Institute for a Secure & Sustainable Environment

2022-2023 Annual Report to THEC

ISSE Mission Statement

The University of Tennessee's Institute for a Secure and Sustainable Environment (ISSE) seeks 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.
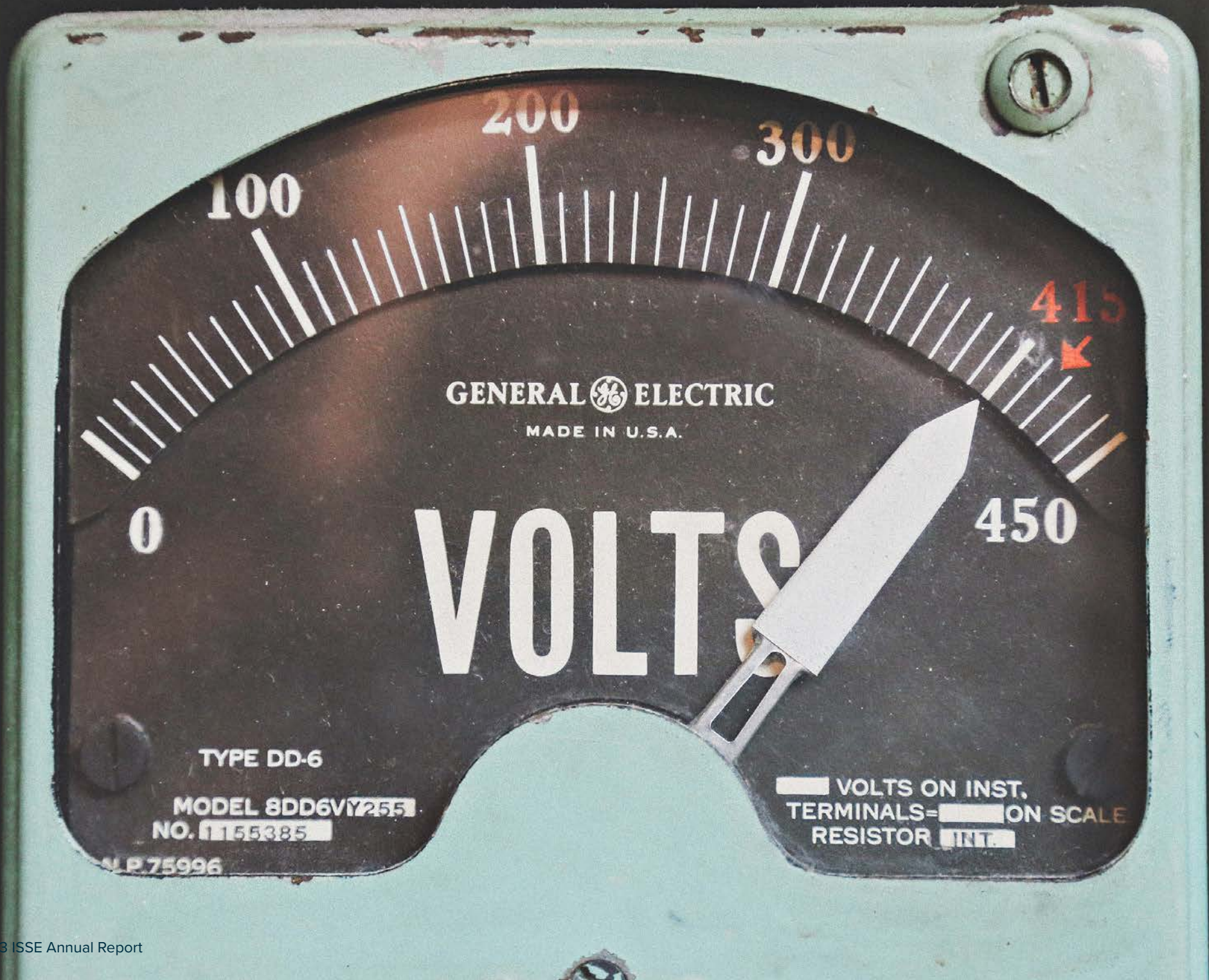
Table of Contents

Contact ISSE

ISSE Main Office
Phone: 865-974-4251
Fax: 865-974-1838
Email: isse@utk.edu

Dr. Mingzhou Jin, Director
Phone: 865-974-1843 or 974-9992
Email: jin@utk.edu

Message from the Director

Since October 2022, ISSE has made a quantum leap forward in all its areas. A record number of proposals were submitted and funded. We have increased our staff by adding several new members to East Tennessee Clean Fuels program and naming Dr. Qiang He as ISSE Associate Director and Dr. Jon Hathaway as Associate Director of the Tennessee Water Resources Research Center.

Our research portfolio has expanded to include Energy and Environmental Justice, an initiative directed by Dr. Chien-fei Chen. Through this, along with US-Japan Researcher Exchange program that ISSE is leading, we have much more international travel coming up. Building on the DOE-funded work of Baoshan Huang and Nick Zhou, ISSE has added a net-zero and decarbonization initiative to its research area. This would provide a promising pathway to rethink the use of the US domestic coal resources by utilizing the low-cost, electrically conductive, and mechanically strong coal-derived solid carbon materials to produce infrastructural components.

Thanks to a $1million EPA award, TNWRRC will help rural, small, and Tribal communities plan for and access funding from the Infrastructure Investment and Jobs Act and other sources. EPA's grant funding will be used to assess communities' most pressing challenges, provide training on water infrastructure and management best practices, help communities navigate the federal funding application process, and strategically invest in reliable infrastructure solutions.

Working with the Office of Research, Innovation & Economic Development, ISSE has launched the Global Energy Ecosystems (GE2) initiative. The goal of GE2 is to develop and deploy sustainable and equitable energy technologies for industry, agriculture, and communities. It will address eight of the United Nation's Sustainable Development Goals: zero hunger; clean water and sanitation; decent work and economic growth; industry, innovation, and infrastructure; reducing inequality; creating sustainable cities and communities; taking climate action; and delivering affordable and clean energy.

ISSE continues to implement its five-year strategic plan to increase its research, educational, and outreach activities at the University of Tennessee. ISSE will promote the development of policies, technologies, and educational programs that will address and help remedy critical environmental issues around the world. We will strengthen our emphasis on cross-disciplinary collaborations that will help bring about global sustainability and environmental equity and justice.

Dr. Mingzhou Jin, ISSE Director

Executive Summary

During 2022-2023, ISSE continued to expand its research and outreach, and this report describes the activities carried out by ISSE staff, students, and ISSE-affiliated faculty.

ISSE has a robust internal operation with 11 support staff, 15 research staff, and four research faculty members as well as several visiting scholars. Our 20 affiliated faculty members represent Haslam College of Business, the departments of Ecology & Evolutionary Biology, Biosystems Engineering & Soil Science, Electrical Engineering and Computer Science, Sociology, Economics, the Baker Center for Public Policy, Civil & Environmental Engineering, and Industrial & Systems Engineering; our advisory board members come from UTK, UTIA, ORNL, TVA, TDEC, and the City of Knoxville.

ISSE principal investigators are currently leading 26 active, sponsored projects for ISSE, and there are 17 individual agencies funding these projects; ISSE was awarded 13 new sponsored projects this year. ISSE research projects have engaged more than 50 UT faculty members, two post-doctoral associates, and many graduate and undergraduate students.

ISSE has funded 12 seed grant projects: six that are in progress and six that were completed this year. Topics addressed by these new projects include: assessing the levels of forever chemicals (PFAS) in surface water in Tennessee aquatic ecosystems; identification of novel pathways for bacterial degradation of polycyclic aromatic hydrocarbons; utilization of waste plastics; assessing the implications of large-scale hydrogen production on power transmission systems; couple mass transfer processes during underground hydrogen storage; and transformational production of sustainable aviation fuel and biofertilizer from black solider fly.

ISSE's research portfolio has expanded by two new areas, energy and environmental justice and decarbonization. In addition, ISSE is leading the development of a researcher exchange program involving the US Embassy in Japan. A contingent from UT, including Chancellor Donde Plowman, will visit the embassy in January.

ISSE Centers & Programs

FEWSUS International Research Coordination Network

FEWSUS stands for International Research Coordination Network to Create Transdisciplinary Nodes of Food-Energy-Water to Support Sustainable Urban Systems. It is funded by the US National Science Foundation. The grant, awarded to faculty and scientists at UT and ORNL, supports the development of an International Research Coordination Network to facilitatw multinational communications and accelerate the development and transfer of multisectoral data, standards, analysis tools, new technologies, and a trained workforce among differently urbanized countries.

Tennessee Water Resources Research Center (TNWRRC)

TNWRRC is a federally designated state research institute supported in part by the US Geological Survey. TNWRRC partners with the state of Tennessee as a primary resource to develop and implement programs that can achieve sustainable quantities of quality water in Tennessee and the nation. Dr. John S. Schwartz directs TNWRRC and is a professor in Civil & Environmental Engineering.

East Tennessee Clean Fuels (ETCF)

ETCF works to increase the use of cleaner American fuels and vehicles and energy saving transportation technologies to improve air quality and health, curb dependence on imported petroleum, and support Tennessee's economy. Its mission is to implement alternative fuel projects in East Tennessee and to make ETCF a sustainable coalition of involved participants from across East Tennessee. ETCF is a 501(c)3 under the umbrella of Transportation Energy Partners. Mr. Jonathan Overly is the Executive Director and Coordinator.

Energy & Environmental Justice Lab

EEJ is dedicated to interdisciplinary exploration into social justice, clean energy, accessibility to renewable resources, and infrastructure resilience. Dr. Chien-fei Chen directs a team of experts to examine social-psychological and policy factors that influence energy and environmental justice, particularly in water systems, built environment, energy efficiency, microgrids, electric vehicles, and solar technology adoption. EEJ's practical research initiatives empower academics, communities, utilities, and policymakers alike, fostering a shared commitment to equitable access to clean energy and a sustainable future.

Appalachian Leadership Institute (ALI)

ISSE partnered with ARC to launch this program focused on the unique challenges and solutions around Appalachia's economic development. ALI trains community leaders who live and work in the region through skill-building seminars, best-practice reviews, and field visits across the 13 states that make up the Appalachian region. The goal is to create leaders who can help the region adapt to these changes and use opportunities to create thriving, equitable, and sustainable communities. Dr. Timothy Ezzell is the PI for this program and a Research Professor in Political Science.

Climate Change Initiative

Researchers at ISSE, working closely with the Climate Change Science Institute at Oak Ridge National Lab, are advancing our understanding of climate change and its impacts on human and natural systems. We use Earth system modeling, integrated ground and remote sensing observations, and advanced data analytical tools to study climate change and its effects on water availability, soil moisture, wildfires, and vegetation. Team members are Drs. Yaoping Yao, Yulong Zhang, Jiafu Mao, Joshua Fu, Mingzhou Jin.

Worker Health and Safety Training at Department of Energy Facilities

DOE Worker Training was developed to protect and inform DOE communities and their workers by delivering quality and flexible safety and health training to target populations of hazardous waste workers and emergency responders. Its mission is to prevent work-related harm by training workers to protect themselves and their communities from exposure during hazardous waste operations and transportation, environmental restoration at nuclear weapons facilities, or chemical emergency responses.

East Tennessee Initiative for Smart Energy Management

The goal of ETISE is to create a regional model for technical assistance and workforce training to effectively integrate smart manufacturing in energy management systems into energy-related business practices. The Department of Energy funds ETISE through the Office of Energy Efficiency & Renewable Energy (EERE), Industrial Efficiency & Decarbonization Office (IEDO), Oak Ridge National Laboratory (ORNL), and the Advanced Materials and Manufacturing Technologies Office (AMMTO).

Center for Freight Transportation for Efficient & Resilient Supply Chain (FERSC)

FERSC is a Tier 1 University Transportation Center consortium led by the University of Tennessee, Knoxville. Its focus is the Infrastructure Investment and Jobs Act (IIJA)'s research priority, Improving Mobility of People and Goods as its primary area. The consortium supports the DOT Strategic Goals of Economic Strength and Global Competitiveness as the primary focus and Equity and Transformation as the secondaries. FERSC Partners are University of Tennessee, University of Illinois Chicago, Oregon State University, California State University Long Beach, North Carolina A&T, and Texas A&M University.

Sponsored Research

PI	Project Title	Sponsor	Co-PI	Start/Stop dates
John Schwartz	Improving the GRSMs understanding of its natural resources and processes and thereby enhancing protection of the Park's resources	US Dept Interior National Park Service - Great Smoky Mountains National Park		6/18/2014 - 6/29/2024
John Schwartz	Increasing water treatment resiliency by using natural flood records to reduce the uncertainty of water hazard predictions under changing climate-University of Alabama	US Dept Interior - US Geological Survey	Timothy Gangaware	12/15/2021 - 12/14/2023
John Schwartz	TN Stream Quantification Tool Training	TN Dept Environment and Conservation		5/1/2020 - 4/30/2024
John Schwartz	Urban Waters Report Card	Metro Gov Nashville	Timothy Gangaware	3/1/2021 - 12/31/2023
John Schwartz	Urban Waters Report Card	Hamilton County Government	Timothy Gangaware	4/1/2022 - 11/30/2023
John Schwartz	Appalachian Community Technical Assistance and Training (ACTAT) Program	West Virginia University		10/1/2018 - 9/30/2024
Jon Hathaway	Wetland Restoration with RSC's	Environmental Protection Agency	John Schwartz	10/1/19 - 9/30/2023
Jon Hathaway	REU Site: Green Infrastructure for Sustainable Urban Environments	National Science Foundation		10/1/2021 - 9/30/2024
Jon Hathaway	Collaborative Research: Reimagining Urban Watershed Management: A Systems Approach to Stormwater Control and Ecological Rehabilitation	National Science Foundation	Anahita Khojandi, Michael Blum	8/1/2022 - 7/31/2025
Khalid Ahmed Alshibli	3D dynamic evolution of pore water-air interaction within saturated sheared sand	National Science Foundation		7/15/2020 - 6/30/2024
Mingzhou Jin	Smart Manufacturing	US Dept Energy/UT-Battelle/Oak Ridge National Laboratory		11/10/2020 - 11/9/2024
Mingzhou Jin	US Food, Loss, and Waste and Its Relationship with Energy consumption and Carbon Emissions	US Dept Energy/UT-Battelle/Oak Ridge National Laboratory		5/27/2022 - 6/30/2024
Mingzhou Jin	East Tennessee Clean Fuels Initiative	East Tennessee Clean Fuels Coalition		7/1/2011 - 6/30/2024
Mingzhou Jin	INFEWS: U.S.-China: Coupled FEWS Modeling for Sustainability of the Global Crop Supply Chain with a Focus on China - US Interactions	National Science Foundation		7/1/2019 - 6/30/2024
Mingzhou Jin	SRS RN: People-Centric Integrated Assessment Model for Regional Sustainability (PIAMRS): Focusing on the Central Appalachian Region	National Science Foundation	Timothy Ezzell, Yulong Zhang, Lisa Zottarelli, Thankam Sunil, Wendy Tate, Paul Armsworth, Liem Tran	1/1/2022 - 12/31/2023
Nick Zhou	Utilizing coal-derived solid carbon materials towards next-generation smart and multifunction pavements	US Dept Energy - National Energy Technology Lab	Baoshan Huang, Wei Hu	1/5/2021 - 3/31/2024
Qiang He	AOP for wastewater treatment from the oil/gas industry	Aramco		3/9/2022 - 3/8/2024
Sheila Webster	Worker Training at DOE facilities	National Partnership for Environmental Technology Education		9/1/2020 - 7/31/2024
Timothy Ezzell	ASPIRE: Appalachian Students Promoting the Integration of Research in Education	National Science Foundation		9/5/2016 - 8/31/2024
Timothy Ezzell	Appalachian Leadership Institute	Appalachian Regional Commission	Katie Cahill, Catherine Wilt	2/6/2019 - 7/31/2024

Newly Awarded Sponsored Research

PI	Project Title	Sponsor	Co-PI	Start/Stop dates
Chien-fei Chen	Advancing Human-Centered Sociotechnical Research for Enabling Independent Mobility in People with Physical Disabilities	University of Michigan		10/1/2022 - 9/30/2026
Chien-fei Chen	Community-centered Decision-making Framework for Microgrid Deployment ot Enhance Energy Justice and Power System Resilience	Iowa State University		9/15/2022 - 8/31/2025
Chien-fei Chen	Planning: Southeast Center for Just, Resilient, and Sustainable Ecosystems (SECURE)	National Science Foundation	Kelsey Ellis, Jennifer First, Fangxing Li, Mingzhou Jin	9/1/2023 - 8/31/2024
Chien-fei Chen	SAI: Integrating human cognition, behavioral mechanisms and societal impacts for large-scale deployment of public charging infrastructure	University of Alabama		9/15/23 - 8/31/2026
Chien-fei Chen	A Community Co-Designed Weatherization and Micro-grid Plan for Equitalbe Energy Security and Environmental Health	Wellcome Trust	Mingzhou Jin, Leon Tolbert	8/1/23 - 5/31/2026
John Schwartz	Urban Waters Report Card	City of Chattanooga	Timothy Gangaware	9/18/2022 - 11/30/2023
John Schwartz	Urban Waters Report Card	Knox County		9/18/2022 - 11/30/2023
John Schwartz	FY2024 Water Resources Program Year 3	US Dept Interior - US Geological Survey	Timothy Gangaware	9/1/2023 - 8/31/2024
Joshua Fu	Estimating Soil Organic Carbon Changes from SAF Feedstock Production in the US with Integrative Satellite Data and Machine Learning	US Dept Transportation Federal Aviation Administration		12/22/2022 - 12/31/2023
Mingzhou Jin	Center for Freight Transportation for Efficient and Resilient Supply Chain (FERSC)	US Dept Transportation	Lee Han, Kevin Heaslip	6/1/2023 - 5/31/2029
Mingzhou Jin	ETISE: East Tennessee Inititiative of Smart Manufacturing for Energy Efficiency	US Dept Energy Office of Energy Efficiency		3/01/2023 - 2/29/2024
Mingzhou Jin	U.S.-Japan Exchange Program fgor Green Growth Collaboration through Clean Energy Technologies (EXCET)	US Department of State	Chien-fei Chen, Kevin Tomsovic	9/1/23 - 8/31/2025
Timothy Ezzell	Closing the Regional Tourism Gap: Promoting Multi-jurisdictional tourism in Cumberland Gap Communities	East Tennessee State University		8/15/2023 - 6/30/2024

Completed Sponsored Research

Faculty/PI	Project Title	Sponsor	Co-PI	Duration
Mingzhou Jin	Anyalysis for Regional and Global Land Ecosystem Modeling	DOE - ORNL - UT-Battelle - Oak Ridge National Laboratory		8/1/2020 - 12/31/2022
Timothy Ezzell	Increasing Economic and Entrepreneurial Opportunities by Promoting Outdoor Recreation Among Underrepresented Visitor Groups	East Tennessee State University		8/15/2019 - 6/30/2023
Jonathan Overly	TDOT I-40 Alternative Fuels Continuation	US Dept Transportation via UT Center for Transportation Research	Yulong Zhang	7/1/2021 - 6/30/2023
John Schwartz	FY2021 and FY2022 Water Resources Program Year 1	US Dept Interior - US Geological Survey	Jon Hathaway, Yaoping Wang, Timothy Gangaware	9/1/2021 - 4/30/2023
John Schwartz	FY2022 and FY2023 Water Resources Program Year 2	US Dept Interior - US Geological Survey	Timothy Gangaware	9/1/2021 - 8/31/2023
John Schwartz	Urban Waters Report Card	City of Memphis	Timothy Gangaware	3/7/2022 - 6/30/2023

Active Seed Grants

Faculty/PI	Project Title	Co-PI	Duration
Jiangang Chen	Assessing the levels of forever chemicals (PFAS) in surface water in Tennessee aquatic ecosystems	Jie Wu, Qiang He	7/1/2022 - 12/31/2023
Alison Buchan	Identification of novel pathways for bacterial degradation of polycyclic aromatic hydrocarbons	Qiang He	7/1/2022 - 12/31/2024
Baoshan Huang	Utilization of Waste Plastics	Qiang He, Brian Long, Pawel Polaczyk	7/1/2022 - 9/30/2023
Kai Sun	Assessing the Implications of Large-Scale Hydrogen Production on Power Transmission Systems	Feng Zhang	7/1/23 - 6/30/2024
Anna Herring	Couple Mass Transfer Processes during Underground Hydrogen Storage	Haochen Li	7/1/23 - 6/30/2024
Tong Wang	Transformational Production of Sustainable Aviation Fuel and Biofertilizer from Black Solider Fly		7/1/23 - 6/30/2024

Completed Seed Grants

Faculty/PI	Project Title	Co-PI	Duration
Khalid Alshibli Ahmed	Geochemical Interaction between CO2 and Caprock for Safe Carbon Sequestration	Nicholas Dygert	1/1/2021-12/31/2022
Qiang He	Toward Precision Environmental Health Risk Management	Cronley & Li	1/1/2021-12/31/2022
Kelsey Ellis	Beat the Heat: Builiding adaptive capacity of vulverable populations in Knox County to combined stressors from climate change and urban heat.	First & Kintziger	7/1/2021 - 12/31/2022
Frank Loeffler	Microbial transformation and degradation of sulfonated per- and polyfluoroalkyl substances.	Shawn Campagna	7/1/2021 - 12/31/2022
Jie Wu	Socioeconomic inequalities and drinking water quality: assessin arsenic concentrations in community water systems by novel field deployable biosensors.	Cronley & He	7/1/2021 - 12/31/2022
Chris Cherry	Micromobility Vehicle Second-Life Battery Applications: Market Inventory and End Use Feasibility Analysis	Daniel Costinett	7/1/2022 - 6/30/2023

ISSE Research Staff, Support Staff, Affiliated Faculty & Advisory Board

Research Staff	
Mingzhou Jin	ISSE Director, Professor of Industrial & Systems Engineering and Civil & Environmental Engineering
Jason Brown	Research Associate II
Chein-fei Chen	Director of Energy and Environmental Justice, Research Associate Professor
Tim Ezzell	Director, Appalachian Leadership Institute, Assistant Research Professor
Tim Gangaware	Research Director, Tennessee Water Resources Research Center
Jon Hathaway	Associate Director, TNWRRC
Qiang He	Associate Director, ISSE
Steven Hoagland	Research Associate II
Jiafu Mao	ORNL Joint Faculty Professor
Jonathan Overly	Director, East Tennessee Clean Fuels
John Schwartz	Director, Tennessee Water Resources Research Center; Professor, Civil & Environmental Engineering
Danniel Siksay	Chief of Staff, East Tennessee Clean Fuels
Ian Simpson	Research Associate III
Sheila Webster	Director, Technology Research and Development Program
Catherine Wilt	Research Associate

Advisory Board	
Erin Webb	Senior R&D Engineer and Group Leader, Bioresource Science & Engineering, ORNL
James Parks	Section Head of Energy and Transportation Division, ORNL
Matthew K. Taylor	Deputy Director of Sustainability Office, TDEC
Rebecca Tolene	VP Environment-Chief Sustainability Officer, TVA
Tim Rials	Associate Dean at UT AgResearch, UTIA
Chris Cox	Department Head, Civil & Environmental Engineering, UTK
Brian Blackmon	Director, Office of Sustainability, City of Knoxville
Jay Price	Sustainability Manager, UTK
Bill Dunne (observer)	Associate Dean for Research and Facilities, Tickle College of Engineering, UTK

Support Staff	
Darcy Ayers	Project Coordinator, East TN Clean Fuels
Chris Black	Membership & Fundraising Coordinator, East TN Clean Fuels
Kellie Caughorn	Senior Administrative Services Assistant, Tennessee Water Resources Research Center
Lissa Gay	ISSE Communications Director
Ainsley Kelso	Communications Coordinator, East TN Clean Fuels
Jennifer Kidd	Project Coordinator, East TN Clean Fuels
Lily Lovingood	Project Coordinator, East TN Clean Fuels
Bonnie Morris	Tennessee Water Resources Research Center
Karen Poland	Financial Associate
Sherry Russell	ISSE Business Manager
Wesleigh Wright	Community Engagement Liaison, East TN Clean Fuels

Affiliated Faculty	
Charles Sims	Baker Center for Public Policy, Department of Economics
Sean Schaeffer	Biosystems Engineering & Soil Science
Walker Forbes	Biosystems Engineering & Soil Science
Jie Zhuang	Biosystems Engineering & Soil Science
Joshua Fu	Civil & Environmental Engineering
Jon Hathaway	Civil & Environmental Engineering
Terry Hazen	Civil & Environmental Engineering
John Schwartz	Civil & Environmental Engineering
Shua Li	Civil & Environmental Engineering
Nick Zhou	Civil & Environmental Engineering
Paul Armsworth	Ecology & Evolutionary Biology
Kevin Tomsovic	Electrical Engineering & Computer Science
Michael Galbreth	Haslam College of Business
Wendy Tate	Haslam College of Business
Mingzhou Jin	Industrial & Systems Engineering
Anahita Khojandi	Industrial & Systems Engineering
Jiafu Mao	Industrial & Systems Engineering
Feng-Yuan Zhang	Mechanical, Aerospace & Biomedical Engineering
Robert Jones	Sociology

ISSE Welcomes New Staff

Darcy Ayers
East TN Clean Fuels
Project Coordinator

Lily Lovingood
East TN Clean Fuels
Project Coordinator

Chris Black
East TN Clean Fuels
Membership & Fundraising
Coordinator

Wesleigh Wright
East TN Clean Fuels
Community Engagement Liaison

ISSE Student Highlights

Ceara Parks Oliver is a second year PhD student in UTK's Department of Civil and Environmental Engineering. Ceara graduated from the University of Oklahoma with a Bachelor of Science in 2013. For the next nine years, Ceara worked for Burns & McDonnell in Dallas, Texas, as a stormwater engineer. Her main responsibilities included project management, performing H&H tasks for transportation-related projects, and public outreach. For her dissertation, Ceara's research will be centered on stream restoration while complimenting it with her stormwater engineering background. The main theme of her dissertation will be focused on applying storm water control measures as an innovative stream restoration approach with respect to compensatory mitigation. Although still early on in her research, she plans on utilizing sediment transport and habitat modeling to develop a currency for compensatory mitigation. The summary will concentrate on the 2008 Compensatory Mitigation Rule of the Clean Water Act and how this research can be utilized to advocate for innovative stream restoration approaches.

Mohammed Elnur is a 3rd-year Ph.D. candidate at the Department of Civil and Environmental Engineering, UTK. He was awarded B.Sc. in Civil Engineering from the University of Khartoum, Sudan. Mohammed received his M.Sc. in Civil Engineering from the University of Glasgow, Scotland, UK. The goal of his current research is to evaluate the integrity of limestone caprock for safe geological carbon trapping by examining the geochemical interaction between supercritical carbon dioxide and limestone rock. Mohammed's research employs multiple techniques including 3D CT imaging, X-ray diffraction, X-ray fluorescence, and flow experiments. His research interests include the behavior of granular material, constitutive modeling of soils, and unsaturated soil mechanics. Mohammed recently published a paper on the Influence of X-ray exposure on triaxial testing when using 3D synchrotron micro-computed tomography.

Mohammad Safi is a second-year Ph.D. student in UTK's Department of Civil and Environmental Engineering. Mohammad Safi received his Bachelor and Master of Civil Engineering in the College of Engineering from Birzeit University, Ramallah, Palestine, in 2019 and 2022 respectively. His current research focuses on the mechanics and the behavior of granular materials (sand particles) under different conditions using both experimental and numerical methods. Mr. Safi is investigating the particle fracture in dry and saturated mediums and the effect of water on sand particle's cracking under different strain levels. On this topic, there is paper under review with the tittle of 'Influence of Pore Water on Fracture of Silica Sand at Particle Scale'. Mr. Safi's research interests include mechanics of granular materials, behavior of granular materials under different conditions, crack formation in sand particles, fracture of particles in granular materials.

Chenyang Wang is a first-year Ph.D. student in UTK's Department of Civil and Environmental Engineering. Chenyang received her Master of Science in Engineering from the University of Chinese Academy of Science, Beijing, China, in 2022. Her current research uses electrochemical technology for organic pollutants in produced water, revealing the process and key factors of pollutant degradation. Ms. Chenyang is dedicated to the development of innovative and environmentally sustainable technology for the efficient elimination of organic contaminants such as BTEX and oil from produced water, leveraging H_2S/SO_4^{2-} as co-contaminants to generate powerful oxidants through self-sustained electrochemical radicalization, aims to simplify the process of produced water treatment through eliminating the need for complex catalysts. Ms. Chenyang recently presented her research at the ISSE 2nd Annual Research Conference.

Yucen Li is a third-year Ph.D. student in UTK's Department of Civil and Environmental Engineering. Yucen received his Bachelor of Engineering in the Beijing University of Technology, Beijing, China, in 2017 and Master of Engineering in Northeastern University, Boston, USA, in 2020. His current research focuses on the electrical conductivity estimation of asphalt concrete with conductive granular carbon particles. Mr. Li also employs multiple techniques to study phase separation during melting/freezing of salt hydrate phase change material. Mr. Li research interests include thermal energy storage of inorganic materials, heat transfer, phase segregation of salt hydrates, numerical methods in engineering problem and digital image processing of X-ray/Neutron beam on materials. Mr. Li recent publication as a co-author is Towards building homeostasis through a low-cost biomimetic synthetic foam for building surface cooling and energy saving.

Prince Brown is a first year graduate student in UTK's Department of Public Policy. Prince received his Bachelor of Science in Criminal Justice from Allen University, Columbia, South Carolina, in 2023. His future research interests will cover how to prepare for Bioterrorism and what causes specific biological attacks. Mr. Brown intends to use certain research methods to study the age distribution of diseases and the large number of cases of acute flaccid paralysis. Mr. Brown's research interests include emergency management and public policy.
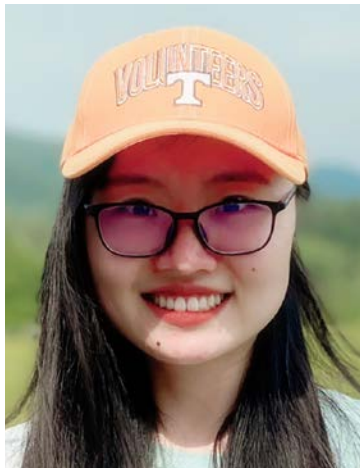
Zhibo Cheng earned her Ph.D. from the Department of Biosystems Engineering and Soil Science at the University of Tennessee, Knoxville in 2023. Prior to this, she received her Master of Science in Environmental Science from the University of the Chinese Academy of Science, China, in 2016. Her research focused on determining the inactivation patterns of naturally occurring soil viruses in the absence of host bacteria. And she has investigated the effects of cadmium (Cd) exposure, along with carbon (C) and nitrogen (N) nutrient concentrations, on virus-host community dynamics within agricultural contexts. Ms. Cheng utilizes a variety of techniques to study virus dynamics, including epifluorescence microscopy, agarose gel electrophoresis, and RAPD-PCR. Ms. Cheng's academic interests lie in soil virology, microbiology, and environmental science. Recently, she has been preparing manuscripts that focus on soil virology research.

Celia Jackson is a first-year master's student in UTK's Department of Environmental Engineering. Celia received her Bachelor of Science in Biology from the University of North Carolina at Chapel Hill in 2018. Her current research focuses on the functioning and efficiency of water resource utilities in rural and tribal communities in eastern Tennessee. Her current research techniques involve obtaining and analyzing data metrics on system, financial, and operating characteristics for these local water utility services. Ms. Jackson's research interests include sustainable methods for water resource management and mitigating climate impacts from urbanization via green design. Her past publication as a co-first author focuses on the effect of land use and stormwater control measures in the Jordan Lake watershed of North Carolina.

Mel Yoshimoto is a second-year Master's student in UTK's Public Health Department. He completed his BA in 2020 at UTK's College of Arts and Sciences, where he studied Psychology and facilitated intergroup dialogue, and returned to his alma mater to pursue an MPH in Epidemiology and MS in Statistics. Mel is currently working with the Knoxville Heat Equity Coalition and University of Nebraska Medical Center to create ArcGIS StoryMaps that communicate heat watch data and provide heat equity education. He is also cross training in bioinformatics with UTK's Food Science Department, where he is conducting research on the phylogeography and distribution of Salmonella enterica serovar Mississippi isolates in the Southeastern United States. Mel is particularly interested in applying his GIS and statistical skills to research involving health geography and spatial epidemiology.

Yue Yao is a third-year Ph.D student in UTK's Department of Industrial and Systems Engineering (ISE). In 2018, Yue completed his Bachelor of Science, followed by his Master of Engineering in 2020, both in ISE at Virginia Tech. He current works as a Graduate Research Assistantship, and his research interest includes climate change, optimization, and supply chain. Yue's ongoing research focuses on evaluating the impact of food shelf-life technologies on reducing food loss and waste, as well as their influence on greenhouse gas emissions and energy consumption within the United States' food supply chain. The project is funded by the Department of Energy (DOE) and involves collaboration with Oak Ridge National Laboratory.


Rachel Wood-Ponce is a fourth-year Ph.D. in UTK's department of Industrial and Systems Engineering. Rachel received her Bachelor of Science in Mathematics with a Pre-Engineering Emphasis from Lee University in Cleveland, TN in 2020. Her current research uses Machine Learning and statistical analysis models for prediction of urban stormwater runoff and forecasting hourly water temperatures at Tennessee Valley Authority fossil power plants. Ms. Rachel's recent works include a chapter titled "Optimization of Green Infrastructure" in Encyclopedia of Optimization and a journal article under review titled "Developing Data-Driven Learning Models to Predict Urban Stormwater Runoff Volume".

Isidora Fletcher received her Bachelor of Science degree in Physics from the University of Tennessee, Knoxville. She is currently completing her PhD in Data Science and Engineering Program at the University of Tennessee, Knoxville. She is a graduate research assistant at the Bredesen Center. She is working with Dr. Anahita Khojandi. The research project she is working on focuses on using reinforcement learning for water management problems. Her interests focus on the use of machine learning to address problems from different areas of research. Her current area of interest is environmental research.

Isabelle Hamby is an undergraduate senior in UTK's department of Civil and Environmental Engineering. Her research for Dr Hathaway has included work on E Coli testing and source tracking in a local creek, studying rainfall interception in the urban tree canopy, and temporal and spatial variability of hydraulic conductivity. She hopes to attend graduate school with specific interests in hydrology, stormwater, climate, low impact development, and blue and green infrastructure.
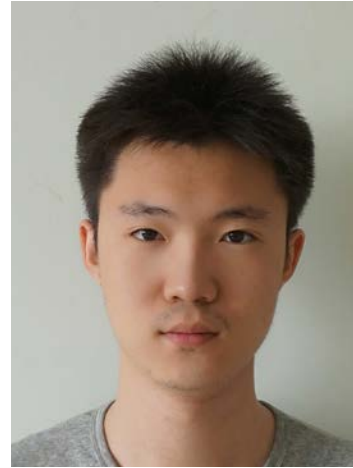
Jian Song is a third-year Ph.D. student in UTK's Department of Civil and Environmental Engineering. Jian received his Bachelor of Engineering in 2017 and Master of Engineering in 2020 in the College of Water Resource and Civil Engineering from China Agricultural University, Beijing, China. Jian's research interests include developing, improving, and utilizing agricultural and hydrological models. He is currently developing an agricultural model for pasture management.

Emily Litrakis is a fourth-year undergraduate student in UTK's Department of Geography and Sustainability. Emily will receive her Bachelor of Arts in the College of Arts and Sciences from the University of Tennessee Knoxville in May 2024. Her current research focuses on the climatology of flash flood in the Southeastern United States, specifically eastern Tennessee, and how emergency managers in the surrounding counties assess their county's risk and use that for hazard preparedness. Ms. Emily Litrakis employs multiple techniques to study the climatology of flash floods and emergency management including data analysis and survey result analysis. Ms. Litrakis research interests include climatology, climate change, and severe weather-related hazards.

Brian Fuson is a third-year student in UTK's Graphic Design Program. He will graduate in Spring 2025 with a bachelor's degree. Mr. Fuson's recent work includes a bee exhibit for the Knoxville Zoo through Honey Bee Tennessee and the design and research for the University of Tennessee aiding dementia through user interface design.

ISSE Advisors & Students

Khalid Alshibli
- Amirsalar Moslehy, G, Civil
- Mohammad Safi, G, Civil
- Mohammed Elbushra Elsheikh Elnur, G, Civil

Alison Buchan
- Ellen Grace Bobo, U, Microbiology
- Taylor Anne Smith, U, Microbiology
- Jill Walton, G, Microbiology

Chien-fei Chen
- Stephanie Tomasik, U, Electrical
- Julia Anne Craven, U, College Scholars Program
- Adam Tsegahun, U, Industrial

Chris Cherry
- Kepler Barnhart, G, Civil

Kelsey Ellis
- Emily Litrakis, U, Geography
- Caroline Parker, U, Public Health
- Ella Hunter, U, Geography, ISSE
- Emily Norris, U, Social Work
- Mel Haruto Yoshimoto, U, Public Health

Timothy Ezzell
- Zoey Crihfield, G, ISSE
- Prince Brown, G, Baker School

Joshua Fu
- Cheng-Pin Kuo, G, Civil

Jon Hathaway
- Ghada Diab, G, Civil
- Gillian Palino, G, Civil
- Isabelle Hamby, G, Civil
- Victoria Rexhausen, G, Civil

Terry Hazen
- Zabrenna Griffiths, G, Genomic Science & Tech

Qiang He
- Caitlyn Smugor, G, Civil
- Hope Newberry, G, Civil
- Xinghan Zhao, G, Civil
- Chenyang Wang, G, Civil

Mingzhou Jin
- David Vance, G, Bredensen Center
- Rongyun Tang, G, Industrial
- Rui Zhou, G, ISSE
- Sarita Rattanakunuprakarn, G, Industrial
- Yue Yao, G, Industrial
- Brian Fuson, U, ISSE

Anahita Khojandi
- Isadora Fletcher, G, Civil

Scott Lenaghan
- John Beatty, G, Biochem/Cell & Molec Biol

Frank Loeffler
- Diana Ramirez, G, Microbiology

John Schwartz
- Ceara Parks Oliver, G, Civil
- Cole Emmett, G, Civil
- Crispin Tucker Martin, U, Civil
- Jian Song, G, Civil
- Matthew Montgomery, G, Civil
- Matthew Tolson, G, Civil
- Probal Saha, G, Civil
- Samantha Jurek, U, Civil
- Asma Itmaizah, G, Civil
- Celia Jackson, G, Civil

Sheila Webster
- Mason Krezinski, U, ISSE

Jie Wu
- Cortney Myers, U, Ctr for Behavioral Health
- Jessie Baer, U, Ctr for Behavioral Health
- Jiamei Huang, G, EECS
- Yu Jiang, G, EECS

Nick Zhou
- Reese Sorgenfrei, U, Civil
- Yanhai Wang, G, Civil
- Yawen He, G, Civil
- Yucen Li, G, Civil
- Yuetan Ma, G, Civil
- Jared Galloway, G, Civil

Joe Zhuang
- Zhibo Cheng, G, Biosystem Engineering & Soil Science
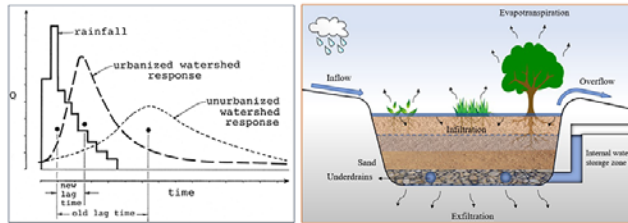
G - graduate student
U - undergraduate student

Enhancing Site Scale Bioretention Modeling to Investigate Watershed Scale Restoration

Ghada Diab[1], Jon Hathaway[1], Whitney Lisenbee[2], Robert Brown[3] and William Hunt[4]

[1]University of Tennessee, [2]Pennsylvania State University, [3]Goodwyn Mills Cawood, LLC, [4] North Carolina State University
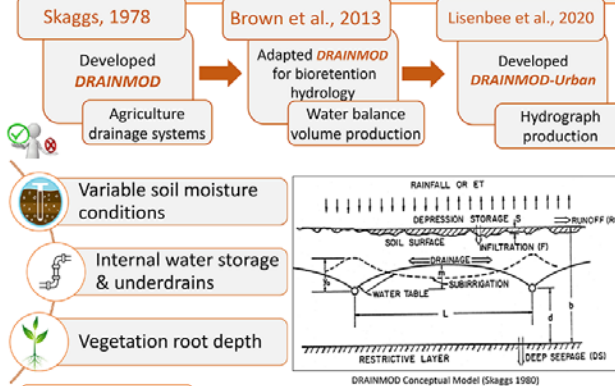
Introduction

- Bioretention is a widely used green Infrastructure that replicates natural hydrology in urban environment.
- Bioretention promotes infiltration and reduces runoff volume and peak flow of stormwater.

DRAINMOD-Urban

Process-based, field scale and long-term model

Skaggs, 1978 → Brown et al., 2013 → Lisenbee et al., 2020

- Developed DRAINMOD — Agriculture drainage systems
- Adapted DRAINMOD for bioretention hydrology — Water balance volume production
- Developed DRAINMOD-Urban — Hydrograph production

- Variable soil moisture conditions
- Internal water storage & underdrains
- Vegetation root depth

DRAINMOD Conceptual Model (Skaggs 1980)

Objectives

1) Assess the model ability to simulate bioretention drainage over a diversity of sites.
2) Verify overflow prediction using a large monitoring dataset with more overflow events.

Methods

Study Area

📍 Nashville, NC, USA

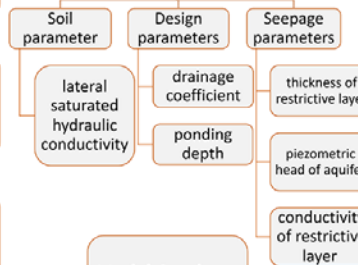| Site	0.6-m media depth		0.9-m media depth	
	Pre-repair	Post-repair	Pre-repair	Post-repair
Monitoring period	1 year	1 year	1 year	1 year
Catchment Imperviousness (%)	83	83	97	97
Catchment Area (ha)	0.68	0.68	0.43	0.43
Bioretention Area (m2)	290	322	206	226
Ponding depth (cm)	13	20	15	27
Fill media depth (m)	0.6	0.6	0.9	0.9
Design event (mm)	25	25	25	25
Fill media composition (%)	86-89% sand, 8-10% silt, 3-4% clay			
Site soil type	Sandy loam - loamy sand			
Drainage configuration	underdrain			

Brown and Hunt (2012)
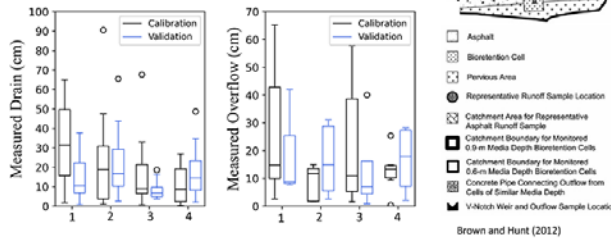
Prepare input files for DRAINMOD-Urban
↓
Split the data into calibration and validation period
↓
Calibrate the model using the most sensitive parameters
↓
Validate the model output using goodness of fit

Calibration Parameters

- Soil parameter: lateral saturated hydraulic conductivity
- Design parameters: drainage coefficient, ponding depth
- Seepage parameters: thickness of restrictive layer, piezometric head of aquifer, conductivity of restrictive layer

Model Goodness of fit
- Nash-Sutcliffe Efficiency (NSE)
- Percent Bias (PBIAS)

Results

Evaluation

NSE ≥ 0.40 → Acceptable
NSE ≥ 0.60 → Good
NSE ≥ 0.75 → Excellent
PBIAS ≤ 25% → Acceptable

Model Output		Hydrographs	
		NSE	PBIAS (%)
Drainage	Calibration	0.14~0.60	2.6~25.1
	Validation	0.19~0.60	5.5~25.4
Overflow	Calibration	0.49~0.89	6.0~38.8
	Validation	0.49~0.81	18.2~56.4

Hydrographs
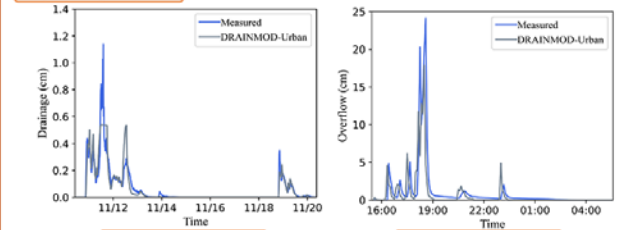
Volumes

Peak Flow

● Calibration   ● Validation
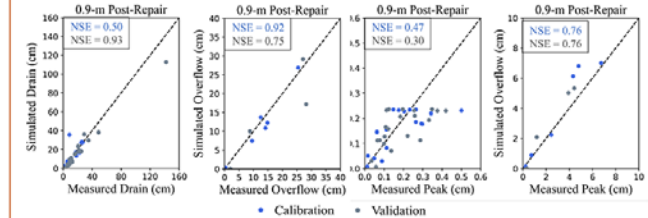
Conclusion

- DRAINMOD-Urban showed strong performance for modeling bioretention outflow hydrographs and volumes, accurately matching measured data.
- DRAINMOD-Urban is well-suited for bioretention application for different sites and varying conditions.

References

[1] Brown, R. A., Skaggs, R. W., & Hunt, W. F. (2013). Calibration and validation of DRAINMOD to model bioretention hydrology. Journal of Hydrology, 486, 430–442.

[2] Lisenbee, W., Hathaway, J., Negm, L., Youssef, M., & Winston, R. (2020). Enhanced bioretention cell modeling with DRAINMOD-Urban: Moving from water balances to hydrograph production. Journal of Hydrology, 582, 124491

Second Annual ISSE Research Conference

Building on the success of ISSE's first annual research conference, the second symposium was held on Monday, September 18, 2023, at UT Conference Center. Dr. Jin opened the event with an overview of ISSE research activities of the past academic year. Internal researchers presented their current work with a view to the future of sustainability across many disciplines, and Seed Grant recipients reported on their projects' progress. Leaders from TDEC Office of Policy & Planning, Eastman Chemical, and Oak Ridge Innovation Institute discussed updates to their ongoing sustainability projects.

ISSE Projects

Brad Day, UTK Associate Vice Chancellor for Research, gave an overview of Global Energy Ecosystems (GE2), and John Schwartz, Director, Tennessee Water Resources Research Center, presented updates on TNWRRC's education and training programs. Jonathan Overly, East TN Clean Fuels Coalitions Director, discussed East Tennessee Clean Fuels progress in Alternative-Fuel and Electric Vehicle Adoption. Chien-fei Chen, Director of Energy and Environmental Justice, summarized activities in one of ISSE's more recent research initiatives addressing energy and environmental justice. A brief description of all ISSE research centers is online at https://isse.utk.edu/isse-centers/.

Seed Projects Presentations

ISSE makes annual funding available for multi-disciplinary, multi-investigator research and support. Each year, ISSE awards three or four seed grants to support research projects that are related to environmental sustainability. The aim is to support project teams as they develop interdisciplinary collaboration and build the capability to secure external funding. These projects were presented at this year's conference:

- Underground Hydrogen Storage, PI Anna Herring, Department of Civil and Environmental Engineering

- Aviation Fuels from Black Soldier Fly, PI Toni Wang, Department of Food Science, UTIA

- Integration of Hydrogen and Grids, PI Kai Sun, Department of Electrical Engineering and Computer Science

- Micromobility Vehicle Second-Life Battery Applications, PI Chris Cherry, Department of Civil and Environmental Engineering

- Assessing levels of PFAS in surface water in Tennessee aquatic ecosystems, PI Jiangang Chen, Department of Public Health

- Identification of novel pathways for bacterial degradation of PAHs, PI Alison Buchan, Department of Microbiology

- Utilization of waste plastics for sustainable and durable asphalt pavements, PI Baoshan Huang, Department of Civil and Environmental Engineering

Reports from ISSE Partners

Three of ISSE's industry partners presented their work that is relevant to the ISSE mission:

- Tennessee Volunteer Emission Reduction Strategy, Rachael Maitland, Senior Policy Analyst, TDEC Office of Policy & Planning

- Eastman's Sustainability Platform and Goals, Becky Horton, Eastman Chemical Company

- UT-ORII Convergence Research Initiatives, David Sholl, Interim Executive Director, UT-ORII

Student Poster Contest

Repeating a popular element of last year's conference, students involved in ISSE research competed in a poster presentation, and awards were given during the wrap-up luncheon.

- 1st Prize, Ghada Diab, Enhancing Site Scale Bioretention Modeling to Investigate Watershed Scale Restoration

- 2nd Prize, Anirban Roy, Understanding Efficient Hydrogen Production via Water Electrolysis

- 3rd Prize, Weitian Wang, 3D Structured Liquid/Gas Diffusion Layers with Flow Enhanced Microchannels for Proton Exchange Membrane Electrolyzers
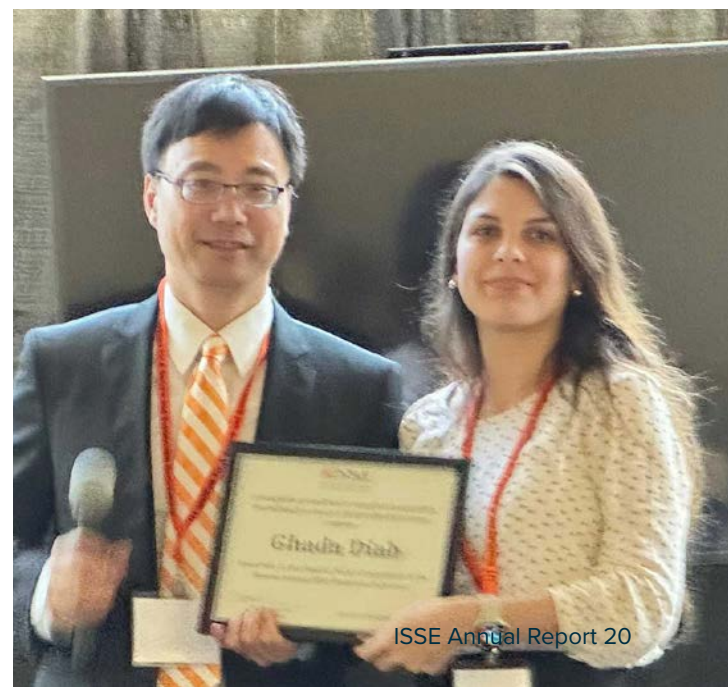
ISSE Research

Clean Energy & Energy Efficiency

TDOT I-40 Alt Fuels Continuation, Jonathan Overly, PI

East Tennessee Clean Fuels Coalition worked with TDOT 2021 through 2023 as a follow-up to a project partnership along I-40 across Arkansas, Tennessee, and North Carolina. The follow-up work focused solely on electric vehicle (EV) charging and compressed natural gas (CNG) refueling locations. With the release of the NEVI funding, the EV charging work to precedence and documents like an Inter-Agency Matrix, a How-To Guide for Local Station Deployment, and Sustainable EVSE Funding Strategies were developed, as well as an extensive list of both gap and site criteria that TDOT could use to evaluate future proposals for NEVI funding.

Utilizing coal-derived solid carbon materials towards next-generation smart and multifunction pavements, Nick Zhou, PI

The purpose of this project is to create and validate an innovative multifunctional smart pavement system. This system will incorporate solid carbon derived from coal, enabling integrated de-icing, self- sensing, and healing induced by microwave, induction, and Ohmic heating. The overarching goal is to offer a cost-effective, resource-efficient, and reliable solution to tackle the challenges of safety, mobility, and resilience on bridges and roadways affected by harsh, snowy winter conditions. Specifically, Phase I research will concentrate on evaluating and demonstrating the technical and economic viability of the proposed system.

Completed tasks:

Tasks 1 & 2: These tasks, focused on an in-depth economic analysis, probe the market needs to ensure the proposed system aligns with current demands, fostering its subsequent adoption and success in the market.

Task 3: This task concentrates on delineating the processing-structure-property relationships for coal-derived carbon. The purpose is to pinpoint the most suitable coal-char types for pavement construction, enabling the refinement of the multifunctional pavement system.

Task 4: This task studied the extensive design, characterization, and demonstration of the pavement material, enabled by the optimized coal-char. It involves the formulation of a robust physics-based model to guide the design and optimization of the pavement layer layup, ensuring its resilience and functionality.

Ongoing task:

Task 5: The final task addresses vital considerations related to scale-up and constructability. It encompasses system-level prototyping and rigorous validation using an accelerated pavement tester to confirm the feasibility and reliability of the proposed system on a larger scale.

In this quarter, the thermal energy storage capacity test was made to perform the energy storage capacity of CPM encapsulated coke particles, as the support to give the foundation of building the multi-functional asphalt pavement construction (Self-sensing, de-icing, and TES capable). The team evaluated and compared the heat generation efficiency of electrically conductive asphalt mixture (ECAM) using coke aggregate with the traditional ECAM utilizing carbon fiber (the separate mix design of both types of ECAM at the optimum content of coke aggregate or carbon fiber have been reported in the previous quarter report). The team has prepared the construction of snow-melting and deicing asphalt pavements using coke aggregate through site surveys.

ETCF staffers Ainsley Kelso and Jenni Kidd spoke with event visitors about Drive Electric Tennessee projects at the 2023 Knoxville Drive Electric Festival at Pellissippi State Community College.

Eco-friendly PCM materials were integrated into concrete and structural buildings to enhance thermal storage capacity and mitigate indoor air temperature fluctuations [1,2]. Building upon this, the encapsulation of PCM emerges as an efficient technique to conserve energy and decrease energy consumption by offsetting excess load during peak times [3,4]. In this study, macro-encapsulated PCM was employed to explore its application in conductive asphalt pavement construction. Here, carbon-based coke particles, infused with organic PCM29 [5] and coated with an epoxy film, acted as "ice-beans." They were combined with standard asphalt aggregates to forge a thermal energy storage capability, subsequently bolstering the freeze-thaw resistance of asphalt concrete. A thermal test was conducted to authenticate the thermal performance of these encapsulated PCMs and to evaluate their prospective utility as thermal-storage binders in asphalt pavement.

Theoretically, the energy storage capacity is composed of both latent and sensible heat energy. For pure coke particles, the storage of sensible heat is predominant due to the particle-packing of homogeneous solid carbon particles. Within the specific temperature range of 10 to 50°C, it is challenging to store latent heat energy as there is no phase transition occurring. However, when considering coke encapsulated with PCM, a large amount of energy can be captured during the phase change process. This process is driven by an increase in Gibbs free energy as the PCM transitions from liquid to solid phase. In this scenario, it is anticipated that the temperature change over time will increase linearly during the sensible energy storage range and keep stable during the latent energy storage range. According to Equations (1) and (2), the temperature is expected to remain nearly constant at the PCM's melting temperature, 29°C.

ETISE

East Tennessee Initiative for Smart Energy Management: Smart Manufacturing for Energy Efficiency and Carbon Emission Reduction, Mingzhou Jin, PI

Supported by the Industrial Efficiency & Decarbonization Office at Department of Energy (DOE), an ISSE team, together with UT Center for Industrial Service and Oak Ridge National, launched the East Tennessee Initiative for Smart Energy Management (ETISE) in April 2023. The goal of ETISE is to create a regional model for technical assistance and workforce training to effectively integrate smart manufacturing in energy management systems into energy-related business practices. Using East Tennessee as a test bed, ETISE will aim to three objectives: 1) understand the SM implementation for energy management by industries and sizes in the region, 2) develop a technical assistance and workforce training model at the regional level through ground service to manufacturers in East Tennessee, and 3) provide DOE strategic suggestions and materials to promote the adoption of SM for energy management. Based on the previous research on the smart manufacturing maturity models, ETISE is conducting a survey ETISE is conducting a survey among small and medium enterprise (SME) manufacturers in the East Tennessee region to understand their smart manufacturing implementation for energy management and emission reduction. Over two years, ETISE will provide more than 12 technical assistances to some of the 2,200 manufacturers with fewer than 500 employees in East Tennessee. In November 2023, ETISE will have a workshop and training session to create awareness and provide knowledge and skills for SMEs related to smart energy management and ISO 50001.

Climate Change

Estimating Soil Organic Carbon Changes from SAF Feedstock Production in the US with Integrative Satellite Data and Machine Learning, Joshua Fu, PI

We have now compiled our georeferenced dataset for the machine learning portion of our project. We have harmonized 29,979 complete soil profiles in the US (Figure 1) from six different databases that include these variables:

1. Measurements of 0-30 cm SOC
2. Previous five years of NDVI 5th, 50th, and 95th percentile
3. Previous five years of land use
4. Previous five years of precipitation and snow
5. Previous five years of minimum and maximum temperatures
6. Slope, aspect, elevation
7. Bedrock geology

We are now refining the models and comparing how well they can interpolate SOC in the US annually, based

on the root mean squared error (RMSE), mean absolute error (MAE), R² values, and the slope of the predicted vs. observed line.

Soil moisture, wildfires, vegetation, and droughts, ISSE researchers and graduate students under direction of Mingzhou Jin, PI

Current knowledge of the spatiotemporal patterns of changes in soil moisture-based terrestrial aridity has considerable uncertainty. The team formed by researchers at ISSE and Oak Ridge National Lab found widespread drying in the global midlatitudes and wetting in the northern subtropics and in spring between 45°N–65°N, during 1971–2016. Using Standardized Soil Moisture Index (SSI) calculated from multi-source merged data sets, the team conducted a formal detection and attribution analysis to show that human forcings, especially greenhouse gases, contribute significantly to the changes in 0–10 cm SSI during August–November, and 0–100 cm during September–April. The team further developed and applied an emergent constraint method on the future SSI's signal-to-noise (S/N) ratios and trends under the Shared Socioeconomic Pathway 5-8.5. The results show continued significant presence of human forcings and more rapid drying in 0–10 cm than 0–100 cm. Our findings highlight the predominant human contributions to spatiotemporally heterogenous terrestrial aridification, providing a basis for drought and flood risk management.

Contemporary fire dynamics is one of the most complex and least understood land surface phenomena. Global fire controls related to climate, vegetation, and anthropogenic activity are usually intertwined, and difficult to disentangle in a quantitative way. The ISSE and ORNL team leveraged an ensemble of five machine learning (ML) models and multiple satellite-based observations to conduct global fire modeling for three fire metrics (burned area,

fire number, and fire size), and quantified driving mechanisms underlying annual fire changes in a spatially resolved manner for the period 2003–2019. Ensemble learning is a meta-approach that combines multiple ML predictions to improve accuracy, robustness, and generalization performance. We found that the optimized ensemble ML well reproduced annual dynamics of global burned area, total fire numbers, and averaged fire size. Additionally, the

ensemble ML captured key spatial patterns of multi-year mean magnitudes, annual variabilities, anomalies, and trends for different fire metrics. The resulting ML-based fire attributions further highlighted the dominant role of enhanced anthropogenic activity in reducing global burned area, followed by climate control, and insignificant positive vegetation control. Spatially, climate dominated a much larger burned area (53.7%) than human (23.4%) or
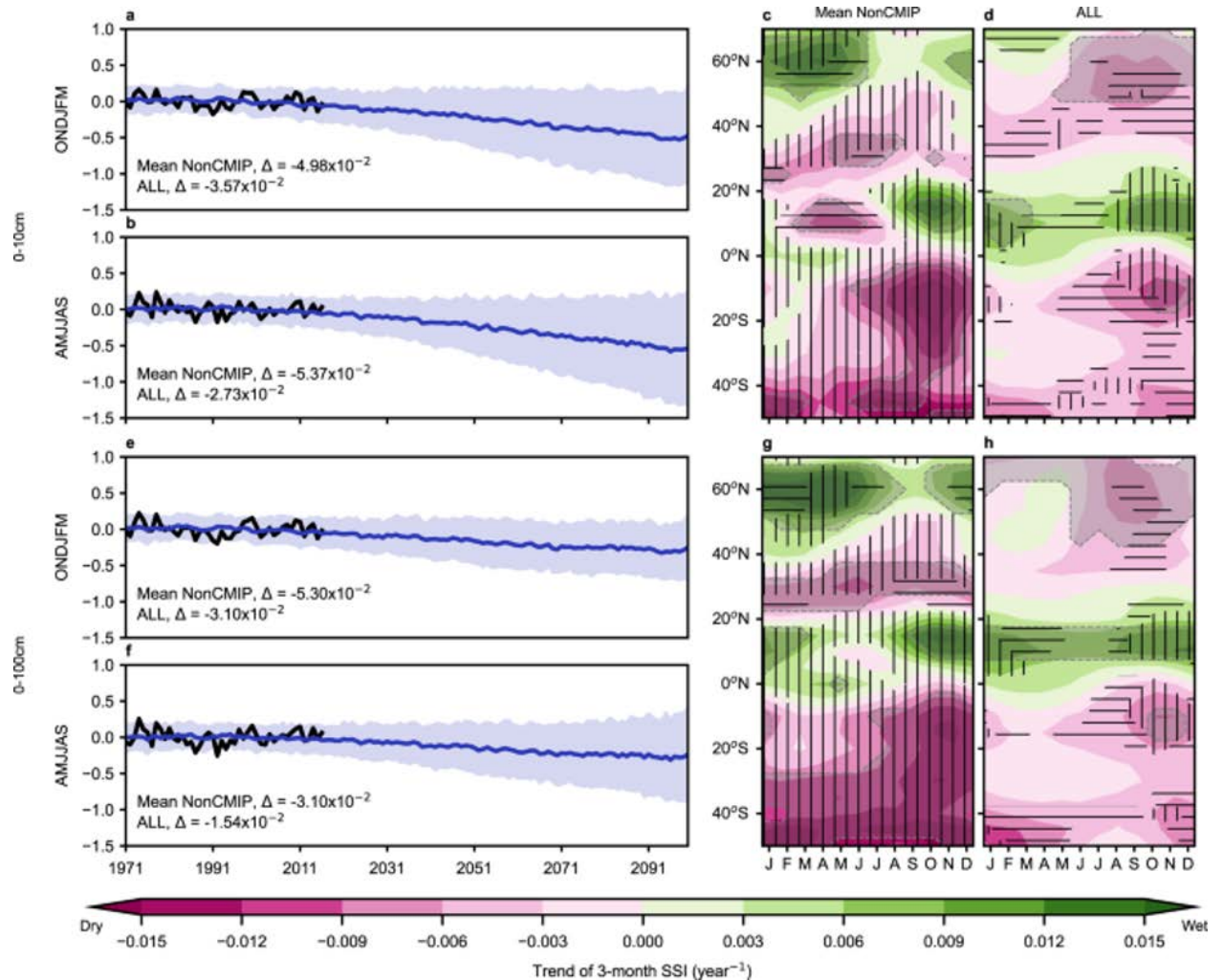

above: Historical and future evolution of the 3-month Standardized Soil Moisture Index (SSI) in the 0–10 cm and 0–100 cm soil layers.
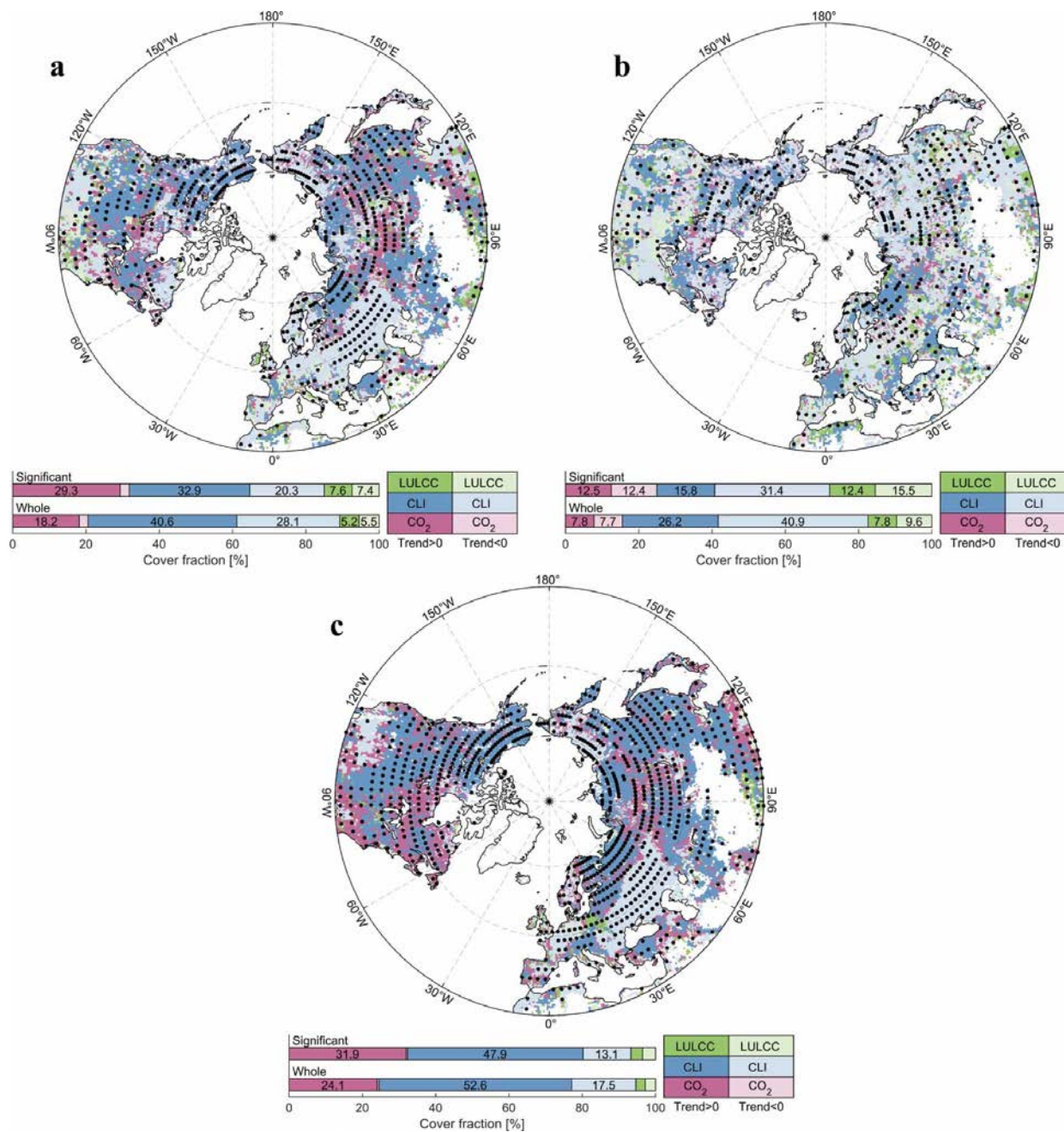
vegetation control (22.9%); however, the counteracting effects from regional wetting and drying trends weakened the net climate impacts on global burned area. The fire number and fire size exhibited similar spatial control patterns with burned area; globally, however, fire number tended to be more affected by climate while fire size more influenced by human activities. Overall, the study confirmed the feasibility and efficiency of ensemble ML in global fire modeling and subsequent control attributions, providing a better understanding of contemporary fire regimes and contributing to robust fire projections in a changing environment. The study results were reported in a recent paper published in Science of Remote Sensing.

In addition, the team studied vegetation seasonality in the northern extratropical latitudes (NEL) and how it responds to climate change (e.g. temperature, soil moisture, shortwave radiation) and human activities (e.g. elevated CO_2 concentration) remains insufficient. The team used two remote-sensing-based leaf area index and factorial simulations from the TRENDY models to attribute the changes in the integrated vegetation seasonality index (S), which captures both the concentration and magnitude of vegetation growth throughout the year, to climate, CO_2, and land use and land cover change (LULCC). The team found that from 2003 to 2020, the enhanced average S in the NEL was primarily determined by the elevated CO_2 concentration and secondly controlled by the combined climate change. Geographically, negative trends in the vegetation growth concentration were dominated by climate change (31.4%), while both climate change (47.9%) and CO_2 (31.9%) contributed to the enhanced magnitude of vegetation growth. Furthermore, around 60% of the study areas showed that simulated major climatic drivers of S variability exhibited the same dominant factor as observed in either the MODIS or GLOBMAP data.
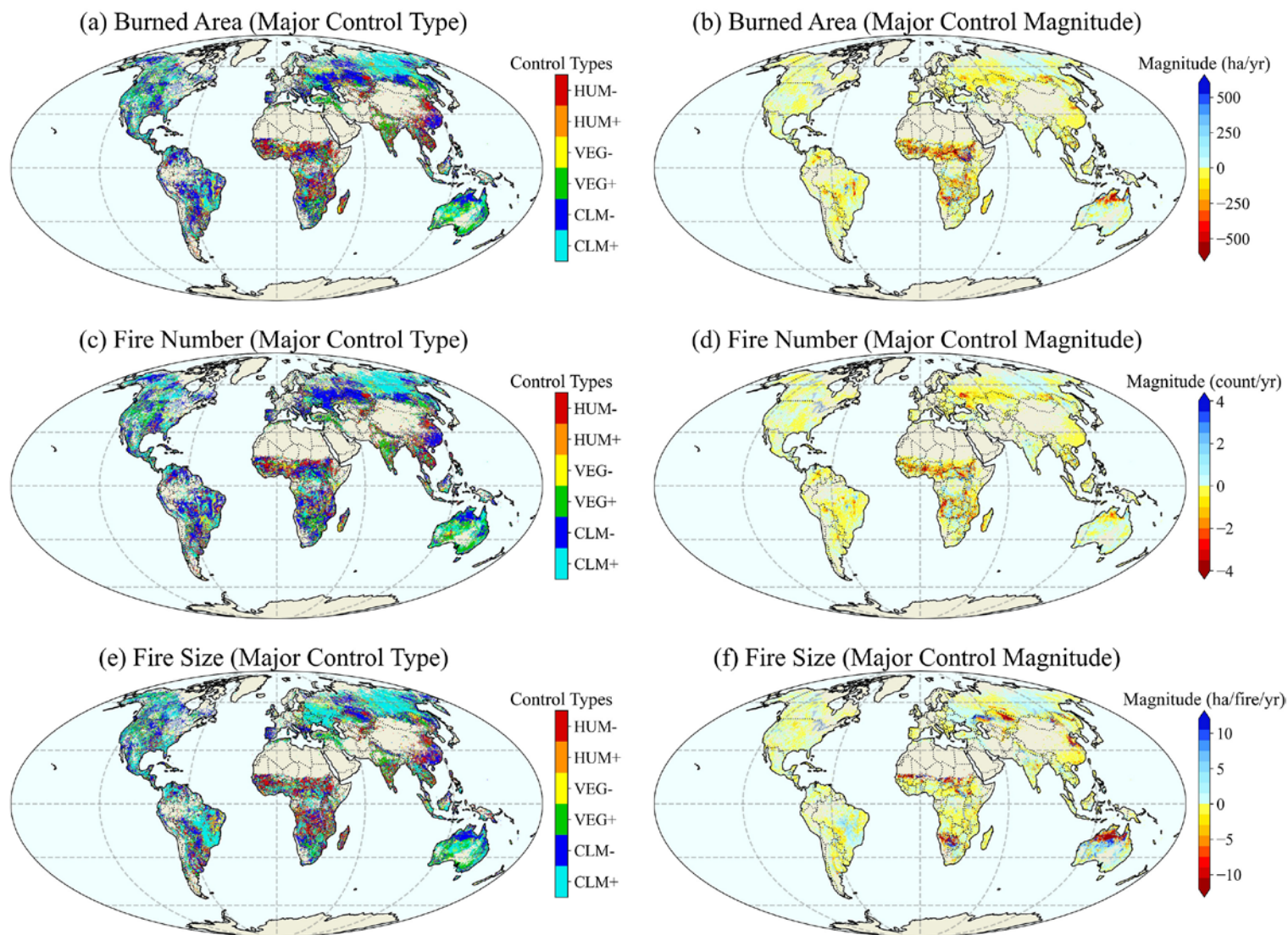
- The research emphasizes the crucial connection between environmental factors and vegetation seasonality, providing valuable insights for policymakers and land managers in developing sustainable ecosystem management strategies amidst a changing climate.
- The results will appear in a paper published in Environmental Research Letters.

(a) Burned Area (Major Control Type)
(b) Burned Area (Major Control Magnitude)
(c) Fire Number (Major Control Type)
(d) Fire Number (Major Control Magnitude)
(e) Fire Size (Major Control Type)
(f) Fire Size (Major Control Magnitude)

left: Spatial pattern of dominant drivers of the trend in vegetation seasonality anomalies. (a)–(c), Dominant driving factors of the trend in vegetation seasonality index anomalies (a), relative entropy anomalies (b), or normalized annual LAI anomalies (c), defined as the driver that induced the highest absolute trend in each grid cell. Regions labeled by black dots indicate trends induced by the dominant driving factor that are statistically significant (p < 0.1). Trend in seasonality index anomalies/relative entropy anomalies/normalized annual LAI anomalies derived by CO_2 fertilization (CO2), climate change (CLI), and land use and land cover change (LULCC).

Regional Sustainability

SRS RN: People-Centric Integrated Assessment Model for Regional Sustainability (PIAMRS): Focusing on the Central Appalachian Region, PI Mingzhou Jin

This planning grant aims to develop and submit a quality Track-1 proposal for building a research network (RN) for the NSF Sustainable Regional Systems program. The goal of the RN is to co-produce a People-Centric Integrated Assessment Model for Regional Sustainability (PIAMRS) with stakeholders for the Central Appalachian region in six years through convergent research involving multiple institutes and disciplines. Applications of PIAMRS will help transform the region from a traditional resource-based economy into a modern sustainable system and generate a new understanding of the co-benefits and trade-offs among multiple outcomes and new theories of changes.

The team conducted a two-day PIAMRS Workshop scheduled during April 3–4, 2023 and shared its progress at National Science Foundation in June 2023. The workshop engaged various stakeholders, including the Tennessee Department of Environment and Conservation,

the Sustainability office of Knoxville, Oak Ridge National Lab, Seven States, East Tennessee Clean Fuel Coalitions, TVA, Three3, etc. The workshop discussed the issues in Appalachia, sustainability opportunities in South Central Appalachian, municipal decarbonization efforts and bio-economy in Appalachia, data availability for evaluating the sustainability of Central Appalachia, datasets relevant to People-Centric Integrated Assessment Modelling in Central Appalachian, regional net zero measurement, and data for Integrated Assessment Modeling. The workshop also ran three charrettes to define socioeconomic metrics, ecologic and environmental metrics, and possible policies and sustainability pathways for Central Appalachia.

Water Research

Understanding the Long-term Effects of Stream Acidification in the Great Smoky Mountains National Park, John Schwartz, PI

Research on stream water quality from long-term effects of acid depositions continues in the Great Smoky Mountains National Park (GRSM). Water quality among GRSM streams is showing slight improvements in some watersheds, however many remain acidified from soils that have been depleted from calcium and other base cations. Our data was observed shifts in biogeochemical processes causing continued acidification associated with soil carbon dynamics. Jason Brown at the TNWRRC manages the water quality monitoring program and has produced a manuscript on a park-wide survey of stream dissolved organic carbon and the continuation of organic acids to continued stream acidification.

Urban Waters Report Card for Tennessee Stormwater Programs, John Schwartz, PI

TNWWRC continues to work with the stormwater (MS4) programs in Nashville Metro, the cities of Chattanooga and Memphis, and counites of Knox, Hamilton, and Shelby, and TDEC staff to develop an Urban Waters Report Card (UWRC). The working group has finalized the parameters that will go into the UWRC with four categories related to water quality, watershed hydrology, stream corridor, and community values. During the 2023 summer, a team at the TNWRRC completed stream surveys and desktop data summaries to beta-test the UWRC. Results of this effort were presented to the working group on September 20th in Murfreesboro to discuss any changes to the grading scales proposed for each parameter in the UWRC.

US Geological Survey 104b Program

This fiscal year three research projects have been funded through the USGS 104b funds that come to the TNWRRC. The three awardees are:

1. Drs. Stephanie DeVries and Ashley Manning-Berg; University of Tennessee, Chattanooga, Department of Geography. Title: Optimizing sampling and processing techniques for improved microplastic source determi-nation in Tennessee waterways.

2. Drs. Emine Finan, Hao Gan, and Shawn Hawkins; UT Institute of Agriculture, Department of Biosystems Engineering & Soil Science. Title: Quantifying Agri-cultural Water Use in Tennessee and Assessing Areas of Potential Water Availability Concern.

3. Dr. Haochen Li; University of Tennessee, Knoxville, Department of Civil & Environmental Engineering. Title: Reconstruct Missing Data in Water Systems with Machine Learning.

Ian Simpson and Matthew Tolson conduct a stream survey to beta-test the UWRC on Turkey Creek in Farragut, Tennessee.

Urban floodplain reconnection through regenerative stormwater conveyances, Jon Hathaway PI

In natural systems, stormwater moves to streams and river networks by way of floodplains, wetlands, and riparian forests which offer treatment and runoff detention. As watersheds are urbanized, these natural flow paths are short circuited by storm drains and pipes that bypass these ecosystem services. This causes increased peak flows in receiving waters with subsequent erosion, volume control, and pollutant problems.

Regenerative stormwater conveyances (RSCs) are an emerging design solution for urban runoff to decrease flow energy, increase infiltration rates, and remove pollutants. Positioned at the stormwater outfall, RSCs comprise an open channel step-pool system lined with vegetation and are sized to fully contain the 100-year storm. These pools are separated by riffle and weir boulder structures to safely convey water during large storm events.

Studies that help identify links between RSCs and local groundwater systems and studies that provide scientifically informed design guidance are limited in scientific literature. The objectives of this project are to: (1) site, design, and create a floodplain wetland using RSC-style natural system design, (2) establish the quality and abundance of wetlands created by the Enhanced RSC installation, (3) develop design guidance for Enhanced RSCs used to reconnect urban watersheds to floodplains and recreated wetlands, and a wetland functional tool to assess restoration outcomes, and (4) use workshops and webinars to educate regulators, designers, and other academics about the use of Enhanced RSCs for wetland restoration.

During this project period, the RSC was constructed at the site. Stakeholders were engaged before construction began to ensure concerns over disturbances in the park would be minimized. Construction was supervised by PhD student Gillian Palino with support from PIs Hathaway, Ludwig, and Schwartz. After construction, Dr. Ludwig assembled a group of volunteers to plant the system with native vegetation. Since construction, the system has maintained stability during heavy rains.

After construction, monitoring of the system hydrology continues. This before-and-after monitoring plan will allow an assessment of the impact on local hydrology. This design process has refined understanding of best practices for RSC design that can be incorporated into guidance documents.

Data collection is underway at the site. We anticipate positive environmental outcomes from the RSC installation, i.e., reduced erosion and increased infiltration to the groundwater system, but this monitoring will allow quantification of these outcomes.

top left: Pre-planting meeting with RSC volunteers.
bottom left: Project after construction, picture taken from stormwater outfall down to middle and lower cells.

Dynamic Evolution of Pore Water-Air Interaction Within Saturated Sheared Sand, Khalid Alshibli PI

The objectives of this research are to monitor solid-water-air interaction within sheared sand under drained condition, to examine the accuracy of the current specimen saturation procedure in yielding fully saturated ATC specimens, and to monitor the change in degree of saturation of sheared sand. Seventeen miniature axisymmetric Triaxial Compression experiments coupled with 3D Synchrotron Micro-Computed Tomography (SMT) imaging were performed at the Advanced Photon Source (APS). One of the objectives of the experiments was to investigate the influence of back pressure (BP) value on the degree of saturation of sheared sand, preliminary investigation of results indicated that the SMT scanning setup and duration play a critical role in the development of gas bubbles within specimens. Four additional experiments using acrylic tubes were conducted to better understand and isolate the effect of x-ray exposure on the specimens.

Specific Objectives

The specific objective for the last year was to investigate the source of the onset of the gas phase within the saturated sand specimens by designing experiments to isolate the influence of x-ray exposure on the development of the gas phase. Specimens of sand were deposited in acrylic tubes and were saturated with deaired and not deaired water and were subjected to 30-minute exposure to x-ray to investigate the effects of x-ray exposure on the onset of the gas phase. In addition, the research team made two trips to APS to conduct more ATC experiments to investigate the effects of drainage (drained versus undrained) and back pressure on the behavior of sheared sand.

Significant results

Analysis of ATC and acrylic tube experiments revealed the following:

1. X-ray exposure may result in the development of gas bubbles due to radiolysis of pore water, the breakdown of water to Hydrogen and Oxygen results in phase change from liquid to gas resulting in gas bubbles developing. The phase changes were dependent on the initial pore water pressure and duration of exposure to the x-ray, with individual gas bubble behavior being dependent on its surrounding sand grains and pore throat sizes leading to changes in the degree of saturation (Fig. 1).

2. Specimens are typically assumed to exhibit no volumetric changes when undrained triaxial experiments are performed on saturated soils. The analysis of both high and low BP undrained experiments scans showed the specimens undergoing volume changes (Fig. 2). Part of the observed volume change was attributed to the water phase which was not expected raising the question of the validity of no volume change assumption for undrained experiments even if the sheared specimen remained fully saturated.

3. Comparison between high and low BP experiments for both drained and undrained conditions revealed that low BP experiments exhibited a significant change in the degree of saturation reaching a 12% change in the degree of saturation in some cases while high BP experiments showed a small variation in the degree of saturation. The reduction in the degree of saturation was due to an increase in air volume within the specimen pore space. Utilizing the acrylic tubes experiments results, the increase in air (gas) volume was determined to be beyond the x-ray exposure effect indicating that shearing of low BP saturated sands results in saturation degree reduction.

New Awards

ISSE & UT to lead U.S.-Japan Exchange Program sponsored by US Embassy in Tokyo

The partnership between Japan and the United States is longstanding and significant. It allows the best of both country's higher education institutions to develop strategies and solutions to promote interdisciplinary problem-solving for global grand challenges. The University of Tennessee (UT) will lead the collaboration between Japan and the USA in an academic, interdisciplinary platform called EXCET (U.S-Japan Exchange Program for Green Growth Collaboration through Clean Energy Technologies). The purpose of EXCET is to encourage communication and collaboration with researchers on issues of renewable energy, green energy, and environmental and energy justice issues.

EXCET will make policy recommendations and identify concrete strategies to promote sustainable, economic, and social development in Japan and the U.S. The UT team and their Japanese counterparts will work together to host workshops, visits, and student and faculty exchanges that will further EXCET's goals of idea generation through collaboration. Experts from Japan and the US will connect to generate ideas from the perspectives of social science and engineering fields to find many different solutions. The UT team is Drs. Mingzhou Jin, Chien-fei Chen, and Kevin Tomsovic.

EPA Awards TNWRRC $1 Million for Community Wastewater Challenges

Tennessee Water Resources Research Center will help rural, small, and Tribal communities plan for and access funding from the Infrastructure Investment and Jobs Act and other sources. EPA's grant funding will be used to assess communities' most pressing challenges, provide training on water infrastructure and management best practices, help communities navigate the federal funding application process, and strategically invest in reliable infrastructure solutions. Dr. John Schwartz, TNWRRC director, is the PI.

Southeast Center for Just, Resilient, and Sustainable Ecosystems (SECURE)

The overarching aim of this interdisciplinary planning grant from NSF is to advance convergent and use-inspired research, education, and outreach ecosystems for mitigating climate impacts and developing solutions that strengthen the power grid, built environment, transportation, and health infrastructures with the integration of social-behavioral, technological, policy, and community engagement factors. The goals are to develop the solutions that strengthen the power grid, built environment, transportation, and health infrastructures with the integration of social-behavioral, technological, policy, and community engagement factors; build a user-inspired research enterprise ecosystem in advancing resilience and equity by expanding collaborations; and establish community engagement to empowers traditionally excluded groups from vulnerable regions to be part of the decision-making. Dr. Chien-fei Chen is the PI.

Wellcome Trust Foundation funds Environmental Health project

With Dr. Chien-fei Chen as the PI, this Equitable Energy Security and Environmental Health project will provide climate mitigation solutions, i.e., community microgrids and weatherization with electrification to reduce energy burdens and greenhouse gas emissions, and improve physical and mental health for underserved communities, including low-to-moderate income households. The project goals are to understand disadvantages of household energy burdens and health infrastructure inequalities among urban low-to-moderate income communities, create a community co-designed clean energy pathway and engagement plan, focusing on local voices for policy implementations and a research model for a local project to scale up to a national level.

Center for Freight Transportation for Efficient & Resilient Supply Chain (FERSC)

FERSC is a Tier 1 University Transportation Center consortium led by the University of Tennessee, Knoxville. Its focus is the Infrastructure Investment and Jobs Act (IIJA)'s research priority, **Improving Mobility of People and Goods** as its primary area. The consortium supports the DOT Strategic Goals of Economic Strength and Global Competitiveness as the primary focus and Equity and Transformation as the secondaries. FERSC Partners are University of Tennessee, University of Illinois Chicago, Oregon State University, California State University Long Beach, North Carolina A&T, and Texas A&M University.

Seed Grants

Beat the heat: Building adaptive capacity of vulnerable populations in Knox County to combined stressors from climate change and urban heat

Research Team Members: Kelsey Ellis, Department of Geography; Jennifer First, College of Social Work; Kristina Kintziger, Department of Public Health

Our work focused on nighttime heat, which is an important factor in heat-health outcomes. We assessed overnight heat in indoor and outdoor living spaces in Knoxville, Tennessee, using iButton hygrochrons in August 2021. Indoor sleep spaces reported a variety of overnight conditions, even within all air-conditioned homes. Indoor sleep spaces were both warmer and cooler than outdoor temperatures overnight, and some participants noted physical health effects of overnight heat in their homes.

Downtown outdoor sleep spaces, including a park and encampment, exhibited an urban heat island signal, staying warmer than other outdoor areas. We provide some recommendations for such future studies, including: 1. focus on purposeful sampling, 2. prepare for participant drop-off due to non-compliance and technological problems, and 3. strategically gather demographic information. We assessed local-level heat vulnerability and adaptive capacities in Knoxville, Tennessee via (1) quantitative data from surveying 422 community residents about their experiences with heat, and (2) qualitative data from in-depth meetings with 16 community stakeholders to identify needs and solutions in extreme heat planning, preparedness, and response, and (3) a city-wide intra-urban heat mapping campaign. Results found that some areas of Knoxville were almost 16 degrees hotter due to differences in impervious surfaces, lack of tree cover, green spaces, and interstate systems. Furthermore,

many survey participants indicated their health was negatively impacted by extreme heat, in particular, low-income and racial minorities faced greater disparities in heat-related health risks and barriers to cooling access. Findings support methods of engaging community members, especially those most vulnerable to heat, along with engaging stakeholders to identify local needs and solutions.

Assessing the levels of forever chemicals (PFAS) in surface water in Tennessee aquatic ecosystems

Jiangang Chen, Department of Public Health, Jayne Wu, Department of Electrical Engineering and Computer Sciences; Qiang He, Department of Civil and Environmental Engineering

Per- and Polyfluorinated Substances is a group of more than 4,000 chemicals with long half-life in the environment. While it is impossible to have a specific testing method for each individual PFAS, we have conducted a series of experiments to demonstrate that feasibility of using AC electrokinetic (ACEK)-enhanced capacitive sensing technology to detect total PFAS based on principle of F-F chemical bond interaction. Total PFAS in the environment should be a better indicator reflecting the overall environmental PFAS exposure in our environment. We also tested PFAS in drinking water samples and in surface water collected near a wastewater treatment plant. We have presented our preliminary results at ISSE annual conference during the funding period.

Currently, we are preparing a manuscript on the proof of the concept of ACEK based PFAS detection. We submitted one Letter of Intent to Foundation for Food & Agriculture Research (FFAR) proposing for PFAS detection but was not chosen. We are also exploring to submit the grant proposals to Smart Health and Biomedical Research in the Era of Artificial Intelligence and Advanced Data Science (SCH).

Training & Education

Tennessee Water Resources Research Center Training, Tim Gangaware

Since October 1, 2022, TNWRRC has offered eight different courses: Levels 1 and 2 of Tennessee Erosion Prevention and Sediment Control (TNEPSC) Training Program for Construction Sites plus a Level 1 and Level 2 TNEPSC Recertification courses; Tennessee Hydrologic Determination Training and its corresponding Recertification course; and the Storm Water Control Measure Inspection and Maintenance Workshop and Recertification Course.

TNWRRC has offered a total of 30 course sessions and trained 2,000 professionals in these workshops. The courses were a combination of virtual, online and in person training. TNEPSC offers three training workshops for developers, contractors, engineers, and other professionals, inspection personnel, and enforcement officials responsible for all aspects of preparation and implementation of Storm Water Pollution Prevention Plans for preventing erosion and controlling sediment at construction sites one acre or more in size.

Tennessee Hydrologic Determination Training is a course for conducting hydrologic determinations. Successful completion of the training course is one of the requirements for certification as a Qualified Hydrologic Professional.

Storm Water Control Measure Inspection and Maintenance Workshops are available to design engineers and architects as well as plan reviewers and other local municipal program personnel. They provide insights on avoidance and minimization approaches to site layout, design guidance on specific permanent stormwater control measures, and experience using tools developed to assist designers and plan reviewers with implementation of runoff reduction and pollutant removal requirements.

Tennessee Stream Quantification Tool, Tool Revision, and Development of a Training Course, John Schwartz and Tim Gangaware

The first version of the Tennessee Stream Quantitation Tool has been revised based on a two-year effort from a working group consisting of Tennessee Department of Environment and Conservation (TDEC), the US Army Corps of Engineers (USACE), and consultants. A pilot training was given between July 31st and August 3rd with staff from TDEC, USACOE Nashville and Memphis District Offices, and the Tennessee Department of Transportation.

Worker Health and Safety Training at Department of Energy (DOE) Facilities, Sheila Webster

The training is funded by a grant from the National Institute of Environmental Health and Sciences (NIEHS) and administered by the Partnership for Environmental Technology Education (PETE). UT has had a continual relationship with PETE and previously with Kirkwood Community College for over two decades.

The delivery of the online course has transitioned to the Roane State Community College (RSCC) campus near the Y-12 complex and other DOE facilities.

Data provided by RSCC was analyzed by the ISSE for the training surveys: "End-of-Course" and "Workplace Follow-Up". Institute for Secure and Sustainable Environment's (ISSE) primary role was to obtain feedback and determine impact of the HAZWOPER ONLINE training in the workplace.

Due to numerous unresolved technical issues with the survey provider, UT researched extensively other survey options. The issue was resolved by the ISSE team developing a custom "End-of-Course" survey to be embedded into the HAZWOPER online course, which students complete as soon as they finish. The survey was provided to PETE to embed in the online course.

To determine how training is applied in the workplace and how it benefits the employee and the employer. ISSE observed classroom training at RSCC. The "Follow-Up" survey was set up to automatically send to participants 60 days after training. The new automated system provides results directly to UT for analysis. This automation helped to resolve the security block of communication that occurs at DOE facilities.

Dr. Sheila Webster presented on models used for follow-up activities to an annual National Trainers Exchange and Awardee Meeting in May 2023 by the NIEHS. The meeting had a theme of "Emerging Workplace Hazards: Creating Adaptable and Innovative Safety and Health Training."

USDA Appalachian Community Technical Assistance and Training Program (ACTAT), Steven Hoagland

The purpose of the ACTAT Program is to improve drinking water and wastewater systems (i.e., water utilities) that are essential to public health and economic development. Many rural Appalachian communities are deeply entrenched in poverty and suffer from declining populations due to the downturn in the coal industry and the closure of major employers. They lack employment opportunities, resources, and enough capital to provide and sustain compliant water and wastewater services for their citizens and to support economic development activities.

In response, the Appalachian Community Technical Assistance and Training Program (ACTAT) builds on over 30 years of service originally established by the National Environmental Services Center (NESC) at West Virginia University (WVU). Work is completed by faculty and staff at the University of Kentucky (UKY), the University of Tennessee-Knoxville (UTK) TNWRRC, and WVU matching appropriate experts in engineering, business and management, law, public health, communications, education, and stakeholder engagement to personalize training and technical assistance responses.

The ACTAT program employs multiple strategies to achieve project goals and objectives including customized, on-site technical assistance at water utilities, regional in-person and virtual trainings, and the development and distribution of educational materials. The ACTAT program is utility-driven providing flexible assistance and educational options to meet utility-specific needs to small rural water utilities throughout Kentucky (KY), Tennessee (TN), and West Virginia (WV). The TNWRRC has helped several communities in east Tennessee, and now is developing a survey of needs to be completed by the rural utilities.

Outreach & Collaboration

ETCF Outreach, Jonathan Overly

East Tennessee Clean Fuels (ETCF) hosts and participates in many outreach opportunities throughout the year, from direct outreach to school districts, aiding them in applying for Clean School Bus funding to helping host several National Drive Electric Week (NDEW) events. ETCF has reached fleets, organizations, and individuals throughout Tennessee in the past year thanks to programs such as Reducing Diesel Emissions for a Healthier Tennessee (RDE4HT) and Drive Electric Tennessee (DET).

Through DET, in 2023 we hosted our "Driving EV Leadership" workshops for multiple utility partners across the state: Memphis Light, Gas, Water (MLGW) on May 25; for Morristown Utilities on June 22; and for PES Energize in Pulaski, Tennessee on July 19. We also hosted the first Drive Electric Tennessee Momentum Summit on November 7, 2022, and the Sustainable Transportation Forum & Expo on November 8-9, 2022, in Knoxville. Both events had great turnouts and were successful. Finally, we aided in hosting several Drive Electric Earth Day (DEED) events in April 2023 and several NDEW events in September and October 2023. Overall, we had a robust year of outreach, and we plan to continue building upon these successes in the new year.

TNWRRC Information Transfer Program, Tim Gangaware

The major emphasis of the information transfer program during FY 2022 was on technical publication support, conference planning and development, and improvement in the information transfer network. The purpose of the program was to support the objectives of the technical research performed under the FY 2021 Water Resources Research Institute Program. During the FY 2021 grant period, a major focus of the information transfer activities was on the participation of the Center staff in the planning and implementation of several statewide conferences and training workshops.

As an on-going sponsor, TNWRRC was involved in the planning and implementation of the 30th Tennessee Water Resources Symposium. The goals of the symposium are: (1) to provide a forum for practitioners, regulators, educators, and researchers in water resources to exchange ideas and provide technology transfer activities, and (2) to encourage cooperation among the diverse range of water professionals in the state. As with previous symposia, the 30th Symposium was very successful with 64 professional presentations and 37 student posters being presented online over the two-day period.

TNWRRC was a co-sponsor of the 2022 Tennessee Stormwater Association Annual Conference, held at Montgomery Bell State Park on October 18-20, 2022. Over 267 attended 53 professional presentations that covered a variety of topics including Green Infrastructure, FEMA Permitting and Grant Funding., Urban Waters Report Card, TN GIS Data Resources and How to ACE your MS4 Audit.

Appalachian Leadership, Tim Ezzell

ALI: The Appalachian Leadership Institute completed its first full year of in-person sessions and graduated its fourth year of fellows in Washington in July. The 2022-2023 class included a wide range of fellows – everyone from a Kentucky blogger to a Tennessee county mayor and a Georgia rural health entrepreneur. We also conducted two successful alumni events and the program now boasts almost 160 graduates. This fall we will launch year five of the Leadership Institute with a kickoff session in Fayetteville, West Virginia at America's newest National Park, the New River Gorge.

right: The Appalachian Leadership Institute Class of 2022-2023.

ACRI: Dr. Ezzell recently began his 21st Appalachian engagement class, now known as ARCI (the Appalachian Collegiate Research Initiative). This year's class, sponsored by the Appalachian Regional Commission, is helping communities in the tristate Cumberland Gap area develop ideas for an upcoming funding proposal. While the proposal will focus on outdoor recreation, the students are helping community member discuss related topics ranging from sustainability to hospitality training and entrepreneurial assistance.

ASPIRE: Dr. Ezzell continues to assist colleagues in the college of education with the ASPIRE program, a project that helps prepare rural Appalachian students for potential careers in health care and assists them and their families in transitioning to life at a college or university. Dr. Ezzell conducts training sessions on Appalachian culture and the Appalachian economy for team members and helps organize and facilitate a steering committee with rural educators.

In February 2023, Dr. Ezzell participated in a panel discussion on Appalachian Development at the Appalachian Carbon Forum in Gatlinburg. He was asked to serve on the Tennessee Department of Health's Community Impact Advisory Board.

Energy and Environmental Justice Related Workshops
The newly-established Energy & Environmental Justice Lab has hosted three workshops during this reporting period. EEJ Director Dr. Chien-fei Chen chaired these workshops.

• Workshop Chair of UTK Energy and Environmental Justice Workshop, Feb. 28th, 2023.

• Workshop Chair of NSF Sustainable Regional System Research Networks (SRS RN): Infrastruc-tures and social-economic policy factors in connecting rural and urban sustainability for the southern US (2nd workshop), University of Tennessee, August 18-19th, 2022

• Workshop co-Chair of NSF Sustainable Regional System Research Networks (SRS RN): Infra-structures and social-economic policy factors in connecting rural and urban sustainability for the southern US (1st workshop), Vanderbilt University, March 23rd-24th, 2022

UTK Research Centers Host Summer Camp for Local Middle Schoolers

During the week of July 10-14, the National Institute for Mathematical and Biological Synthesis (NIMBioS), the Institute for a Secure and Sustainable Environment (ISSE), the Center for Ultra-Wide-Area Resilient Electric Energy Transmission Networks (CURENT), and the University of Tennessee (UT) collaborated to host "Adventures in STEM," where middle school students learned concepts related to Science, Technology, Engineering, and Math (STEM) through fun, hands-on activities, teamwork, and field trips, while engaging with scientists and engineers.

The camp, designed for rising 7-9 grade students, focused on ecology, biodiversity, electric circuitry, renewable energy, solar and wind power, and more. Generous financial support came from Emerson Electric and Emerson Process Management, Knoxville, with additional support from NIMBioS.

The week kicked off with ice breakers and outdoor activities that used observations, inferences, and data collection to help students draw conclusions about the world around them using circuits, magnetism, and electric motors in hands-on activities.

This collaboration between academic, industry, and community partners, including educators, STEM graduate students, public school teachers, and field experts, allowed campers to learn about real world applications and how science and technology could shape their future. Campers talked with engineers and current undergraduate and graduate students to learn about their paths to a career in environmental engineering.

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Chen, Chien-fei, Keynote Speaker, Taiwan-US Net-Zero Justice Transition Workshop—Challenges and Solutions of Improving Equity, Urban Heat and Energy Transition in the Era of Global Boiling, September 11th, 2023, National Cheng Kung University, Taiwan.

Community Engagement and Energy and Environmental Justice and their Connection to DEI, February, 17, 2023, NSF Engineering Research Center DEI Director Meeting

Ellis, K. N., J. First, K. Kintziger, and E. Hunter: Beat the heat: Beat the heat: Building adaptive capacity of vulnerable populations in Knox County to combined stressors from climate change and urban heat. GEOSYM. 9 February 2023.

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Energy and Internet Insecurity Impacts and Justice, to Industry Program of CURENT, March 3rd, 2023, University of Tennessee

Energy and Internet Insecurity Impacts: A Mixed Methods Approach with Micro and Macro-level Analysis, February 15th, 2023, Department of Architecture Engineering, Penn State University

Energy Justice, Concentrated Disadvantage and Social-Psychological Factors Affecting Technology Adoption on February 28th, 2023, University of Idaho

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Hazen, T. C. Invited Webinar. Exxon Valdez vs. Deepwater Horizon and Considerations for Peru Repsol Spill. Online. Lima, Peru. January 27, 2022. Pontificia Universidad Católica del Perú. https://pucp.zoom.us/webinar/register/WN_fxuMvZBkT-manioIkjgJ_Qw

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ISSE Goals for 2023—24

Director's Goals, Mingzhou Jin

ISSE continues to make global and local impacts on all aspects of sustainability, from water, energy, green infrastructure, electric vehicles, regional development, food security, waste management, energy and environmental justice, to building environments. ISSE will engage more faculty members at UT and other high-level research institutions to conduct interdisciplinary research and provide solutions to pressing issues faced by people and societies. Globally, ISSE will increase its international research collaborations with our partners in Japan, the United Kingdom, Argentina, and many others. The research collaboration with Oak Ridge National Lab on global climate change will continue, investigating droughts, floods, soil moisture, wildfires, and vegetation vulnerability.

With the large grants from Wellcome Trust, US Department of Agriculture, and Environmental Protection Agency, ISSE will grow its research and outreach activities focusing on people, especially those in disadvantaged areas. Working with community-based organizations, ISSE will reach communities and co-produce solutions with them to improve environmental justice and sustainability through clean energy transition, better wastewater treatment, and gravel tree stormwater systems. East Tennessee Clean Fuels will continue to be the national leader promoting the adoption of EV and other alternative fuel vehicles. ISSE also plans to engage more local corporations and governments, helping them achieve net-zero goals.

Besides research, ISSE plans to grow its training programs through its TN Water Resource Research Center and Appalachian Leadership Institute to better serve the State of Tennessee and the Appalachian region, continue to support graduate and undergraduate students to be ready for their careers, and engage high school and middle students to attract them into the STEM field.

East Tennessee Clean Fuels, Jonathan Overly

In the upcoming year, East Tennessee Clean Fuels plans to continue the steady growth of our Coalition by onboarding new team members and assistants, growing our membership and sponsorship programs, expanding the reach of the Drive Electric Tennessee program, finding innovative ways to highlight the successes of alternative fuel fleets in the state, participating in and leading many ongoing projects and future proposals, and continuing to act upon our commitment to equity in the clean fuels space. We plan to continue the progress of successful programs such as the EMPOWER Workplace Charging program and begin work on the Drive Electric USA 2.0 national project that was awarded to us last year.

We want to work towards expanding our current DriveElectricTN Chapters and create new chapters across Tennessee in regions with less access to electric vehicle education and outreach. Our Coalition will continue to focus on diversity, equity, and inclusion in all the projects we take on, including supporting the Clean Cities Energy Environmental Justice (CCEEJI) program and creating new relationships with Community-Based Organizations (CBOs). Finally, we hope to facilitate opportunities for our staff to learn and gain new skills in their fields that will positively impact the Coalition's mission.

Estimating Soil Organic Carbon Changes from SAF Feedstock Production in the US with Integrative Satellite Data and Machine Learning, Joshua Fu

We plan to continue refining the machine learning models and apply the best-performing model (e.g., the model with the lowest out-of-bag error) to predict SOC for the year across the CONUS on an annual basis. This will allow us to map SOC stocks from 1984-2022 and the rate of change over time as well as the trends in both climate and land use that help explain patterns in SOC. Then, we will compare our maps of modeled historical SOC to an ensemble of 6 dynamically downscaled Climate Intercomparison Project 6 (CMIP6) models. This will enable us to constrain future estimates of SOC at a 4km scale and highlight regions most and risk where interventions could significantly improve future SOC stocks.

Energy & Environmental Justice, Chien-fei Chen

As one of the newest initiatives at ISSE, we will look to strengthen our presence through these five areas:

1. Explore new local non-profit organizations and collaborate with experts and researchers from academia and industry across various fields.

2. Build a center for energy and environmental justice (EEJ) to broaden the impact on the Southeastern region for our NSF SECURE project.

3. Build an EV Equity Community Comprehensive Tool to measure social, behavioral, technological and policy factors affecting the adoption of electric vehicles.

4. Seek external founding opportunities to explore integration within the social science, engineering, and policy arenas.

5. Explore new ways to connect with research centers that will lead to greater international collaboration.

Paving the Way for a Sustainable Future

The project will move on to full scale demonstration and testing using UTK's Accelerated Pavement Tester (APT) facility. The experiments will help to understand the performance of this novel pavement system under simulated service conditions. This project will provide a promising pathway to rethink the use of the US domestic coal

resources by utilizing the low-cost, electrically conductive, and mechanically strong coal-derived solid carbon materials to produce infrastructural components. It does not require any change to existing paving equipment and process and makes it possible to produce multifunctional smart pavements at costs comparable to those of regular pavements.

Stormwater Management and Environmental Sustainability, Jon Hathaway

Over next year, our work will continue to evaluate stormwater control system function at both the site and watershed scales. This will require innovative approaches such as computational modeling, real time control, and highly interdisciplinary research. We will also continue to run the ISSE REU program sponsored by NSF, which has successfully trained a diverse cohort of 20 students thus far. A new project will begin focusing on urban forestry and its interactions with stormwater management and environmental sustainability. With this project, we will implement a number of tree-centric stormwater controls and also work to build workforce development and environmental awareness in East Knoxville.

REU Site: Green Infrastructure for Sustainable Urban Environments

During this project year, we will recruit another exception cohort of students to take part in the summer 2024 program. Based on the program evaluation conducted for summer 2023, we will modify our approach as needed to ensure knowledge transfer and an enriching experience for the REUs. Further, the top two students from 2023 will be invited to present their work at a national conference in 2024. Finally, we anticipate the work of the REU students will contribute to peer reviewed publications in the future.