

A word from the ISSE Director...

Professor Mingzhou Jin was appointed as director of the Institute for a Secure and Sustainable Environment (ISSE) in Fall 2018. He is also associate department head for Industrial and Systems Engineering (ISE) and director of Tickle College's Reliability and Maintainability Engineering graduate program. Professor Jin's research areas include data analytics and operations research; modeling and analysis for the environment, sustainability, and climate change; logistics, transportation, and supply chain management; and advanced manufacturing.

"Ming is a team builder who can bring people together around a concept," said ISE Department Head John Kobza. "I expect he will build on ISSE strengths while exploring some new directions. He also has an energy and passion around people and sustainability. I think it will be an exciting time for ISSE."

The mission of ISSE is to promote the development of policies, technologies, and educational programs that cut across multiple disciplines, engage the university's research faculty and staff, and grow in response to pressing environmental and security issues facing the state, the nation, and the globe. ISSE's specialized centers, programs, and initiatives address a range of issues that fall under the broad rubric of sustainability. It is a state-funded Center of Excellence.

"ISSE has strong research, education, and outreach programs in water resources, clean fuels, and several other areas related to sustainability," Professor Jin said. "These programs connect ISSE with local stakeholders and help faculty members identify research topics with societal impact. ISSE provides a collaborative platform for faculty at UT to conduct interdisciplinary sponsored research. The convergent research could make a local, national, and global impact on environment and sustainability."



Dr. Mingzhou Jin. ISSE Director

In this, our first annual newsletter, we have highlighted several of ISSE's ongoing projects in the areas of research, education, and outreach to give you a flavor of the variety of projects in ISSE's portfolio.

We are always looking for new opportunities for research and collaboration. If you are interested or would like more information on our projects or programs, please peruse our website or contact me. I hope you enjoy *News from ISSE*.

ISSE is online at isse.utk.edu.



INSTITUTE FOR A SECURE & SUSTAINABLE ENVIRONMENT

Wildfire Effects from Chimney Tops 2 Fire

Extrême wildfires occurred throughout the Southeast during the Fall 2016 drought. A wildfire in Gatlinburg, Tennessee clearly demonstrated to the public the magnitude and complexity of this issue, with tragic loss of life, extensive property damage, and forest loss in the Great Smoky Mountains National Park (GSMNP).

This wildfire started on November 25, 2016 near Chimney Tops in the GSMNP and is now identified as the Chimney Tops 2 Fire. High winds on the 28th allowed wildfire expansion, with intense burns in the Table Mountain Pine regions within the West Prong of the Little Pigeon River basin. It then moved northward from the GSMNP into the city of Gatlinburg, burning an area of 72.6 km², with roughly 44.4 km² burned within the GSMNP.

Since limited research has been conducted on the environmental impacts of wildfires in the Eastern US, a multidisciplinary team from the University of Tennessee sought to characterize the response of soil chemistry and microbial communities to landscape disturbances from wildfire. The UT research team is John Schwartz and Qiang He from the Department Civil and Environmental Engineering, and Jennifer Schweitzer and Karen Hughes from the Department of Ecology and Evolutionary Biology.

The team is also supported by Charley Driscoll from Syracuse University and many others from the University of Tennessee: L. Cao, S. Kiven, X. Giam, M. Hubert, L. Moorehead, M. Papes, K. Sheldon, S. Reamer, K. Beals, and A. Swystun. The research is funded by the UT Office of Research and Engagement, and two grants from National Park Service. Also, Karen Hughes received a NSF RAPID grant to study responses in fungal community structure as a result of the wildfire.

This research is ongoing. Since the wildfire, water samples have been collected from LeConte Creek and the West Prong of the Pigeon River in the GSMNP on a bimonthly basis and at additional control sites. Four sets of soil samples have been collected from about 20 sites among high- and medium-burn intensity areas and unburned sites. Soil chemistry analyses have been



completed. An additional set of soil samples will be collected in spring 2019.

Preliminary results of the soil chemistry analyses have found differences mostly in base cations between burned and unburned sites. This is also demonstrated in the water samples, where increased base cation export was observed but not inorganic nitrogen and sulfate. Water and soil pH appeared to increase in the burn areas. Microbial communities (fungal and bacterial) have been characterized using genomic techniques. Fungal communities shifted in composition with the identification of species commonly observed in post-fire disturbed areas. Plant community abundance and richness decreases with increased fire intensity.

The research team continues their work with the final goal of comprehensively integrating the many findings from each of the ecosystem components. Research will continue through 2019-2020 to observe the longer term effects of the Chimney Tops 2 Wildfire.

Assistance to the Town of Farragut

Researchers at the Institute for a Secure and Sustainable Environment are working with the Town of Farragut, Tennessee to identify, locate, and survey the different stormwater structures that are owned by the town. This inventory and survey are required for maintaining Farragut's MS4 permits, and the information collected will allow them to develop a stormwater infrastructure improvement plan.

This multi-year effort is led by ISSE researcher Thanos Papanicolaou and supported by a team that includes Christopher Wilson, from UT's Department of Civil and Environmental Engineering, and Tim Gangaware, with ISSE's Tennessee Water Resources Research Center, as well as students such as Caroline Stephens, who is a junior at UT and from Farragut. The team has identified and surveyed the stormwater assets in six of the Farragut communities including Concord Hills, Fox Den, Kings Gate, Old Stage Hills, Thornton Heights, and Village Green. The asset surveys used a waterproof snake camera to inspect the interior of the catch basin inlets, manholes, and culverts.

In the end, a GIS map of the town with all the assets is being compiled along with a detailed report. Farragut will use the map to prioritize those structures in most need of repair.



UT student and Farragut resident Caroline Stephens uses a snake camera to inspect the inside of this catch basin.



A GIS map of Farragut with asset locations. The map identifies which ones need the most attention.



TNWRRC Intern Sean Murphy and Farragut Stormwater Manager Lori Saal review attributes to describe stormwater grates.

ISSE researchers and faculty teams offer technical assistance to organizations, companies, communities, and municipalities. ISSE teams will work within your budget to provide expertise in areas that fall under the broad umbrella of environmental sustainability. To facilitate work on smaller projects with quick turn-arounds, ISSE has a Basic Ordering Agreement for easy and efficient contracting with the university.

Instrumenting Outdoor Lab at UT Gardens

Living wetlands were constructed at the UT Gardens in the Fall of 2015 to demonstrate the function of natural treatment infrastructure in the urban landscape. The wetlands capture runoff from a gravel parking area as well as the surrounding manicured botanical gardens, filtering out pollutants before the water enters the Tennessee River.

The wetlands contain four pools, each of which was planted using a unique strategy to showcase a range of aesthetic options to visitors. Three of the four pools are lined with an aquatic-safe PVC liner, and the fourth pool was left unlined.

By visual observation, the constructed wetlands are a success based on their capacity to support a variety of wetland plants, trap fine sediment from the parking area, and support an abundance of wildlife. However, data are needed to quantify the function of these built systems and to better understand the similarities or departures from natural wetlands.

In 2018, funds provided by an ISSE seed grant were used to transform the created wetlands at UT Gardens into an outdoor experiential learning laboratory. These funds allowed for the purchase of instrumentation, site installation, and needed field supplies for biological sampling procedures. The funds were also used to support the development and hosting of a cloud-based web interface that will host data collected from the outdoor wetlands laboratory and publish it to the web for easy downloading and viewing in a customizable “wetland science dashboard.”

In total, four systems were deployed (one in each wetland pool) to continuously monitor, record, and publish water quality parameters of dissolved oxygen,

water temperature, and turbidity. This real-time continuous data is transmitted via wireless routers to the cloud and published to a web dashboard at <https://tiny.utk.edu/wetlands>, making it accessible for use in university classes around the world.

The wetlands continue to be a destination for learners, volunteers, and budding future practitioners.



Installing monitoring equipment



Visitors use the new elevated boardwalk to experience wetland wildlife from a new perspective.



Web dashboard at <https://tiny.utk.edu/wetlands>

Each Spring, ISSE issues a Request for Seed Grant Proposals, making annual funding available for multi-disciplinary, multi-investigator research and support to faculty and staff at UTK and UTIA. The purpose of a seed grant is to provide start-up funds as leverage for obtaining larger external grants. The RFP is posted in early Spring on the website: isse.utk.edu.

Highlighting ISSE Students

Sa'ad Abd Ar Rafie is a PhD student in UT's Department of Civil and Environmental Engineering at the University of



Tennessee, Knoxville. He earned his B.Sc. degree in Civil Engineering from Bangladesh University of Engineering and Technology in Dhaka, Bangladesh.

Sa'ad is working with Dr. Terry Hazen and ISSE's Methane Center to investigate the impact of fire on interactions between the subsurface microbiome and the cycling of nutrients and carbon. His research aims to build on past studies that suggest the methane and carbon dioxide flux of forest soils are affected by fire, in part due to changes in the microbiome as well as physical disturbances impacting its capacity as an atmospheric methane sink. Little is known right now about the impacts of fire upon the subsurface microbiome, and how it affects carbon cycling through ecosystems.

Sa'ad's work aims to explain the changes in the microbial community and biogeochemistry of the surface and subsurface following the prescribed burn treatment of forest soils, as related to nutrient and carbon cycling. The goal of his work is to help develop microbial ecology-based models that can help predict the

geochemical impact of fire upon sites of concern by compositional analysis of the microbiome.

The systems biology approach of the research on fire-affected microbiomes builds on the Methane Center's vision to deepen the conceptual understanding of ecosystem processes (having methane as a driver) for a more environmentally sustainable future.

Sa'ad's current research interests are carbon cycling, microbial ecology, organic contaminant degradation, bioremediation, soil biogeochemistry, wastewater treatment, and membrane bioreactor technology.

Jiamei Huang is a first year

PhD student in Electrical Engineering and Computer Science. Her research addresses point-of-need water quality monitoring using electronic sensors.



Heavy metals such as lead (Pb), arsenic (As), and mercury (Hg) in drinking water are detrimental to human health. In the past year, Ms. Huang's team focused on developing biosensors using a UTK proprietary technology, AC electrokinetics-based capacitive (ABC) sensing technique, to

detect and identify trace amounts of metals in water.

Using low cost, micro-sized, interdigitated electrodes, ABC sensors have achieved highly sensitive tests for several heavy metal ions including lead, mercury, and copper. The tests are a thousand times more sensitive than existing assays, and it takes only minutes to perform the tests.

To improve the capability and efficiency of handling complex water samples, the team designed a four-channel, interdigitated sensor array that will incorporate sensors for different targets. Also, the multichannel sensor is more cost effective than a single channel sensor.

The new sensor works well with a multi-channel impedance analyzer. A microcontroller-based reader is currently being developed and it is expected to make the detection system portable and automated. The micro-controller will make the detection "smart" as it incorporates a data processing algorithm such as principal component analysis (PCA) to reach a component analysis of different substances in water.

This project was funded through an ISSE seed grant in 2017-18, which was extended to 2018-19.

Tourism in Appalachia: Trends and Strategies

Tourism has become an important industry in communities throughout the Appalachia Region. However, for other communities in the region it remains an unrealized source of economic development. Consequently, in Fall 2017, the Appalachian Regional Commission (ARC) issued a Request for Proposals (RFP) to study the tourism industry in Appalachia, using both qualitative and quantitative analysis.

ISSE's proposal was awarded the grant. The research team was led by Dr. Tim Ezzell (ISSE Research Scientist and Lecturer in UT's Political Science Department), and included Professor Rachel Chen and Assistant Professor Stefanie Benjamin in UT's Department of Retail, Hospitality, and Tourism; Catherine Wilt, ISSE Research Director; and Bruce Decker, Founder and Owner of Collective Impact, LLC.

The research team conducted and analyzed two surveys—a stakeholder survey and a visitors' survey. The stakeholder survey was emailed to tourism leaders, workers, and business owners in the ARC region. There were over 600 responses. The visitor survey was distributed via card racks at welcome centers and visitor centers in the region. There were almost 600 responses from 28 states.

Case studies were conducted by making site visits to a dozen Appalachian communities across the region. The research team met with leaders and stakeholders in each community and were able to see conditions first-hand. A few of the findings from the study include:

- Under “areas for improvement,” Internet access ranked highest, followed by roads, cleanliness and litter, and signage.
- Top needs were identified as private investment, broadband improvements, workforce development, and downtown revitalization.
- The majority of visitors to the Appalachian region came away with a more positive view of the region.
- Public lands are vital to the industry, with over 80 percent of destinations having them and more than 80 percent of travelers visiting them.
- Innovation is disrupting the tourism industry, and small rural communities need help adapting to changes.

The ARC study will be completed and released to the public in Summer 2019. Keep an eye on the ISSE website for a link and read the findings.



East Tennessee Clean Fuels

East Tennessee Clean Fuels (ETCleanFuels) is a 501(c)3 housed in ISSE. Its mission is to advance the use of cleaner alternative fuels and vehicles to improve air quality and health, reduce petroleum dependence, and support Tennessee's economy. ETCleanFuels partners with Nashville based Middle-West Tennessee Clean Fuels to serve fleets across Tennessee.

ETCleanFuels provides top-notch member services, fleet support, and up-to-date industry information to fleets across the state. For example, ETCleanFuels communicated with over 40 school system fleet managers in 2018 to help them understand alternative fuel school bus options and funding that could help offset new bus costs. Funding included CMAQ, state EPA program funds, and the forthcoming VW funds. ETCleanFuels assisted school districts in these counties: Weakley, Cocke, Grundy, Dickson, Perry, Hancock, Madison, Montgomery, and Shelby. This outreach will be available to school districts as they continue to seek information and funding for alt-fuel buses.

For the fourth year in a row, ETCleanFuels is managing state EPA funding that is part of the Diesel Emissions Reduction Act. With TDEC, ETCleanFuels created the *Reducing Diesel Emissions for a Healthier Tennessee* rebate program that provides about \$250,000 annually to help reduce fleet diesel emissions and put cleaner, alt-fuel vehicles in use. In the first three years, over \$570,000 was provided to fleets across Tennessee that have, so far, replaced over 280,000 gallons of diesel fuel and reduced related emissions.



ETCleanFuels Fuels Fix

Fuels Fix (www.fuelsfix.com) is an alt-fuels news site that ETCleanFuels started over a decade ago. Each month, ETCleanFuels solicits articles and videos from the 80+ DOE Clean Cities coalitions (cleancities.energy.gov/coalitions/locations/) across the country as well as from industry partners. *Fuels Fix* is a resource for fleet managers and professionals in the alternative fuels industry to learn what other fleets are doing.

Over 800 people subscribe to the monthly email, and the Twitter account @FuelsFix has almost 700 followers. Many readers are related to other US DOE Clean Cities Program coalitions that crisscross the US. These include public and private fleet managers and maintenance staff; local, state, and federal government representatives; utility fleets; fuel suppliers; faculty and staff from higher education; and other Clean Cities Coalition stakeholders from a broad spectrum of businesses.

In July 2018, representatives from Tennessee Clean Fuels, propane provider Ferrellgas, and Central States Bus Sales joined Clarksville-Montgomery County School System personnel to celebrate the expansion of the propane-powered school bus fleet from 16 to 23 buses. They plan to have as many as 100 propane buses in the next few years. Director of Schools Millard House II is pictured in the middle.

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ISSE Staff Citings

ISSE Director **Mingzhou Jin** received the 2018 Tickle College of Engineering Outstanding Faculty Service Award. Also, he was elected as a Fellow of the Institute of Industrial and Systems Engineers.

John Schwartz, TNWRRC Director and an ISSE researcher in UT's Department of Civil and Environmental Engineering, serves on a committee with the National Academies of Science, Engineering, and Medicine that comprehensively evaluates the Watershed Protection Plan for New York City's drinking water supply.

ISSE researcher **Thanos Papanicolaou** received the 2018 Hans Albert Einstein award from the American Society of Civil Engineers, one the most prestigious distinctions in hydraulic engineering.

ISSE researcher **Joshua Fu** has been chosen to receive the 2018 Lyman A. Ripperton Environmental Educator Award for his education efforts related to controlling air pollution.

Former TNWRRC Director **Bruce Tschantz** was honored with a Public Dam Safety award for his lifetime achievements in dam safety.

Terry Hazen, UT-Oak Ridge National Laboratory Governor's Chair for Environmental Biotechnology, was listed by Clarivate Analytics as one of the world's most cited researchers.

Leah Stephens participated in the 2018 EURECA undergraduate research symposium and exposition. She won honorary mention for her work on an ISSE seed project.

The University of Tennessee is an EEO/AA/Title VI/Title IX/Section 504/ADA/ADEA institution in the provision of its education and employment programs and services. All qualified applicants will receive equal consideration for employment and admission without regard to race, color, national origin, religion, sex, pregnancy, marital status, sexual orientation, gender identity, age, physical or mental disability, genetic information, veteran status, and parental status.