.J., Roysdon, D., Jones, B., Hall, C., and Walker, D.M. 2017. Impact of water fluctuation and intermittency on stream fish community structure. TN American Fisheries Society Meeting, Knoxville, TN.
- Payne, J., and Murdock, J. The effect of water depth on lake hypoxia. Society for Freshwater Science National Meeting, Raleigh, NC. June 2017.
- Poston, K.B., Reed, E., Munasque, L., VandenBerge, D., and Kalyanapu, A.J. September 11-15, 2016. 2015 South Carolina flooding and dam failures. Dam Safety 2016 Conference, Association of Dam Safety Officials, Philadelphia, PA.
- Ranjan, P., Hornsby, S.B., and Arias-Chavez, L.H. 2017. The role of polyamide morphology in determining contact angle variability. Twelfth Annual TTU Research and Creative Inquiry Day, Cookeville, TN.
- Slagle, T.J., Curtis, W.J., Goodman, N., Perkin, J.S. 2017. Spatial and temporal variability of fish assemblage structure in the Roaring River, Tennessee. Twelfth Annual TTU Research and Creative Inquiry Day, Cookeville, TN.
- Slagle, T.J., Curtis, W.J., Goodman, N., and Perkin, J.S. 2017. Spatial and temporal variability of fish assemblage structure in the Roaring River, Tennessee. TN American Fisheries Society Meeting, Knoxville, TN.
- Stafford, A., Granstaff, E., and Mattingly, H.T. March 2017. Southeastern Stream Temperature Monitoring Project (STMP): Prioritizing future monitoring sites in Tennessee. Tennessee Tech Tomorrow, Cookeville, Tennessee.
- Stafford, A., Granstaff, E., and Mattingly, H.T. April 2017. Southeastern Stream Temperature Monitoring Project (STMP): Prioritizing future monitoring sites in Tennessee. Tennessee Geographic Information Council's Annual Conference, Knoxville, TN. WON SECOND PLACE AWARD, BEST SPATIAL ANALYSIS.
- Templeton, L.M., Barnett, E.M., and Arias-Chavez, L.H. Forward osmosis for enhanced sustainability at the food-energy-water nexus. Twelfth Annual TTU Research and Creative Inquiry Day, Cookeville, TN.
- Underwood, C.D., Curtis, W.J., Gebhard, A.E., Wellemeyer, J.C., and Perkin, J.S.

2017. Diel fish community turnover in riffle habitats. TN American Fisheries Society Meeting, Knoxville, TN.

- Underwood, C.D., Curtis, W.J., Gebhard, A.E., Wellemeyer, J.C., and Perkin, J.S. 2017. Diel fish community turnover in riffle habitats. Twelfth Annual TTU Research and Creative Inquiry Day, Cookeville, TN.
- Varner, R.A., Schubert, K.E., Himes, J.H., and Arias-Chavez, L.H. Thermal desalination for utilization of waste heat from nuclear power production. Twelfth Annual TTU Research and Creative Inquiry Day, Cookeville, TN. WINNER OF FIRST PLACE IN UNDERGRADUATE POSTER COMPETITION IN CHEMICAL ENGINEERING.
- Walker, D.M., Talbert, D., Smith, D., Tinker, P., and Crowther, T. Sept. 29-30, 2016. From the bottom or from the top? A salamander's effect on the detritivore ecosystem. The 22nd Annual Meeting of the Tennessee Herpetological Society, Knoxville, TN.
- Walker, D.M. October 24, 2016. Evolution of the slimy salamander microbiome: A protective reservoir against funal pathogenesis. Centre College, Danville, KY.
- Walker, D.M. Sept. 29-30, 2016. The current status of snake fungal disease in Tennessee. The 22nd Annual Meeting of the Tennessee Herpetological Society, Knoxville, TN.
- Wellemeyer, J.C., Perkin, J.S., Fore, J., Wisby, J., Clark, M., and Boyd, C. 2017. Development of fish community indices of biotic integrity for West Tennessee streams. West TN Water Resources Symposium, Jackson, TN.
- Wellemeyer, J.C., Perkin, J.S., Fore, J., Wisby, J., Clark, M., and Boyd, C. 2017. Comparing fish community biotic integrity metrics across regions of western Tennessee: Does one IBI fit all? TN American Fisheries Society Meeting, Knoxville, TN.

4. Technical Reports:
   - Ferrell, H., Hurt, C., and Bettoli, P.W. 2017. Genetic stock assessment and hatchery contributions of sauger stocked into Old Hickory Lake, Tennessee. Fisheries Report 17-03, Tennessee Wildlife Resources Agency, Nashville.
   - Kalyanapu, A.J., Dullo, T.T., Bhuyian, N.M., Stuber, C.E., and Kaczmarek, C. 2016. Field trip to Obion River system. Final report submitted to Dr. Chris Clark, University of Tennessee, Institute of Agriculture.
   - Kissell, R. Long-tailed weasel *(Mustela frenata)* status and distribution survey in Arkansas. Final report to the Arkansas Game and Fish Commission.
   - Murdock, J.N., and Knorp, N.E. July 2016. Effects of *Didymosphenia geminata* on riverine food webs in the upper Tennessee River basin. Final report to the Gulf Coast Marine Fisheries Commission. 55 pp.
   - Murdock, J.N., Hix, L.A., and Engle, A.N. August 2016. Determining stream susceptibility to colonization and proliferation of the alga *Didymosphenia geminata* in the Chilhowee Reservoir watershed. Natural Resource Report NPS/GSMP/NRR -- 2016. National Park Service, Fort Collins, Colorado.
   - Murdock, J.N., Engle, A.N., and Moyer, G. September 2016. Monitoring for *Didymosphenia geminata*: An environmental DNA appraoch. Final report to the Gulf Coast Marine Fisheries Commission.
   - Ridgeway, J., and Bettoli, P.W. 2016. Sampling and population characteristics of bighead carp and silver carp in the Tennessee and Cumberland river systems. Fisheries Report 16-08, Tennessee Wildlife Resources Agency, Nashville.

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