THE UNIVERSITY of TENNESSEE
KNOXVILLE
Institute for a Secure & Sustainable Environment

ANNUAL REPORT AND JULY 2014 - JUNE 2015 APPROPRIATION REQUEST TO THE TENNESSEE HIGHER EDUCATION COMMISSION

ISSE *a Center of Excellence at The University of Tennessee*

July 2012 - June 2013
Annual Report

and

July 2014 - June 2015
Appropriation Request

to the

Tennessee Higher
Education Commission

September 2013

Institute for a Secure & Sustainable Environment

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Table of Contents

INTRODUCTION

Dr. Chris Cox, ISSE Director

The year 2012-2013 marked the first full year in which the Institute for a Secure and Sustainable Environment operated under its new financial model of emphasizing investment in tenured and tenure-track faculty research. As a result, faculty and student engagement doubled this year in comparison to last. Faculty members engaged by ISSE activities increased this year, up from 23 faculty members engaged last year to 46 faculty members engaged this year. As would be expected, the engagement of faculty resulted in a concomitant increase in student and post doc engagement, up from 16 last year to 33 this year. Publications showed a modest increase (up from 20 to 22), but we expect to see much more robust scholarship in future years as publications stemming from faculty-led research moves through the peer review process.

Two major faculty-led seed project initiatives began in 2012-2013. The first is the development of a multi-decade database that will enable researchers to examine environmental issues within the watersheds of the Tennessee Valley Authority (TVA) system in an integrated multifaceted manner. This interdisciplinary capacity-building effort is expected to increase the competitiveness of UT researchers on water related research. This effort is co-funded by ISSE and the UT Office of Research and Engagement through a competitive process, and a second year of support through this mechanism has recently been secured. Numerous grant applications and research manuscripts have begun to leverage the work of this seed project. The second initiative is a seed project aimed at producing feedstock and value-added chemicals from renewable biomass. In this project, four investigators, from three different departments are teaming to develop a process that includes pretreatment of the biomass and both chemical and biological catalytic processes for biomass component conversion. This project is cofounded by ISSE and UT's Sustainable Energy Education and Research Center (SEERC). A number of smaller faculty-led projects were completed or are on-going in the areas of biofuels, drinking water quality both in the developed and developing world, global methane reduction through wastewater treatment, international air quality, climate model validation, wetlands, and environmental education. The goals of these seed projects are to stimulate new interdisciplinary collaborations between faculty, to generate preliminary data to pursue competitive grant funding, and to support graduate education at UT. This year, ISSE also supported faculty research through acquisition of critical research equipment and instrumentation with the goal of increasing the capability of faculty researchers to pursue emerging areas of research.

Introduction (cont)

Many of the programs managed by ISSE's internal staff had very productive years in the outreach arena. The Tennessee Water Resources Research Center (TNWRRC) reached more than 3000 construction and stormwater professionals with its training, implemented three major stormwater management projects in communities in East Tennessee, and began developing new training materials to implement the next generation of advanced stormwater treatment. Outreach programs such as Adopt-A-Watershed and Tennessee Yards and Neighborhoods (soon to be renamed Tennessee Smart Yards) educated more than one thousand Tennesseans about water quality and protection. The East Tennessee Clean Fuels Coalition was successful in educating and engaging many Tennesseans about alternative-fueled transportation.

Finally, two of ISSE's other initiatives were successful in stimulating international collaboration. The Center for International Networking Initiatives/GLORIAD initiated several new links in its expanding global network for scientific collaboration and has positioned itself for its next round of funding in the cyber security area through a partnership with Cisco Systems. Collaborations that have grown out of the China-US Joint Research for Ecosystem and Environmental Change (JRCEEC) resulted in jointly authored research papers between US and Chinese institutions, exciting research opportunities for faculty members, and new opportunities for students from both countries to study oversees.

2012-13 Programmatic Report

2012-2013 Programmatic Report

Tennessee Water Resources Research Center (TN WRRC)

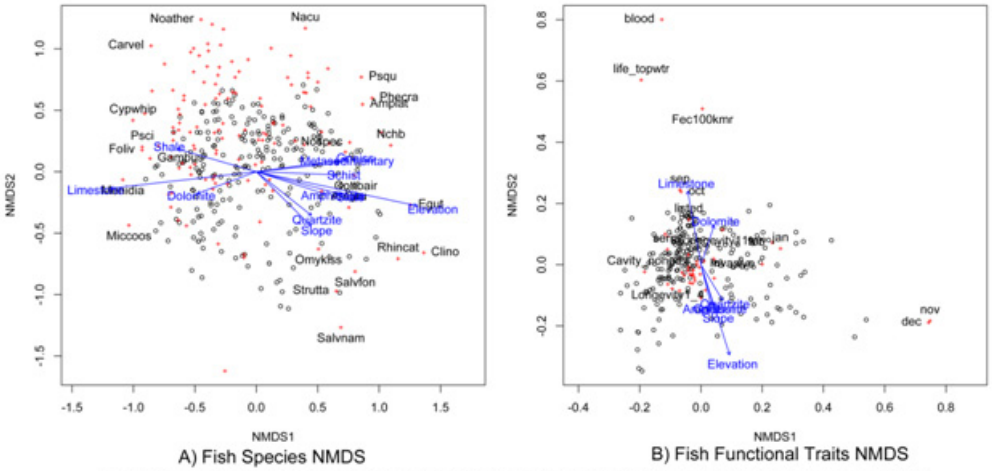
TVA database mining and development of long-term research watersheds

This seed project is a 50/50 partnership with UT's Office of Research and Engagement and involves creation of an integrated database representing hydrologic, water quality, climate, weather, land use, macroinvertebrate, and fish data in the TVA system. The purpose of the database is to facilitate investigation of system level questions related to water resources, such as impacts of anthropogenic disturbances to watersheds that may take years to be observed, potentially highlighting subtle climate signal trends, and providing opportunities to examine responses of watersheds to Best Management Practice (BMP) implementations and restoration practices in a comparative way. The TVA watersheds also provide the unique opportunity to consider various river management constraints within the context of a complex energy system (hydro, coal, nuclear—all involve water resources). Project leaders include Drs. John Schwartz and Ungtae Kim, both from Civil and Environmental Engineering, Dr. Carol Harden from Geography, and Dr. Richard Strange from Forestry, Wildlife and Fisheries. This year, Dr. Liam Tran will join the team in order to help with GIS and database schema to enable the data to be stored, maintained, and queried in a robust manner.

Efforts in the first year were largely focused on gathering and understanding the available data in relation to the geography of the region (which sub-basins are the most data rich, thereby representing the best targets for intensive investigation). Preliminary analysis of the data has already begun, with discipline specific studies underway in assessing the hydrology, fish population dynamics, and reservoir management practices associated with the system. At the moment the data is segregated in a manner to address these discipline-specific questions. Activity in the coming year will focus on the creation of a GIS-based, integrated database to allow more comprehensive, interdisciplinary, systems-level questions to be addressed.

Initial work focused on mapping the locations of TVA rain gauges, TVA stream flow gauging stations, TVA aquatic biota sampling sites, TVA power generation facilities, USGS stream gauges, NWS climate stations, and TDEC biotic sampling sites in the context of geographical features such as terrain, road networks, stream/river networks, and political and watershed boundaries. These data sources were cross referenced with STORET, the EPA's data archive of water quality data. Land use data for 1992 and 2006, acquired from the National Land-Cover-Database (Federal Multi-resolution Land Characteristics Consortiuum), were superimposed on the maps and changes over this period noted. These maps (seen on the following page) enabled the group to determine that the Emory and Little River watersheds had the greatest quantity of data available from TVA and other sources, thereby making them suitable candidates for future investigations.

Initial analysis of the hydrologic data is aimed at determining if precipitation and runoff relationships in the basin have been stationary over the last 30-year period. In addition the group is examining if land-use changes over the period 1992 to 2006 have affected the unit hydrographs within the basins. Additional analysis related to the adequacy of reservoir operational procedures to meet multi-objective criteria in the face of changing climate are also underway.



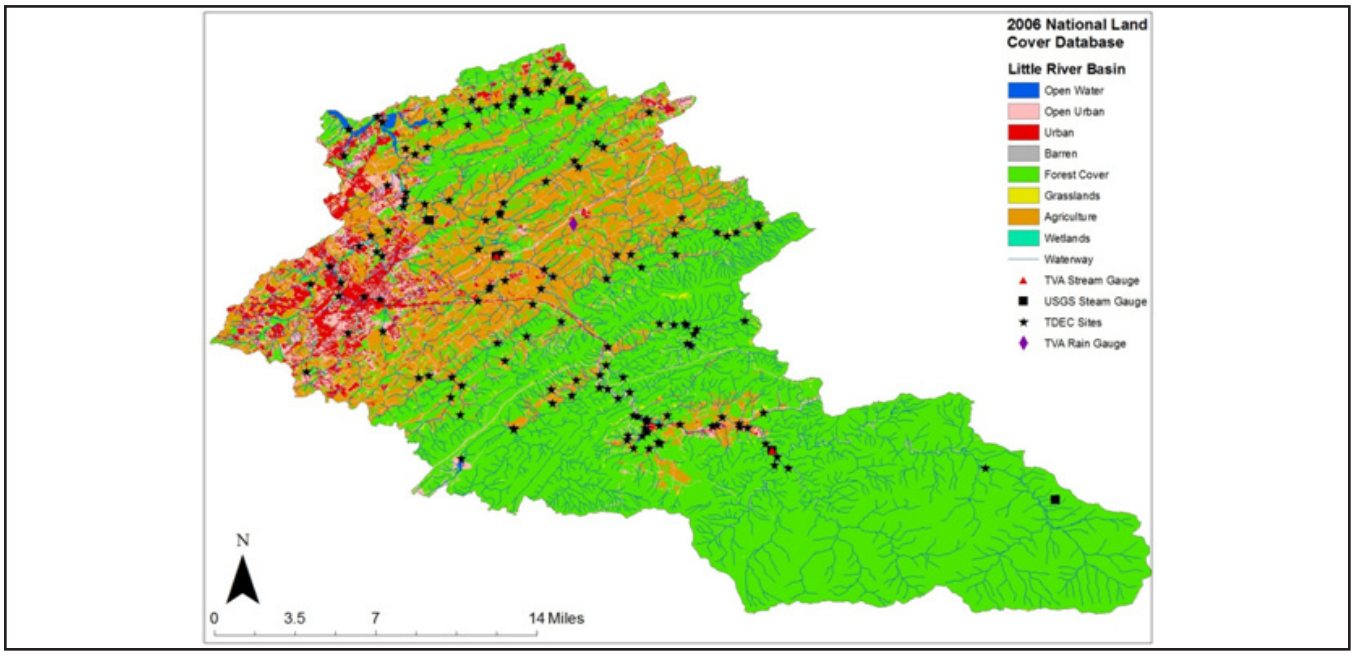
A) Fish Species NMDS

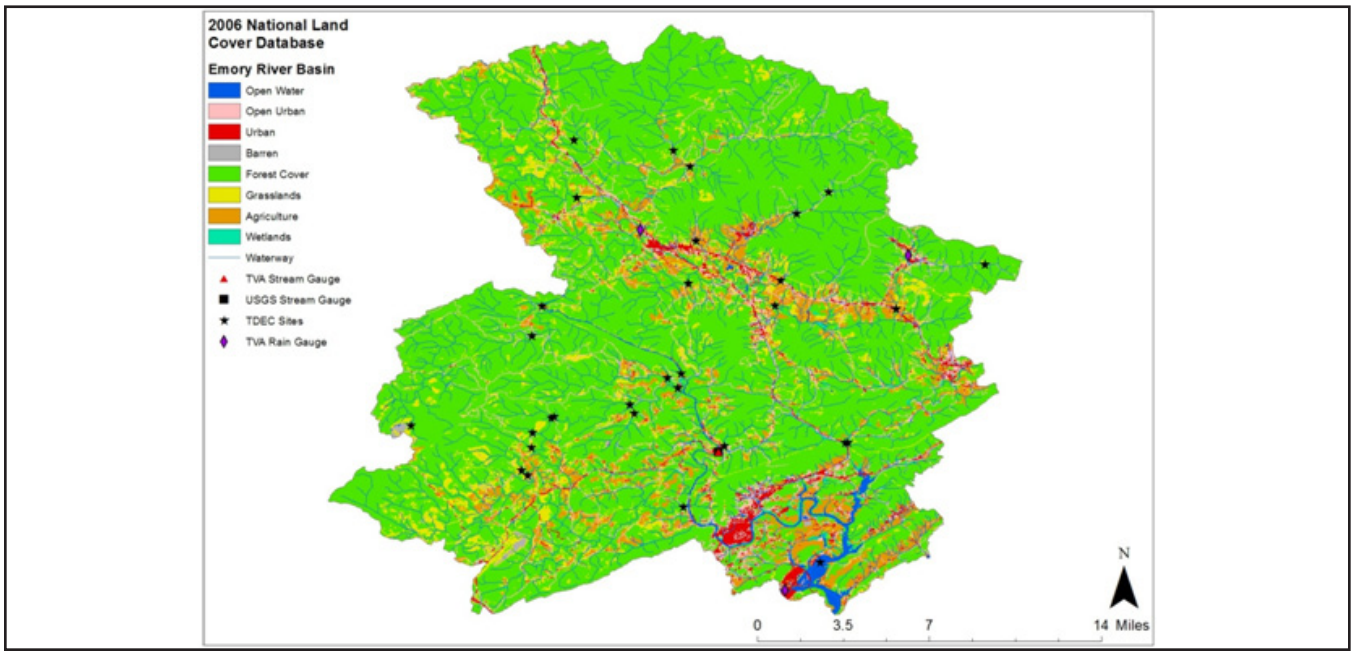
B) Fish Functional Traits NMDS

In both plots the open circles represent localities and the blue arrows indicate the fitted abiotic factors. The red crosses indicate; A) Fish Species values, B) Fish Functional Traits values

2012-2013 Programmatic Report

Initial analysis of the fisheries data involves examining a dataset comprising 225 localities in the upper Tennessee River sampled between 2009 and 2011. Models were developed to explain variation in fish species and functional traits as a function of abiotic factors within the watershed. Initial results indicate that abiotic factors explained 10% of the variation in the fish species dataset and 15% of the variation in the functional traits dataset. The abiotic factors with the most explanatory power in both models were elevation, slope, and limestone (see figure on previous page). These results support a hypothesis that human-mediated biotic factors, e.g., land use and forest cover, may influence fish species occurrence and community assembly of fish functional traits more than abiotic factors. Currently, the researchers are seeking to increase the explanatory power of the model by adding abiotic factors such as stream substrate type and stream order, and biotic factors such as riparian vegetation and land use in the watershed. With this new data the researchers intend to make a comparison of the explanatory power of abiotic and biotic factors, and possibly discern if human mediated factors have more of an influence on fish communities than abiotic factors.





2012-2013 Programmatic Report

USGS Projects

The TNWRRC is one of 54 state-level Water Resource Research Institutes of the US Geological Survey (USGS) and administers several state-level USGS grants through this program. Due to the federal budget sequestration, USGS only distributed 60% of the planned funding for this year. In order to allow funded projects to continue as planned, ISSE funds were used to cover the federal shortfall. Funded grants include:

Towards Determining Channel Protection Flows in Urban Watersheds Through Effective Strategies for Stormwater Management and Stream Restoration – PI: John Schwartz (year 2)

This project seeks to develop a field assessment and modeling protocol to better understand how to protect streams from excessive bank and bed erosion. The Pistol Creek watershed in Maryville, Tennessee is the basis of the study. The study is combining in situ bed erosion measurements, geomorphological approaches, and existing watershed models to develop a comprehensive protocol.

Engineered Strategies to Remediate Trace Organic Contaminants using Recirculating Packed-Bed Media Biofilters at Decentralized Wastewater Treatment Systems – PI: John Buchanan

This project seeks to quantify the removal of organic compounds found in wastewater related to pharmaceutical and personal care product usage in recirculating packed media biofilters in the context of decentralized wastewater treatment systems. These compounds are notoriously difficult to remove by conventional treatment and have been detected in groundwaters under septic fields, thereby indicating the need for effective decentralized treatment systems.

Long Term Evaluation of Norris Dam under Changing Environments – PI: Ungtae Kim

This project is closely integrated into the TVA data mining project described above. TVA reservoir operation procedures are designed to take into account multiple factors such as dam stability, hydropower generation, cooling requirements for nuclear power facilities, flood control, navigation, and more. The Norris reservoir is also intertwined with the entire TVA system, such that the network as a whole must be able to satisfy the hierarchy of operational demands. This research seeks to determine if current operational policies of the reservoir will be able to meet these criteria in the future under conditions of climate change and the resulting weather patterns projected for the TVA region.

Chemical and Morphological Analyses of Trout Otoliths as a Measure of Aluminum Exposure in Streams Impacted by Acid Deposition in the Great Smoky Mountains National Park – PI: Michelle Connolley

This project expands on Dr. Connolley's earlier work in assessing the uptake of aluminum in trout through the morphology of their otoliths (ear bones). Aluminum toxicity is believed to be the mechanism by which trout are adversely affected in acidified streams. The project will lead to a better understanding of the limits of aluminum that brook and rainbow trout can tolerate and the role of calcium in buffering the effects of aluminum.

Refilling the Bucket: Recharge Processes for the Memphis Aquifer in the Exposure Belt in Western Tennessee – PI: Brian Waldron

This project seeks to develop a better understanding of recharge processes in the unconfined region of the Memphis aquifer. Direct recharge from upland surfaces may be extremely slow, requiring more than 100 years. It is hypothesized that more rapid recharge may occur along hillsides, gullies, and stream valleys in parallel with direct recharge. A better understanding of these processes is necessary to understand the sustainability of water supply from this aquifer in the face of changing land usage and climate.

Training Activities

TNWRRC coordinates two statewide training and certification programs for the Tennessee Department of Environment and Conservation (TDEC). The Tennessee Erosion Prevention and Sediment Control Training and Certification program (TNEPSC) is comprised of three basic courses:

- The Level I Fundamentals of Erosion Prevention and Sediment Control for Construction Sites is a one-day foundation-building course for individuals involved in all aspects of land disturbing activities. It was offered 17 times in nine communities with 1270 people attending.
- The Level II Design Principles for Erosion Prevention & Sediment Control for Construction Sites is an intensive two-day course for engineers and other design professionals focused on engineering technology needed to plan and design practices and controls for preventing erosion and managing sediment and other stormwater pollutants on construction sites. It was offered nine times in four communities with 275 professionals attending.
- The Level I Recertification is a half-day course for those who have successfully completed the Level I course and need to renew their Level I certification. Recertification is required every three years. It was offered 18 times in 12 communities with 1,443 people attending.

2012-2013 Programmatic Report

The Tennessee Hydrologic Determination Training Program (TN-HDT) is the second training program coordinated by TNWRRC for TDEC. The TN-HDT program consists of a three-day course designed to provided participants with a basic understanding of the underlying scientific principles, the legal ramifications, and the practical investigative techniques surrounding the determination of wet weather conveyances versus streams and other surface water features. The course was offered twice with a total of 45 people attending.

Low Impact Development Stormwater Manual and Training Courses

The TNWRRC, including faculty and graduate students from the Department of Civil and Environmental Engineering (CEE) and the Department of Biosystems Engineering and Soil Science (BESS) are working with staff from TDEC Division of Water Resources to develop the first edition of the *Tennessee Permanent Stormwater Management Design Manual*. TDEC has established stormwater runoff reduction as the primary treatment objective for new development and redevelopment projects across Tennessee. This new manual will provide detailed design guidelines for permanent stormwater control measures that meet this treatment objective. The primary purpose of this manual is to serve as a technical design reference for designated and non-designated (unregulated) MS4 (municipal separate storm sewer system) communities in Tennessee. It is intended to provide the information necessary to properly meet the minimum permanent stormwater management requirements as specified in MS4 permits

In addition, TDEC has contracted the TNWRRC to develop and deliver two new training courses that will inform local officials, administrators, design professionals and consultants, and private sector companies on the use of the manual to develop, implement, and maintain the permenant stormwater control measures and practices described in the manual. These courses will be offered beginning in the fall of 2014.

UT Stormwater Permit Assistance

In early 2012, TDEC notified officials at the University of Tennessee that the UT Knoxville campus had been designated as a MS4 community and must obtain coverage under the Tennessee general permit for MS4 discharges. Since that time TNWRRC staff and faculty from the CEE and BESS departments have been working closely with staff from UT Facilities Services to prepare the Notice of Intent (NOI) and supporting documentation to submit to TDEC. The NOI describes how the University plans to comply with the requirements of the MS4 permit over the next three-to-four year period.

A key element of the campus-wide stormwater planning process is a draft Stormwater Management Master Plan by developed faculty and graduate students from the Department of Civil and Environmental Engineering. This draft Master Plan included the compilation of available information on drainage infrastructure, hydrologic assessment of stormwater flows to the existing system, and proposed best management practice (BMP) improvements to the system. The Master Plan was submitted to UT Facilities Services in June 2013 and will be reviewed and updated along with the overall Campus Master Plan over the next year or two. The TNWRRC and faculty and students from CEE and BESS will continue to work with staff from Facilities Services to develop a comprehensive stormwater management program for the University of Tennessee, Knoxville campus that meets the minimum requirements of the MS4 permit over the next two-to-three years.

Knox County Adopt-A-Watershed Program

The 2012-13 Knox County Adopt-A-Watershed (AAW) Program engaged approximately 1500 students across 12 middle and high schools in hands-on learning activities to prepare them to conduct an activity that would improve the well-being of their schools' watershed. AAW is managed by the TNWRRC and is sponsored by Knox County Stormwater and the Water Quality Forum. Service learning projects are curriculum-based and the selected activities are coordinated with community partners to ensure they meet a need within the watershed.

Several key efforts this year among classes included the removal of exotic invasive plants along stream corridors in order to allow native species to be re-established, stabilization of eroding hillsides, and the establishment and maintenance of campus rain gardens. Classes in the Conner Creek, Stock Creek, Beaver Creek, and Ten Mile Creek Watersheds together removed about 8,000 pounds of plant material. Seventh grade science classes at Powell Middle and West Valley Middle schools applied a total of 1050 square feet of erosion control blankets to eroding slopes on their campuses. Austin East high school science classes installed a rain garden and raised plants for it in their school's greenhouse while a Powell Middle Environmental Club maintained two campus rain gardens.

AAW also continued its support of six campus-based outdoor classrooms. Hardin Valley Academy classes took inaugural steps to establish an outdoor learning space by organizing their first community work day. Through local marketing, students rallied 60 community members to assist in the repair of a footbridge over Conner Creek and to remove 1500 pounds of privet.

2012-2013 Programmatic Report

Construction classes at Halls High replaced and/or repaired 600 feet of the perimeter fence at the Halls Outdoor Classroom (HOC) and students, teachers, and local partners organized a HOC community spring celebration with approximately 250 in attendance. In addition, AAW was a partner in the South Doyle Middle school-community coalition that received $30,000 from Dow Chemical to build an outdoor classroom amphitheater along Baker Creek.

Above: Students and community members join together in the Hardin Valley Academy High School Outdoor Classroom Community Work Day

Left: AmeriCorps member assists in the Hardin Valley Academy High School Outdoor Classroom Community Work Day

Below: Austin East High School students help to install campus rain garden

Top two pictures above: Powell Middle School students work with AmeriCorps member to apply erosion control matting on campus hillside

Bottom picture above: Powell Middle School students work to maintain their campus rain garden

2012-2013 Programmatic Report

Tennessee Yards & Neighborhoods (TYN)

A primary effort of the Tennessee Yards & Neighborhoods (TYN) program in 2012-13 has been to establish a new set of priorities in seven focal areas (i.e., administration, programming, expansion, marketing, participant retention, data management, and fundraising) based on a comprehensive assessment of the recently completed three-year pilot program. In the administrative arena, progress was made through a restructuring of the statewide management team and the addition of new advisory board members. Programmatically, TYN teamed up with the Lower Clinch Watershed Council to develop and pilot a six-hour Homeowners Rain Garden Workshop, with four workshops being conducted and two demonstration gardens installed. TYN is now packaging this workshop as a train-the-trainer module and will be doing three workshops across the state for stormwater professionals and Extension agents. These workshops will be used not only as a way to distribute this module, but also as a means to promote and expand TYN. TYN Homeowner Landscape and Rain Barrel Workshops also continued throughout the year in Knox, Shelby, and Hamilton Counties.

TYN also continued its partnership with the Beaver Creek Task Force, designing and overseeing the installation of three residential rain gardens in a stormwater retrofit initiative being conducted in partnership with the Cedar Crossings Homeowner's Association. In addition, it developed a Homeowner's Stormwater Assessment tool that homeowners can use as a first step in determining the types of stormwater best management practices that may be appropriate for their home landscape. A related resource that is near completion is a comprehensive native garden database accessible through the TYN website (tyn.utk.edu) that homeowners can use to select appropriate plants for their landscaping situation.

On the marketing front, TYN is rebranding itself, including transitioning to a new name—Tennessee Smart Yards—and logo. The name was selected based on three key criteria: 1) it reflects making a positive change on our landscapes, 2) it evokes action and making wise and sound choices, and 3) it is memorable. Many additional exciting changes are in the works for Tennessee Smart Yards, with the aim of making the program more accessible and appealing to a broader demographic of homeowners across Tennessee.

Newly installed rain garden at Cedar Crossing subdivision

Participants roll up their sleeves at a TYN Rain Garden Workshop to install a demonstration rain garden

City of Lakeland, in partnership with Shelby County Extension, conduct a six-hour TYN Homeowner Landscape Workshop

TENNESSEE SMART YARDS

2012-2013 Programmatic Report

Watershed Initiatives

TNWRRC served as project manager for three watershed initiatives in FY13, two in the Beaver Creek Watershed and a new initiative in the Stock Creek Watershed. TNWRRC uses the partnerships cultivated during these initiatives to provide opportunities for research and service learning activities for students and faculty.

Beaver Creek Watershed:

A 1,400 foot streambank restoration project, designed by Dr. Keil Neff (Civil and Environmental Engineering), was implemented during the fall of 2012. Dr. Joann Logan (Biosystems Engineering and Soil Science), used the riparian planting for this project as a service learning opportunity for her students. One of Dr. John Schwartz's classes modeled an additional 1,000 feet of stream for the design of the next stage of this project. Also in the fall, site preparation for the Harrell Road Stormwater Demonstration Park was completed. In the spring a retrofit to re-route stormwater through the site from an adjacent subdivision was implemented. The Tennessee Department of Agriculture 319(h) grant for Beaver Creek administered by TNWRRC was closed.

The final project of this grant was the installation of a cistern to provide irrigation for the Halls High School Greenhouse. The TNWRRC is managing a new grant from the Nature Conservancy's Tennessee Healthy Watershed Initiative for Knox County Stormwater to complete the park at Harrell Road. In FY14 the TNWRRC will oversee the design and installation of three different pervious pavement treatments and other green infrastructure stormwater BMPs.

Stock Creek Watershed:

TNWRRC is currently managing a Tennessee Department of Agriculture 319(h) grant received by the Knox County Soil Conservation District in April of 2013 for the Stock Creek Watershed in South Knox County. This grant is primarily for repairing failing septic systems, a major cause of impairment to Stock Creek according to research conducted by Dr. Alice Layton of the Center for Environmental Biotechnology. TNWRRC will use this opportunity to develop a protocol for identifying and repairing septic systems for use by Soil Conservation Districts and MS4s across Tennessee.

Below: Dr. Joann Logan, BESS, teaches her students how to plant trees in the Mill Run riparian zone

Roy Arthur, TNWRRC, and Elliot Weidow, AmeriCorp Team member in the Adopt-A-Watershed program coordinated by TNWRRC, stand by the newly installed cistern at Halls High School

2012-2013 Programmatic Report

China-US Joint Research Center for Ecosystem and Environmental Change (JRCEEC)

The China-US Joint Research Center for Ecosystem and Environmental Change was established in 2006 to enhance collaboration among Chinese and US scientists in environmental research and education. The center's partners include the University of Tennessee (UT), Oak Ridge National Laboratory (ORNL), Purdue University, the Chinese Academy of Sciences (CAS), and University of Science and Technology of China (USTC). In 2011, the Center was accepted into the China-US EcoPartnership program, which was established by the US Department of State and the China National Development and Reform Commission. Drs. Jie (Joe) Zhuang and Gary Sayler are key leaders of this initiative. Prior to this year, the JRCEEC was housed completely within ISSE. Beginning this year, primary support for the JRCEEC was provided by the UT Institute of Agriculture (UTIA) with ISSE playing a secondary role.

JRCEEC 2012 Annual Conference

The sixth annual China-US workshop (and the 2nd annual symposium of the Ecopartnership) was held on September 17-19, 2012 in Shenyang, China. The theme of the workshop was "Land Use, Ecosystem Services, and Sustainable Development." More than 200 scientists, students, US consulate officers, and industry and government leaders attended the conference. Eleven keynote speeches and 44 oral presentations were made through four concurrent workshops on biomass and bioenergy, ecosystem management, environmental pollution and remediation, and eco-city and clean development. More than ten UT and ORNL faculty members presented their research and participated in pre- and post-conference field trips.

Collaborative Research Group

Within the sustainability framework of JRCEEC, a collaborative research group (CRG) on Biogeochemistry & Climate Change, led by Sean Schaeffer (UTIA faculty) and Xudong Zhang (CAS professor), has been established to bring together outstanding faculty members and their students to collaborate on cutting-edge research and to provide students with international technical and cultural training. This CRG was kicked off in January 2013 through the first group meeting held at the UT Institute of Agriculture with attendance of four faculty visitors from the Chinese Academy of Sciences, four ORNL scientists, and four UT faculty members. This group held a workshop on "Biogeochemistry of Carbon and Nitrogen" in Shenyang, China on June 27-28, 2013. More than 150 faculty and students participated in the workshop. The participants from UT and ORNL were Mark Radosevich, Sean Schaeffer, Melanie Eldridge, Melanie Mayes, Joe Zhuang, and two Haslam Scholar undergraduate students (Kenna Rewcastle and Imani Chatman). Primary outcomes include: 1) three joint manuscripts are in peer-review or in preparation; 2) two book chapters have been prepared for a book currently edited by Gary Sayler, Terry Hazen, Steven Ripp, and others; 3) a Chinese PhD student has joined Schaeffer's group for a year-long isotopic research project on terrestrial cycles of carbon and nitrogen; 4) Chinese collaborators have collected or are collecting soil samples for Melanie Mayes (ORNL Research Staff) for joint research. The experiences of this biogeochemistry group will contribute to the success of other CRGs.

Group picture from JRCEEC's 6th annual workshop held in Shenyang, China on September 17-19, 2012

2012-2013 Programmatic Report

Topical Workshops

In the summer of 2013, JRCEEC organized four workshops or special forums. The activities not only facilitated creation of new opportunities for research collaboration and data/sample exchange but also promoted UT's international reputation. A joint program of Systems Biology for Environmental Remediation is very likely to be established by 2015. ORNL's Biosciences and Environmental Sciences Division mentioned these activities in their June newsletter. Participants from UT and ORNL include Anthony Palumbo, Terry Hazen, Frank Loffler, Gary Sayler, Alice Layton, Joe Zhuang, Melanie Mayes, Jun Yan, Jun Wang, and Chuyi Wang. The themes of the workshops are listed below:

- "China-US Ecopartnership for Environmental Sustainability," hosted by the CAS's Institute of Geographic Sciences and Natural Resources Research and Research Center for Eco-Environmental Sciences, Beijing, China, May 24, 2013
- China-US Joint Workshop on "Systems Biology for Environmental Sustainability," hosted by Shenyang University and CAS's Institute of Applied Ecology, Shenyang, China, May 27-28, 2013
- US-China Workshop on "Advances in Environmental Microbiology and Biotechnology," hosted by Nanjing University, Nanjing, China, May 31, 2013
- "Frontiers in Environmental Research," hosted by CAS's Institute of Soil Science, Nanjing, China, June 1, 2013

Undergraduate Summer Research

This summer, UT undergraduates and Haslam Scholars Kenna Rewcastle and Imani Chatman (minority student) spent six weeks in Shenyang, China completing a soil science research project funded by the U.S. National Science Foundation (PI Jie Zhuang) at CAS's Institute of Applied Ecology. This extended visit also facilitated cultural exchange between students of the two countries. Rewcastle's and Chatman's visit culminated with a formal presentation of the research that they had completed and a short lecture on their lives as undergraduates in the U.S., which was given to the faculty, senior researchers, and graduate students at the Institute.

The 100 PhD Program

Important progress has been made during the first half of 2013 in building support at UT and the China Scholarship Council (CSC) for a new UT-China PhD program. A Memorandum Of Understanding is currently under review by UT's legal office and by CSC. Partnering Chinese institutions have been selected. A search for participant faculty at UT and in China is ongoing.

Industry Engagement

A technology business meeting was held with the Municipal Government of Shenyang, Liaoning province, China in September 2012 to explore approaches to developing effective China-US partnerships in clean and sustainable technology. More than 30 business leaders including venture capitalists met with the representatives from Purdue University and UT. The Municipal Government of Shenyang is willing to open an Ecopartnership Technology Office in Shenyang to facilitate the business of technology transfer in Northeast China. In addition, JRCEEC and the Ecopartnership program have contacted Procter & Gamble, Dow Chemical Corporation, John Deere, and National Geographic Society for possible cooperation. The Water Conservation Fund of the National Geographic Society has provided $48,500 to fund a collaborative project on treatment of urban pond/lake water, which is located in the Northeast Normal University, China. Other companies expressed interest in collaboration, but no agreement has yet been reached.

Other Activities

ORNL engagement:

Interaction with ORNL program leaders (Virginia Dale, Keith Kline, and Tim Theiss) in biomass and bioenergy sustainability opened a discussion on collaboration and scientific exchange in bio-based agricultural development among ORNL, UTIA, and China. Coordinated by JRCEEC, UTIA will make a joint faculty appointment for Dr. Jay Gulledge (Director of ORNL Environmental Sciences Division). Such interactions will be strengthened through a special forum on "Biomass Production and Ecosystem Management" in Beijing on December 12-13, 2013 and a China-US Joint Workshop on "Land Use Change: An Opportunity for Agricultural Sustainability," which will be held at Shenyang Agricultural University, China on December 14-16, 2013, with six UT/ORNL faculty participants.

International training:

A training class was offered in May-June 2013 by Dr. Melanie Eldridge (CEB scientist) and Mr. Jun Wang (PhD student at CEB) in Beijing to facilitate joint R&D activities of engineered yeast for detecting emerging toxic chemicals in environmental and food systems.

Faculty visit and joint research proposal:

A number of UT faculty and students visited China in the summer of 2013 for joint research and academic exchange. They are UTIA faculty (Mark Radosevich,

Sean Scheaffer, Jenifer Debruyn, and Joe Zhuang), UT undergraduate students (Kenna Newcastle and Imani Chatman), and UTK faculty (Steven Wilhelm, Aimee Classen, and Qiang He). A number of Chinese faculty also visited UT and ORNL, including Xu-Dong Zhang, Hong-Bo He, and Xin-Yu, and Li Zhang from CAS, Jian-Yu Zhu from Southeast University, and Jing-Kuan Wang from Shenyang Agricultural University. Two joint research proposals are pending, which were prepared for U.S. NSF and/or NSF of China by UT/ORNL and Chinese scientists. They are 1) "IRES: Soil Carbon Preservation and Stability in Ecosystems as Affected by Biomass Input, Water, Nitrogen, and Temperature" ($212,388; PI: Jie Zhuang) and 2) "Dimensions US-China: Quantitative Linkages between Phylogenetic and Functional Rhizosphere Biodiversity" ($1,999,989; PI: Gary Sayler and Da-Li Guo).

Administrative visit:

A minister-level Chinese delegation (Development Research Center of the State Council—China's think-tank) visited UT and TVA on December 14, 2012 to update China's sustainability policy and national programs and to explore opportunities for collaboration with UT, ORNL, and TVA. Three Chinese delegates, Dr. Shi-Jin Liu (Deputy Director—Vice-Minister Level—of the Development Research Center), Dr. Wen-Kui Zhang (Deputy Director of the Enterprise Research Institute, Development Research Center), and Dr. Lei Yu (Associate Professor in Shanghai Academy of Social Sciences), met the faculty and leaders of UT, ORNL, and TVA , including Gary Sayler, Matt Murray, Larry Bray, Patricia Ezzell, David Bjornstad, Milton Russell, Marc Gibson, Robert Shelton, Tim Ezzell, Eric Drumm, William Park, Christopher Clark, Carol Harden, Yingqui (Philip) Li, and Jie Zhuang at UT's Baker Center. In addition, an eight-member delegation of Shenyang Agricultural University, led by Professor Yu-Long Zhang (the university president) visited UT in July 2012 for potential collaboration in research and education.

Joint Research Products

A number of refereed research papers have been published based on the joint efforts of JRCEEC faculty and students. The publications include a special journal edition and six research papers that are listed among the other ISSE related scholarly publications.

2012-2013 Programmatic Report

East Tennessee Clean Fuels Coalition (ETCleanFuels)

I-75 Green Corridor Project

The goal of this DOE-funded project is to develop the world's longest biofuels corridor by adding B20 biodiesel and E85 ethanol refueling infrastructure along I-75 from Sault Ste. Marie, Michigan to Miami, Florida. Through the effort of the project, additional biofuels refueling stations are being added along the 1,786-mile corridor to enable drivers of flex-fueled vehicles (FFV) or diesel vehicles to utilize E85 or B20 respectively along their entire journey. ETCleanFuels Executive Director Jonathan Overly is the project Principal Investigator.

Through June 2013, the project has added 18 E85 stations and nine B20 stations to the corridor; two of the completed stations offer both biofuels. New stations were added this year in Michigan, Georgia, and Florida. Through June 30, 2013 the cumulative biofuels sold totals 1,979,374 gallons. Project leaders expect to sell over 2,500,000 gallons of E85 and B20 annually, representing on the order of 1.75 million gallons of gasoline and diesel displaced by American-produced renewable fuels.

A website has been developed to provide additional information about the project, including a Google map showing the locations of available refueling stations along the corridor: www.CleanFuelsCorridor.com. The original grant was to run from late 2009 to December 2013; however, a no cost extension will allow the project to run through December 2014 to facilitate installation of additional stations.

Idle Reduction Projects

ETCleanFuels is partnering with Oak Ridge National Laboratory (ORNL) and the National Transportation Research Center (NTRC) to develop an Idle Reduction Conspectus and an idle-reduction signage plan for the ORNL campus. The conspectus is a reference compendium of idling recommendations for all vehicles manufactured for sale in the United States over the last 10 years. The aim of the idling reduction program is to reduce onsite greenhouse gas emissions through implementation of a plan that places idling-limitation signage at 15-20 locations around the ORNL facility. Kristy Keel-Blackmon leads this project for ETCleanFuels.

In addition, ETCleanFuels is working closely with IdleAir to develop additional IdleAir locations in Tennessee and in other southeastern US states for class eight tractor trailers, as well as to determine how the coalition can better disseminate the benefits that are derived from using truck stop electrification.

Events & New Alternative Fuel Vehicles at Work in East TN

In fall 2012, Morgan County Schools became the first school district in Tennessee to use gaseous fuels (propane and natural gas) in their school buses. ETCleanFuels began discussing alternative fuel options with leaders from the school district in 2009. In 2011, approval was received to purchase one Type D (large, flat front, rear engine) school bus that runs only on compressed natural gas (CNG) and two Type A (small)

school buses that run on propane. All three buses began regular service in district pupil transportation operations in August 2012. A grand opening for this milestone was celebrated in November 2012 which can be viewed through videos (http://www.youtube.com/user/ETCleanFuels/videos), and photographs (http://www.flickr.com/etcleanfuels) of the event.

In May 2013, East Tennessee's first public CNG station located along a major interstate was opened in Athens, Tennessee. Coalition members PBG Energy, Inc. and Athens Utilities Board worked together to open this station, whick can refuel vehicles ranging in size up to class eight tractor trailers. The station is branded "Waypoint CNG" and is collocated at the Roberts Brothers Motors diesel engine service center just off I-75 at exit

2012-2013 Programmatic Report

49 on Holiday Drive. Future plans include dual-fuel natural gas conversion capability for refueling heavy-duty trucks, to enable regional fleets to use this cleaner-burning fuel.

First Responders Training

In partnership with the National Alternative Fuels Training Center, or NAFTC, ETCleanFuels provided first-responder training related to accidents involving electric vehicle (EV) and gaseous fuel vehicles. The first-ever event of its kind in East Tennessee, seven-hour training workshop was held in March 2013 at the Knoxville Fire Department's Training Academy.

Alternative Fuel Road Shows

Alternative Fuel Road Show events include presentations regarding various aspects of owning and operating alternative fueled vehicles, together with the opportunity to spend significant time to see and drive vehicles that operate on natural gas, electricity, propane, biodiesel and E85. Five events were planned across Tennessee with three held in Kingsport, Knoxville and Chattanooga during March 2013.

Growth of Gaseous Fuel Partnerships Across the State

Partnerships with the Tennessee Gas Association and the Tennessee Propane Gas Association are opening more discussions and opportunities for Tennessee fleets to explore the use these fuels. One major part of this effort is managing monthly state-wide conference calls that discuss topical issues related to each fuel. ETCleanFuels hosts a conference call for each fuel every month. The calls usually feature a speaker who addresses a current facet of this rapidly changing industry. As attendance at these calls continues to grow, new opportunities for converting fleets to these fuels emerge.

Development of Coalition Committees

Through its quarterly coalition meetings, ETCleanFuels has initiated alt-fuel committees during the last year. Four committees have been created: natural gas, propane, biofuels and EVs. These committees will serve as ambassadors for their chosen fuel to foster its greater use across the region; identify the most important topics and issues related to their chosen fuel and facilitate discussion of these issues; and provide leadership to increase the use of their fuel across the region.

Publications

ETCleanFuels produces two publications: the statewide alternative fuels newsletter, The Tennessee Clean Fuels Advisor, and the Clean Cities-powered ezine, The Fuels Fix (www.FuelsFix.com). The newsletter is produced twice per year and printed and mailed to roughly 3,000 recipients in 18 states. The Ezine, now in its 5th year, initially targeted the alternative fuels scene in the southeastern US, but expanded its scope to nationwide with the Winter 2013 issue. It now features the alternative-fuel, idle-reduction, and other innovative petroleum-reduction activities of about 20 partners including many of DOE's Clean Cities programs.

2012-2013 Programmatic Report

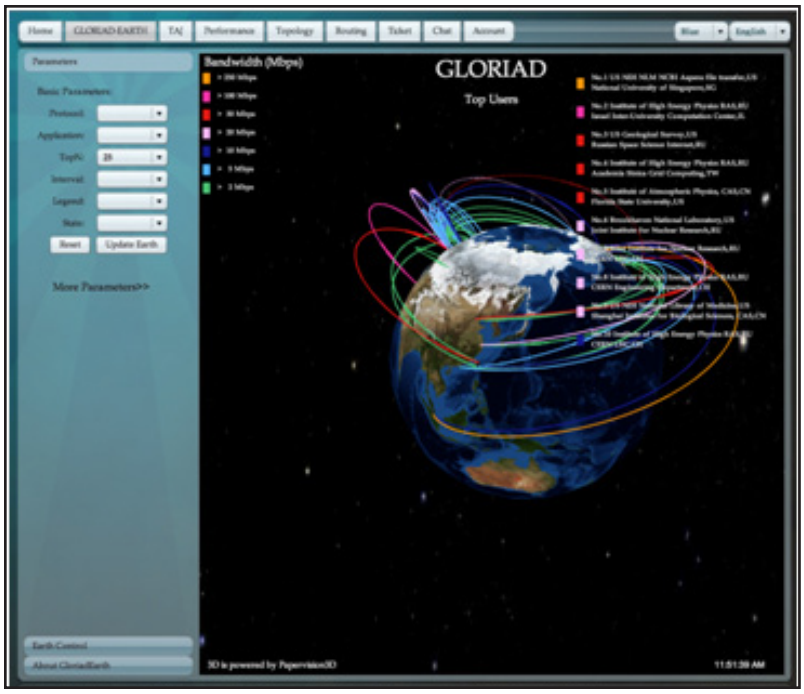
Center for International Networking Initiatives/GLORIAD

The US National Science Foundation (NSF) and US Agency for International Development (USAID) have provided a total of $22M in funding for the Global Ring Network for Advanced Application Development (GLORIAD) to build and manage cyberinfrastructure (especially advanced network services) connecting science and education communities across the globe. GLORIAD's international partners have invested over $220M cumulatively. GLORIAD enables global open science cooperation via carefully organized collaboration and co-funding with public and private sectors in Europe, Asia, and Africa. The countries served by the GLORIAD program, funded by the NSF since 1997, now circle the northern hemisphere. Partners include Russia, China, Korea, the Netherlands, Canada, the five Nordic countries, Egypt, India, and Singapore. The GLORIAD network serves every knowledge discipline—from high-energy physics to atmospheric and climate change science to renewable energy research to nuclear nonproliferation to genomics and medicine to economics and history.

During the past year, GLORIAD has added approximately $1M in equipment contributions from Cisco Systems, Inc. for its network measurement, monitoring, and security work—this in addition to approximately $1M each from NSF and USAID for GLORIAD's general program activities and its work in Africa, respectively.

In addition to its day-to-day work managing network links between the US, Russia, China, Korea, Egypt, Singapore, India, and GLORIAD's other European and North American partners, the GLORIAD team launched a new 10 Gbps link across North America, worked with Chinese partners on a special 1G link for genomics data transfer, worked with Korean partners on new 12.5 Gbps trans-Pacific links for US-Korea science, began work with Russian and Nordic partners on a 10 Gbps upgrade of the current US-Russia network, worked with Russian and US partners on a special US-Russia openflow demonstration, and improved access to the India link for researchers in Bangalore.

The GLORIAD team began a new partnership with Cisco Systems and Qosient on network measurement, monitoring and security work—leveraging nearly $1M in equipment contributions from Cisco and deploying advanced argus technology throughout the GLORIAD-US infrastructure, enabling rich insight into utilization and performance of the GLORIAD network. The work on GLORIAD's new monitoring and security system has been extensive and should pave the way for new work and new funding opportunities in the near future.



GLORIAD organized its annual board meeting—this year in Chicago, Illinois—with participants representing 15 countries including its latest partners in North and West Africa. GLORIAD signed new partnership agreements with the Asia-Pacific Advanced Network (APAN), Baharicom, and Lightwave Wireless. It successfully passed NSF's 2.5-year review of its current five-year program.

As illustrated in the picture to the right, GLORIAD sees single applications each day now running greater than 250 million bits per second. The vast majority of traffic transiting GLORIAD is sourced/destined at US federal research facilities (US DOE, NASA, NOAA, USGS, NIH, etc.).

Other Initiatives

Renewable Production of Chemical Feedstocks and Value-Added Chemicals

Biobased products will provide the economic incentive required to support a robust biorefining industry. Integrating production of these high value chemicals with high-volume, low value biofuels from lignocellulosic biomass will result in an overall profitable operation that also reduces the nation's dependence on foreign supplies of strategic raw materials, diminishes the environmental footprint of chemical manufacture and dramatically increases the contribution of the domestic rural economy to the nation's industrial sector. By realizing this high potential impact, a multi-disciplinary and multi-institutional team of chemists and biochemical engineers from the Center for Renewable Carbon (Professors Nicole Labbe and Joseph Bozell), UT Departments of Chemistry (Professor Brian Long) and Chemical and Biomolecular Engineering (Professor Cong T. Trinh) are gathered to develop an integrated chemical and biocatalytic processes for rapid, cost-effective transformation of biomass (cellulose, hemicellulose, and lignin) into high-value products (Figure 1) while also generating fundamental knowledge regarding interaction of the catalytic and biocatalytic systems with carbohydrates and lignin.

Starting January 2013, with the financial support of ISSE and UT's Sustainable Energy Education and Research Center (SEERC), the team has recruited talented and motivated postdoctoral researchers, graduate students, and undergraduate students. Significant progress by this highly collaborative team will have significant impact on the biorefining economy, enabling them to seek external funding resources, and publish scientific findings in high-impact journals. A team lead by Drs. Labbe and Trinh have been working to metabolically engineer a novel, robust, and efficient microbial biocatalyst *Yarrowia lipolytica* that can produce high levels of alpha-ketoglutaric acid (KGA) from sugars and grow in a solution of at least 10% of 1-ethyl-3-methyl imidazolium acetate [Emim][OAc], an ionic liquid. Currently, the team is investigating the capability of this microbial biocatalyst to produce KGA from enzyme-treated cellulose in ionic liquids and further engineer the strain to convert cellulose directly into KGA. Meanwhile, a team lead by Drs. Long and Bozell, have synthesized a large number of lignin dimers and oligomers and are exploring the catalytic modification of those lignin models, as well as carbohydrates for the production of high-value organics. Additionally, with the support of ISSE and UTIA, the team has recently acquired a state-of-the art Agilent gas chromatograph/mass spectrometer that significantly increases the group's analytical capability.

The team is positioned to combine both chemical and biochemical catalysis for the production of high-value products. Additionally, they are currently in the process of pursuing external, multi-investigator funding through agencies such as the National Science Foundation.

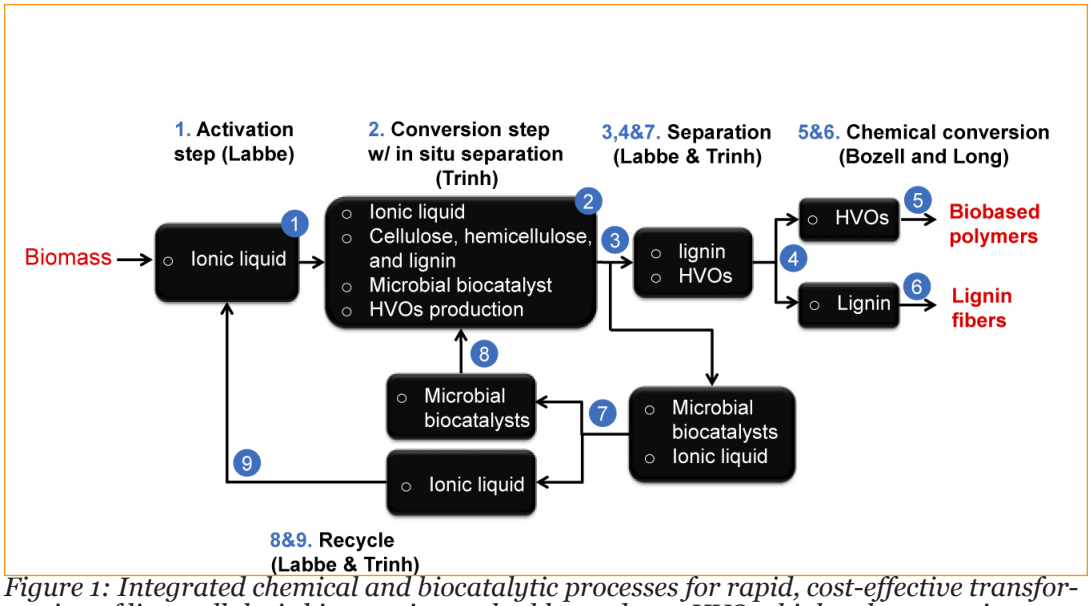


Figure 1: Integrated chemical and biocatalytic processes for rapid, cost-effective transformation of lignocellulosic biomass into valuable products. HVOs: high value organics, e.g., diols, fumaric acid, succinic acid, 2-ketoglutaric acid, glutamate, malic acid, and aromatic molecules.

2012-2013 Programmatic Report

International Center for Air Pollution and Energy Study (ICAPES)

Led by Dr. Joshua Fu, ICAPES contributes solutions to complex problems in air pollution control and energy strategies through the evaluation of innovative and sustainable energy and air pollution control/prevention practices. The Center integrates theoretical advances, air quality monitoring data, and air quality models to develop sustainable energy strategies via interdisciplinary collaboration. The center promotes implementation of these strategies through community collaboration, leadership, and education to facilitate climate change adaptation. From July 2012 to June 2013, ICAPES has accomplished the following achievements:

- contributed to a comprehensive, integrated set of software tools (ABaCAS: Air Benefit and Cost Assessment and Attainment System) to predict the impact of proposed pollution control technologies on air quality and to evaluate the resulting health and environmental benefits in comparison to cost of implementation.
- applied several of the tools to to air quality problems in the Yangtze River Delta
- partnered with EPA, the Energy Foundation, and Tsinghua University and Zhejiang University in China to convene the "International Conference on Air Pollution Control Benefit and Cost Assessment," at Hangzhou, China in June, 2013. A preconference workshop providing training on ABaCAS was also held.
- hosted visiting professors: Dr. Shuxaio Wang from Tsinghua University; Dr. Dustin Zhu from South China University of Technology; Dr. Yu Zhao from Nanjing University, China; Dr. George Lin from National Central University, Taiwan
- secured $100,000 in external funding from the Energy Foundation

In 2013-2014 ICAPES will continue to:

- conduct modeling assessments of climate and air quality interactions as well as the impacts of hemispheric transport of air pollutants to regional air quality and regional climate over the continental US and Asia
- develop integrated control strategies to address issues associated with international transport of air pollutants and its climate effects across studied countries
- improve the integrated ABaCAS tool to support the above activities and to provide decision support to improve the resilience of climate/air and energy infrastructure
- support the US EPA in organizing international workshops and conferences in the US and China.

Waterborne Transmission of Rotavirus

Globally, an estimated 884 million people live without access to clean water and an estimated 3.6 million people die each year from water borne illnesses (http://water.org/water-crisis/water-facts/water/). In numerous regions of the world these illnesses are directly related to poor sanitary conditions as shown in the figure below. Over the past 4 years and in collaboration with Columbia University, a team of UT investigators led by Drs. Alice Layton and Larry McKay have been monitoring surface and ground waters in one village of Bangladesh in order to determine the prevalence of diarrheal disease pathogens in these waters and to determine the rates of reduction of microbes between the surface and ground waters. In 2012, ISSE provided the UT investigators with funding to collect another set

Typical sanitation conditions in a rural Bangladesh village consist of latrines and effluent holding ponds. Drinking water is generally obtained from tubewells.

of surface and ground water samples from Bara Haldia Bangladesh with the goal of trying to identify the rotavirus vaccination strain. In the combined data set consisting of samples dating back to March 2009, it was found that the percentage of wells containing rotavirus has declined from ~ 30% in 2009 to ~ 15% in January 2011, to non-detectable in November 2012. It also appears that contrary to the initial belief that rotavirus vaccinations were to start in 2012; rather, rotavirus vaccinations in this village began sometime 2010. This may explain the declining amount of rotavirus detected in the January 2011 well water samples relative to the 2009 ground water samples. Thus although the team was not able to validate specific rotavirus transmission from surface water to ground water, the lower prevalence of rotavirus in drinking water is a positive sign for the children's health. These water samples also provide a good set of samples to examine the microbial communities and potential pathogens in ground water and surface water through new molecular biology techniques and bioinformatics. From these samples the team has

generated eight DNA and two RNA based metageomic sequence libraries to help identify the range of bacteria and viruses present in ground water sources. In ground water samples, several potential bacterial pathogenic sequences have been found including those from V*ibrio cholera*, and *Shigella* suggesting that the drinking water in these villages still contain diarrheal pathogens. Four publications related to this work were published in 2012-2013. Following the analysis of the metagenomic libraries the results will be summarized for publication and funding will be sought for the use of metagenomic analyses to detect specific human pathogens.

Linkages between Watershed and Drinking Water Quality

Microorganisms present in drinking water represent poorly understood public health risks despite their low concentrations. Indeed, data on waterborne disease outbreaks suggest that drinking water continues to be one of the most important media for infectious diseases worldwide, including developed countries. A major knowledge gap in the design of effective control strategies is the lack of understanding of the mechanisms underlying microbial survival and persistence in drinking water. An ISSE-funded preliminary study under the direction of Dr. Qiang He investigated the linkages between watershed characteristics, distribution systems, and water quality.

Using high-throughput metagenomics tools, this project for the first time applied a systematic approach linking all relevant processes to the microbiological quality of drinking water. It is revealed that the core populations of drinking water microbial communities are dominated by *Alphaproteobacteria* and *Betaproteobacteria* affiliated to the families of *Methylobacteriaceae*, *Sphingomonadaceae, Comamonadaceae,* and *Oxalobacteraceae* with significant seasonal changes. The characteristics of the source water and the disinfection step in the drinking water treatment process train are found to be the most important factors controlling the bacterial community structure in drinking water. Despite its potential in enhancing the removal of microbial contaminants, membrane filtration as an increasingly popular treatment alternative to rapid sand filtration is not shown to have impact differing from that of conventional rapid sand filtration on drinking water microbial communities.

This project revealed the importance of premise plumbing in controlling the microbiological quality of drinking water. To gain insight into the effect of premise plumbing service age on the level of microbial contamination in stagnant drinking water, water at the point of use (POU) was subsequently analyzed. It was observed with statistical significance ($p<0.05$) that as service age of a premise plumbing system increased so did the microbial concentration in stagnant drinking water. Results also indicated that partially re-piping premise plumbing systems may greatly reduce the abundance of microorganisms, again demonstrating the impact of service age on microbial quality of stagnant drinking water in premise plumbing and suggesting re-piping as a potential risk-mitigating strategy. Further analyses focused on the chlorine decay rates in copper pipes. Chlorine was found to decay faster in newly built premise plumbing systems than old systems and fastest in unused copper pipes. The effect of increased usage was also analyzed; increasing the usage in older premise plumbing systems decreased the chlorine decay rate while the same increase in usage in newer systems increased the chlorine decay rate.

Findings from this research provide much needed insight into the processes shaping the microbial communities in drinking water and the knowledge base for the development of effective strategies for the control of microbial contaminants in drinking water. Several manuscripts from this research are in preparation or review. Dr. He has leveraged the metagenomic methods developed in this project to secured a $182,000 grant from TDOT, “Modeling Pollutant Loading from TDOT MS4 Stormwater Discharges,” with a focus on pathogenic microorganisms in stormwater. Additional proposals are in preparation for submission to NSF on the microbiological quality of drinking water.

Global Climate Model Validation

Dr. Abigail Gaddis completed her doctoral research on using the June 1991 eruption of Mt. Pinatubo in the Philippines to determine the predictability of the climate to perturbations using the Community Earth System Model, CESM1.0. Volcanic eruptions present a unique opportunity to compare climate simulations to real-life perturbation effects over relatively short time scales. Model runs both with and without simulated eruptions were compared to determine the magnitude and duration of any climate signals resulting from the eruptions. The results were also compared with observations in order to determine the accuracy of the climate models. It was found that the stratospheric water vapor increased in both the observations and simulations, and that this perturbation persisted longer than other signals. This finding lends evidence that climate models are able to accurately represent the effects of long-term radiative forcing in the atmosphere. In addition, the standard deviation of the simulations without simulated eruptions was greater than in simulations

2012-2013 Programmatic Report

with eruptions, suggesting that the model responds to climate forcing in similar ways regardless of the initial condition of the climate. The ability of the model to predict the effects of the eruption also improved as the grid size of the simulation decreased, demonstrating the need for additional computing power to obtain the most accurate climate projections. Dr. Gaddis's doctoral research was supported by ISSE. Her research advisors were Dr. John Drake, a research professor in the department of Civil and Environmental Engineering and Dr. Kate Evans in the Computational Earth Sciences group at ORNL. Dr. Chris Cox served as her academic advisor in the Department of Civil and Environmental Engineering. She is currently submitting her work for publication in peer reviewed journals and is presently continuing her work through a post-doc position with ORNL.

Biofuels Research

Dr. Chris Cox is investigating the conversion of lignocellulosic biomass to biofuels. The critical step in the process is the conversion of cellulose found in plant cell walls to sugar molecules that can be fermented into ethanol or other biofuels. *Clostridium thermocellum* is an example of an organism that is capable of both producing enzymes capable of releasing sugar from crystalline cellulose and fermenting the resulting sugars into ethanol. Although the fermentation efficiency of *C. thermocellum* is too low for commercial biofuels production, it is often used as a model organism to better understand the fundamentals of cellulosic bioethanol fermentation. Prior to fermentation, biomass must be pretreated to increase the bioavailability of the cellulose. During the pretreatment process, toxic compounds are formed which inhibit the growth and metabolism of *C. thermocellum*. As part of her dissertation research, Dr. Jessica Linville developed a mutant strain of *C. thermocellum* that is tolerant to the compounds released during pretreatment. Both the mutant and wild-type strains were sequenced to identify the specific mutations present in the adapted strain. A total of 73 different mutations occurred in the strain as it evolved and 24 of these, termed core mutations, were present in seven isolates of the final strain. Further comparisons of the gene expression patterns between the two strains shed light on the mechanisms of tolerance. These findings make important contributions to the development of industrially robust strains of consolidated bioprocessing microorganisms. Dr. Linville graduated in May of 2013. Two of her papers have been accepted for publication and she has one additional manuscript in preparation.

Jinlyung Choi is a PhD candidate in Chemical and Biomolecular Engineering who is also working on *C. thermocellum* under the direction of Dr. Cox. He is studying the mechanisms by which the enzymes that hydrolyze cellulose into simpler sugars are regulated. So far he has identified several genes that code for these enzymes that may potentially be regulated by the same protein. One strategy for producing commercially viable cellulosic biofuels is to create engineered bacteria in which the cellulolytic genes such as those found in *C. thermocellum* are introduced to an organism that is high in fermentation efficiency. Understanding how these genes are regulated in the native host, will provide useful information in designing engineered strains. Jinlyung has one manuscript in preparation and should complete his PhD in 2014.

UTIA Cherokee Woodlot Wetlands Project

Drs. Matt Gray (Forestry, Wildlife, and Fisheries) and Andrea Ludwig (Biosystems Engineering and Soil Science) are leading a group of UT researchers in developing constructed wetlands on the UTIA Cherokee Woodlot property. The wetlands would serve a dual teaching and research purpose. ISSE provided assistance to the planning stages of the project by funding several Civil and Environmental Engineering students to survey the site and do preliminary engineering design and cost estimates related to earthwork, drainage and parking at the site under the guidance of Dr. Jenny Retherford. This project provided a valuable hands-on learning opportunity for the students while at the same time providing invaluable planning information and cost estimates to the UTIA team at a critical stage of their project.

DOE Rooftop Solar Challenge Project

ISSE Research Director, Catherine A. Wilt, served as a Co-Principal Investigator on a project titled "Inducing Photovoltaic Market Transformation in Tennessee," to encourage wider use of solar energy by streamlining permitting processes, cutting red tape, and lowering the costs for rooftop solar systems in communities across Tennessee.

The University of Tennessee was one of 22 teams nationally to receive a research award under the Department of Energy's SunShot Rooftop Solar Challenge. Inspired by President Kennedy's "moon shot" program that put the first man on the moon, the SunShot Initiative is a collaborative national effort to dramatically reduce the costs of solar energy, making it cost-competitive with other forms of energy before the end of the decade.

2012-2013 Programmatic Report

In the University of Tennessee's project, ISSE staff worked alongside other UTK researchers at the Howard H. Baker Jr. Center for Public Policy and the Tennessee Solar Institute to increase market penetration of solar photovoltaic (PV) installations in the State of Tennessee. UTK partnered with local government departments and electrical distributors in four communities: Knoxville and Knox County, Memphis and Shelby County, Nashville, and the City of Franklin. Over the course of the 16-month effort, the project partners accomplished the following goals:

- developed best practices and processes to streamline permitting and interconnection applications,
- standardized interconnection processes and requirements for PV installations,
- identified alternative financing models for funding solar projects and worked with the real estate community to better value solar installations associated with properties, and
- developed unified planning and zoning criteria.

As a direct result of this research effort, all four partner cities now meet or exceed the streamlined permitting and interconnection processes developed; these four cities now serve as models for other communities across the country. In addition, the project produced a rooftop solar application for both Android and iOS Smartphones to allow Tennesseans to more easily navigate the process of installing rooftop solar panels. According to DOE metrics for the Rooftop Solar Challenge, the four partner cities increased the efficiency of their rooftop solar permitting, interconnection, financing and zoning procedures by approximately 75 percent.

Environmental Service Learning Workshop

In support of an US EPA Environmental Education proposal effort, a team of UT faculty members offered a workshop to assist other UT faculty members in incorporating environmental service learning into their courses. The Environmental Service Learning Workshop was held on the UT campus May 8-9, 2013. It was geared toward, but not limited to, faculty who planned to teach one-hour First-Year Studies (FYS) 129 courses in connection with the 2013-14 Life of the Mind Freshman Reading Program theme: Sustainability. Tenureline faculty participants received a $500 honorarium for attending the workshop and an additional $500 upon completion of a environmental service learning project in a course they were teaching. Lecturers, of whom there were two, received a total of $625. Funding for the faculty stipends was provided jointly from ISSE and Willdan Energy Solutions-TVA partnership.

The workshop covered topics including advantages of service learning, UT service learning policies, avoiding problems, regional environmental issues, planning an environmental service learning course, objectives driven course design and assessment, making connections with community partners, and evaluating service learning projects. Workshop instructors offered personalized support and follow-up for faculty teaching their courses during the following year. The workshop instructors were: Joanne Logan, Biosystems Engineering and Soil Sciences; Mike McKinney, Earth and Planetary Sciences and Director of Environmental Studies; John Nolt, Philosophy and Chair of the Committee on the Campus Environment; Ruth Darling, Assistant Provost and Director of First-Year Studies; Kelly Ellenburg, Campus Coordinator of Service Learning; and Stan Guffey, Tennessee Teaching and Learning Center Faculty Scholar.

Workshop participants included Andrew Bliss, Music; Guoxum Chen, Nutrition; Christopher Cherry, Civil and Environmental Engineering; Qiang He, Civil and Environmental Engineering; Sharon Jean-Philippe, Forestry, Wildlife and Fisheries; Bonnie Ownley, Entomology and Plant Pathology; Matt Pamental, Philosophy; Andrew Sherfy, Biosystems Engineering and Soil Science; Marcy Souza, Biomedical and Diagnostic Sciences (Vet School); Carolyn Staples, Graphic Design; and Curtis Stewart, Plant Sciences.

Equipment Purchases

ISSE made several equipment purchases in 2012-2013 to enhance research capabilities in various departments, as follows:

- *Auto-Titrator with accessories* (PI John Schwartz, Department of Civil and Environmental Engineering)—This instrument is routinely used to measure alkalinity and acidity content in water samples. It supports several research projects, including one related to water quality monitoring in the Great Smoky Mountains National Park
- *Gas Chromatograph SRI 8610C* (PI Annette Engel, Earth and Planetary Sciences)—This instrument is routinely used to measure organic compounds in gaseous and aqueous environmental samples, and was notably lacking in the research labs of EPS. The PI has recently won a 5-year NSF grant in which this instrument will be used; her share of the budget is nearly $800K.
- *Mussel Tagging System and Related Data Loggers* (PI Mike McKinney, Earth and Planetary Sciences)—This system allows researchers to find relocated mussels after they have been released to the environment.

2012-2013 Programmatic Report

The data can be used to assess the effectiveness of the relocation program. Furthermore, mussels are effective bioinidicators of stream health.

- *Gas Pycnometer* (PI Ed Perfect, Earth and Planetary Sciences)—This device allows the porosity of soils to be accurately measured. Dr. Perfect will apply the instrument in research related to carbon sequestration and enhanced gas recovery by hydraulic fracturing.
- *Carbon Flux System* (PIs Carol Harden, Geography and Sean Schaeffer, Biosystems Engineering and Soil Science)—This system allows investigators to measure the fluxes of carbon dioxide and methane from land and surface waters into the atmosphere. Applications include assessment of the effect of land management practices on terrestrial carbon storage.

Other Activities

The Center for Sustainable Business and Development (CSBD) led by Dr. Rachel Chen has completed a study entitled: Forecasting Economic Impacts of Hosting 4-H in Hardeman. A new CSBD project titled "The Economic Impacts of Trails, Greenways, and Bikeways: from Green to Gold," funded by the Tennessee Department of Transportation will begin next year. The CSBD will host the 2013 Leadership Summit: Sustainable Quality of Life on Thursday, the 3rd of October and Wednesday, the 6th of November, 2013. The campus-wide summit provides a unique opportunity for students to interact with panels of state leaders at the commissioner or deputy commissioner levels.

Catherine A. Wilt, Research Director at ISSE, was appointed to serve on Knox County's Regional Solid Waste Board. The Knox County Commission approved her appointment for a six-year term at their meeting on October 25. Regional solid waste boards, as stipulated by Tennessee law, serve functions related to approval or disapproval of regional solid waste plans, annual solid waste and recycling activity reports, and other issues that may impact the Regional Solid Waste Plan (details regarding the responsibilities and authority of Regional Solid Waste Boards can be found in T.C.A. 68-211-801 et seq.).

ISSE co-sponsored the 2nd Annual Watershed Symposium, held on September 18, 2012. Dr. David Feldman was the keynote speaker. Of the 191 attendees, 62 were undergraduate students and 37 were external to UT. The third symposium is scheduled for February 2014.

ISSE was a co-sponsor of a workshop held at the Baker Center on May 2-3, entitled: Electrifying the Vehicle Market in the Southeast. This program was developed by Dr. David Greene, Baker Fellow and ORNL Corporate Fellow and Dr. Chris Cherry, Civil and Environmental Engineering. Over 100 attended. Other sponsors included: Clean Cities, Baker Center, Nissan, Tennessee Energy Education, TNSCORE, FedEx, and UT's College of Engineering, Office of Research and Engagement, Center for Transportation Research, and Civil & Environmental Engineering.

New Project: Assessment of Methane Resources from Municipal Wastewater in Chile

Built upon a collaboration between Dr. Qiang He and ISSE Director Dr. Chris Cox on methane production from animal waste, which was supported by the EPA P3 program, a new collaborative project has recently been funded by the EPA Global Methane Initiative program, "Assessment of Methane Resources from Municipal Wastewater in Chile" ($99,748; PI: He, Q.; Co-PI: Cox, C.D. & Reed, G.D.).

Climate change is a major challenge to a safe and secure environment. In order to reduce the release of methane as a potent greenhouse gas and curb global warming, methane emission from various anthropogenic sources has been extensively evaluated. However, municipal wastewater treatment facilities (WWTFs) as a significant source of methane emission has not received attention from the Global Methane Initiative (GMI), making it critical to systematically assess technologies and management practices for the reduction and recovery of methane from wastewater. Notably, most of the methane from wastewater is generated in developing countries and countries with economies in transition, where wastewater is often poorly or not treated at all, resulting in large methane emissions. Thus, it is essential to assess technological options most suitable for these countries for the reduction of methane emission from the wastewater sector.

Therefore, using Chile as a model GMI partner country, the objective of this project is to evaluate the potential of anaerobic digestion and combined heat and power (CHP) technology for the recovery of methane from municipal WWTFs as a clean fuel. Results from this proposed project will provide much needed guidance for selecting environmentally and economically sustainable technologies for waste treatment and methane recovery in Chile. The outcomes of this project include the reduction of methane emission as a potent greenhouse gas that will benefit the U.S. and other countries from the mitigation of climate change, and the promotion of U.S. technology and expertise for enhanced methane capture and use in Chile and the world clean energy market. If the current project (1st-stage) is successful, the PIs will pursue a larger 2nd-stage proposal to implement the recommendations from the 1st-stage project.

2012-2013 Programmatic Report

Research Accounts

Project Name	PI	Title	Start	End	Award Amount
R011334309--Shanghai Doctor Asphalt Tech Co	Huang, Baoshan	Laboratory Investigation of Performance of Rubber Modified Asphalt Binder and Mixture	12/1/2012	8/31/2013	$ 20,001.00
R012531077--Racheff Environment Fund	Cox, Chris	Unrestricted Research Support	5/31/1985	12/31/2047	$ -
R013101002--NSF SCI-0441102	Cole, Gregory	Global Ring Network for Advanced Applications Development - GLORIAD	1/1/2005	7/31/2012	$ 4,468,183.00
R013190034--ARRA-NSF-OCI-0943314	Cole, Gregory	The Taj: A New Model for Global Federated Network Infrastructure for Science and Education	8/1/2009	7/31/2012	$ 2,293,378.00
R013601030ISSE Support Fund	Cox, Chris	Unrestricted Research Support	4/15/2007	12/31/2047	$ -
R013601041--UT-B 4000060337	Parker, John	DOE-ERSP FRC Multiscale Investigations of Immobilization and Natural Attenuation	6/19/2007	9/30/2012	$ 240,186.00
R013601-75--ED-08-23630-00	Gangaware, Timothy	Beaver Creek Restoration Initiative	12/16/2007	12/15/2012	$ 871,574.69
R013601098--ED-09-26773-00	Hanahan, Ruth Anne	Tennessee Yard and Neighborhood Program	10/16/2008	10/15/2013	$ 92,000.00
R013601121--DOE-DE-EE0001709	Overly, Jonathan	I-75 Green Corridor Project	10/1/2009	12/31/2014	$ 818,091.00
UT-B 4000088499	Sheffield, John	The Role of Developing Countries in Fusion Energy	12/14/2009	9/30/2013	$ 50,010.00
R013601132--LERDWG	Cox, Chris	Secretariat to the Laboratory Energy R&D Working Group	7/1/2010	12/31/2013	$ 42,000.00
R013601136NSF OCI-0963058	Cole, Gregory	IRNC:ProNet: GLORIAD	8/1/2010	7/31/2015	$ 1,907,541.00
R013601138--NSF OCI-0963058	Cole, Gregory	IRNC:ProNet: GLORIAD - Equipment & Maintenance	8/1/2010	7/31/2015	$ 13,000.00
R013601139--Ruby Falls CSBT Fund	Chen, Jui-Chi	Unrestricted Research Support for Center for Sustainable Business and Tourism	9/17/2010	12/31/2047	$ 25,000.00
R013601143--USDI-USGS-G11AP20107	Gangaware, Timothy	FY2011 WRRIP Application for TN Water Resources Center	3/1/2011	2/28/2014	$ 61,344.00
R013601147--Knox County 10-370	Gangaware, Timothy	CAC AmeriCorps Water Quality Forum - Adopt-A-Watershed	12/1/2010	11/30/2013	$ 145,500.00
R013601153--SERDP W912HQ11C0067	Parker, John	Assessing the potential consequences of subsurface biomediation	7/7/2012	7/6/2014	$ 32,126.64
R013601154--East TN Clean Fuels Coalition	Cox, Chris	Administrative Support for East Tennessee Clean Fuels Coalition - 2012	7/1/2011	7/31/2013	$ 264,170.00
R013601155--USAID-AID-OAA-A-11-00018	Cole, Gregory	GLORIAD in Africa	8/26/2011	11/25/2013	$ 3,249,117.00
R013601156--USAID-AID-OAA-A-11-00018	Cole, Gregory	GLORIAD in Africa	8/26/2011	11/25/2013	$ 126,667.00

2012-2013 Programmatic Report

Research Accounts

Project Name	PI	Title	Start	End	Award Amount	FY13 Expenditures
R013601157--NSF OCI-0963058	Cole, Gregory	IRNC:ProNet: GLORIAD - Equipment & Maintenance	8/1/2010	7/31/2015	$ 3,568,710.00	$ 849,580.35
R013601159--NSF OCI-0963058	Cole, Gregory	IRNC:ProNet: GLORIAD - Equipment & Maintenance	8/1/2010	7/31/2015	$ 15,000.00	$ 8,504.14
R013601160--NPETE	Webster, Sheila	Worker Training at Department of Energy Facilities	9/1/2011	8/31/2012	$ 107,470.08	$ 23,645.00
R013601161--TN Dept. of Agriculture 25926	Hanahan, Ruth Anne	Tennessee Yards & Neighborhoods (TYN) Framework: Retooling for an Enduring Program	4/16/2011	4/15/2014	$ 11,140.00	$ 518.73
R013601163--UT-B 4000110499	Wilt, Catherine	Technical support to the ORNL's Energy Program Evaluation Projects	12/1/2011	5/15/2013	$ 76,376.00	$ 25,377.90
R013601164--Purdue University JRCEEC	Redus, Sharon	China-US Joint Research Center for Ecosystem and Environmental Change (JRCEEC)	3/15/2012	8/31/2012	$ 26,650.00	$ 14,464.17
R013601165--NSF CBET-1220731	Zhuang, Jie	Self-Protection of Organic Carbon in Soil Pores under Organic Agricultural Practices	6/1/2012	5/31/2014	$ 90,844.00	$ 46,270.15
R013601172--MeadWestvaco	Fu, Joshua	Air quality assessment to MeadWestvaco on potential VOC emission controls in Beijing, China	8/1/2012	1/31/2014	$ 36,060.00	$ 9,463.83
R013601173--USDA NIFA 2012-51130-2046	Schwartz, John	Renewal of Integrated Watershed Management in Oostanuala Creek Watershed, Tennessee	9/1/2012	8/31/2015	$ 144,777.00	$ 7,813.70
R013601174--Natl Partnership (PETE) 10491	Webster, Sheila	Worker Training at Department of Energy Facilities	9/1/2012	8/31/2013	$ 107,500.00	$ 88,029.57
R013601175--Energy Foundation-1208-16611	Fu, Joshua	Air Quality Management and Assessment Capacity Building and Training in China	9/1/2012	8/31/2013	$ 100,000.00	$ 59,476.90
R013601176--TDEC - 32701-01367	Gangaware, Timothy	TN Permanent Stormwater Management Handbook	11/1/2012	6/30/2014	$ 77,432.00	$ 5,419.29
R013601177--LERDWG	Cox, Chris	Secretariat Lab Energy R&D Group 2012	10/1/2012	9/30/2013	$ 25,000.00	$ 10,142.31
R013601181--TN Dept of Agriculture 35925	Gangaware, Timothy	Beaver Creek Restoration Initiative	3/16/2013	7/1/2013	$ 47,810.31	$ 36,796.01
R013601183--Hardeman County 16930	Chen, Jui-Chi	Forecasting Economic Impacts of Hosting 4-H Camp in Hardeman County, TN	5/6/2013	6/30/2013	$ 8,000.00	$ 1,538.29

2012-2013 Programmatic Report

ISSE Related Publications *(UT affiliated authors shown in bold)*

Chen, R.J.C. 2013. How Can Stores Sustain Their Businesses? From Shopping Behaviors and Motivations to Environment Preferences. *Sustainability* 5(2): 617-628; doi:10.3390/su5020617

Chen, R.J.C. 2013. Beyond Management and Sustainability: Visitor Experiences of Physical Accessibility in the Great Smoky Mountains National Park, USA. *Journal of Management and Sustainability* 3(2): 145-154.

Dai, Y.S., Baek, S.H., Garcia-Diaz, A., Yang, B., Tsui, K.L., **Zhuang, J**. 2012. An enhanced engineering perspective of global climate systems and statistical formulation of terrestrial CO2 exchanges. *Theoretical and Applied Climatology* 107(3-4): 347-359.

Díaz-Robles, L.A., J. S. Fu, G.D. Reed. 2013. Emission Scenarios and the Health Risks Posed by Priority Mobile Air Toxics in an Urban to Regional Area: An Application in Nashville, Tennessee. A*erosol and Air Quality Research* 13: 795–803; doi: 10.4209/aaqr.2012.07.0165

Ferguson, A. S.; **Layton, A. C.;** Mailloux, B. J.; Culligan, P. J.; Williams, D. E.; Smartt, A. E.; **Sayler, G. S;** Feighery, J.; **McKay, L. D.;** Knappett, P. S. K.; Alexandrova, E.; Arbit, T.; Emch, M.; Escamilla, V.; Ahmed, K. M.; Alam, Md., J.; Streatfield, P. K.; Yunus, Md.; van Geen, A. 2012. Comparison of Fecal Indicators with Pathogenic Bacteria and Rotavirus in Groundwater. *Science of the Total Environment* 431: 314-322.

Fu, J. S., X. Dong, Y. Gao, **D. C. Wong, Y. F. Lam.** 2012. Sensitivity and Linearity Analysis of Ozone in East Asia: the Effects of Domestic Emission and Intercontinental Transport. *Journal of Air and Waste Management Association* 62 (9): 1102-1114; doi:10.1080/10962247.2012.699014

Fu, J. S., N. C. Hsu, **Y. Gao, K. Huang,** C. Li, N.-H. Lin, S.-C. Tsay. 2012. Evaluating the influences of biomass burning during 2006 BASE-ASIA: A regional chemical transport modeling. *Atmospheric Chemistry and Physics* 12: 3837-3855; doi:10.5194/acp-12-3837-2012

Gao, Y., J. S. Fu, J. B. Drake, Y. Liu and J.-F. Lamarque. 2012. Projected changes of extreme weather events in the Eastern United States based on a high-resolution climate modeling system. *Environmental Research Letters* 7; doi:10.1088/1748-9326/7/4/044025

Guo, T.L., Q.J. Wang, W.J. Bai, **J. Zhuang.** 2013. Effect of land use on scouring flow hydraulics and transport of soil solute in erosion. *Journal of Hydrologic Engineering* 18(4): 465-473.

Guo, T.L., Q.J. Wang, D.Q. Li, **J. Zhuang,** L.S. Wu. 2013. Flow hydraulic characteristic effect on sediment and solute transport on slope erosion. *Catena* 107: 145-153.

Huang, K., G. Zhuang, Y. Lin, Q. Wang, **J. S. Fu,** R. Zhang, **J. Li,** C. Deng, and Q. Fu. 2012. Impact of anthropogenic emission on air-quality over a megacity – revealed from an intensive atmospheric campaign during the Chinese Spring Festival. *Atmospheric Chemistry and Physics* 12: 11631-11645; doi:10.5194/acp-12-11631-2012

Huang, K., G. Zhuang, Y. Lin, Q. Wang, **J. S. Fu,** Q. Fu, T. Liu, and C. Deng. 2013. How to improve the air quality over mega-cities in China? --- Pollution characterization and source analysis in Shanghai before, during, and after the 2010 World Expo. *Atmospheric Chemistry and Physics* 13:5927-5942; www.atmos-chem-phys.net/13/5927/2013/ doi:10.5194/acp-13-5927-2013

Jardine, P., Shao, M.A., and **Gentry, R.,** Eds. 2013. Impacts of Land Use and Climate Change on Hydrological Processes in China in *Journal of Hydrologic Engineering Special Issue* 18(4). This special issue is the outcome of a series of China-US collaborative research projects in hydrology and land use within the framework of JRCEEC.

Jetter, L. and **R.J.C. Chen.** 2012. An Exploratory Investigation of Knowledge Sharing and Cooperative Marketing in Tourism Alliances. *International Journal of Hospitality and Tourism Administration* 13(2): 131-144.

Knappett, P. S. K.; **McKay, L. D.; Layton, A.;** Williams, D. E.; Alam, Md. J.; Mailloux, B. J.; Ferguson, A. F.; Culligan, P. J.; Serre, M. L.; Emch, M.; Ahmed, K. M.; **Sayler, G. S.;** van Geen, A. 2012. Unsealed Tubewells Lead to Fecal Contamination of Drinking Water in Bangladesh. *Journal of Water & Health* 10: 565-578.

Knappett, P. S. K.; **McKay, L. D.; Layton, A.;** Williams, D. W.; Mailloux, B. J.; Alam, Md. J.; Huq, Md. R.; Mey, J.; Feighery, J. E.; Culligan, P. J.; Mailloux, B. J.; **Zhuang, J.;** Escamilla, V.; Emch, M.; **Perfect, E.; Sayler, G. S.;** Ahmed, K. M.; van Geen, A. 2102. Implications of Fecal Bacteria Input from Latrine-Polluted Ponds for Wells in Sandy Aquifers. *Environmental Science & Technology* 46: 1361-1370.

Li, L., C. H. Chen, C. Huang, H. Y. Zhang, G. F. Huang, Y. J. Wang, H. L. Wang, S. R. Lou, L. P. Qiao, M. Zhou, M. H. Chen, Y. R. Chen, **J. S. Fu,** D. G. Streets, and C. J. Jang. 2012. Process analysis of regional

2012-2013 Programmatic Report

ozone formation over the Yangtze River Delta, China using the Community Multi-scale Air Quality modeling system. *Atmospheric Chemistry and Physics* 12: 10971-10987; doi:10.5194/acp-12-10971-2012, 2012.

Li, N., T.-M. Fu, J. Cao, S. C. Lee, X.-F. Huang, L.-Y. He, K.-F. Ho, **J. S. Fu**, Y.-F. Lam. 2013. Sources of Secondary Organic Aerosols in the Pearl River Delta Region in Fall: Contributions from the Aqueous Reactive Uptake of Dicarbonyls. A*tmospheric Environment* 76: 200-207; http://dx.doi.org/10.1016/j.atmosenv.2012.12.005

Mailloux, B.J., E. Trembath-Reichert, J. Cheung, M. Watson, M. Stute, G. Freyer, A.S. Ferguson, K.M. Ahmed, M.J. Alam, B.A. Buchholz, J. Thomas, **A. C. Layton,** Y. Zheng, B.C. Bostick and A. van Geen. 2013. Advection of Surface-Derived Organic Carbon Fuels Microbial Reduction in Bangladesh Groundwater. *Proceedings of the National Academy of Sciences* 110: 5331-5335.

Shi, W.J., **J. Zhuang,** T. Xu, C. Beasley, **S. Ripp, F.M. Menn, A.C. Layton, G.S. Sayler.** 2013. C60 reduces the bioavailability of mercury in aqueous solutions. *Chemosphere*; doi:10.1016/j.chemosphere.2013.09.027

Yang, Y.F., Q.J. Wang, **J. Zhuang**. 2013. Estimating hydraulic parameters of stony soils on the basis of one-dimensional water absorption properties. A*cta Agriculturae Scandinavica* Section B - Soil and Plant Science 63(4): 304-313.

Zhang, Y. and **Q. He**. 2013. Characterization of bacterial diversity in drinking water by pyrosequencing. *Water Sci. Technol.: Water Supply* 13(2): 358-367. DOI: 10.2166/ws.2013.037

Summary of Faculty and Student Partication

Faculty Actively Engaged in ISSE Research

Name	Affiliation
Andrew Bliss	Music
Joseph Bozell	Forestry, Wildlife and Fisheries
John Buchanan	Biosystems Engineering and Soil Science
Guoxum Chen	Nutrition
Rachel Chen	Retail, Hospitality and Tourism Management
Chris Cherry	Civil and Environmental Engineering
Chris Cox	Civil and Environmental Engineering
Jennifer DeBruyn	Biosystems Engineering and Soil Science
John Drake	Civil and Environmental Engineering
Annette Engel	Earth and Planetary Sciences
Kate Evans	ORNL
Joshua Fu	Civil and Environmental Engineering
Matt Gray	Forestry, Wildlife and Fisheries
David Greene	Economics
Carol Harden	Geography
Terry Hazen	Civil and Environmental Engineering
Qiang He	Civil and Environmental Engineering
Don Hodges	Forestry, Wildlife and Fisheries
Phillip Jardine	Biosystems Engineering and Soil Science
Sharon Jean-Philippe	Forestry, Wildlife and Fisheries
Ungtae Kim	ISSE, Civil and Environmental Engineering
Niki Labbe	Forestry, Wildlife and Fisheries
Alice Layton	Microbiology
Joanne Logan	Biosystems Engineering and Soil Science
Brian Long	Chemistry
Andrea Ludwig	Biosystems Engineering and Soil Science
Larry McKay	Earth and Planetary Sciences
Micheal McKinney	Earth and Planetary Sciences
Keil Neff	Civil and Environmental Engineering
John Nolt	Philosophy
Bonnie Ownley	Entomology and Plant Pathology
Jack Parker	Civil and Environmental Engineering
Edmund Perfect	Earth and Planetary Sciences
Mark Radosevich	Biosystems Engineering and Soil Science
Steven Ripp	Center for Environmental Biotechnology
Kevin Robinson	Civil and Environmental Engineering
Jennifer Rutherford	Civil and Environmental Engineering
Gary Sayler	Microbiology
Sean Schaeffer	Biosystems Engineering and Soil Science
John Schwartz	Civil and Environmental Engineering
Andrew Sherfy	Biosystems Engineering and Soil Science
March Souza	Biomedical and Diagnostic Services (Vet School)
Carolyn Staples	Graphic Design
Curtis Stewart	Plant Sciences
Richard Strange	Forestry, Wildlife and Fisheries
Liem Tran	Geography
Cong Trinh	Chemical Engineering
Steven Wilhelm	Microbiology
Larry Wilson	Forestry, Wildlife and Fisheries
Daniel Yoder	Biosystems Engineering and Soil Science
Jie Zhuang	Biosystems Engineering and Soil Science

Post-docs, Graduate Students, and Undergraduate Students Involved in ISSE Research

Student	Degree/Major	Graduation
John Anderson	PhD/Energy Science and Engineering	2015
Kati Ayers	MS/Geology	
Tony Bova	PhD/Energy Science and Engineering	2015
Imani Chatman	BS/Ecology and Evolutionary Biology	2015
Si Chen	PhD/Civil Engineering	2014
Chris Cline	BS/ Civil and Environmental Engineering	
Jinlyung Choi	PhD/Chemical & Biomolecular Engineering	2014
Michelle Connolly	Post-doc/Center for Environmental Biotechnology	
Xinyi Dong	PhD/Civil Engineering	2014
Joshua Frerichs	MS/Environmental Engineering	Spring 2013
Abby Gaddis	PhD/Civil Engineering	Summer 2013
Yang Gao	PhD/Civil Engineering	Fall 2012
Adrian Gonzolez	PhD/Civil Engineering	2015
Jacob Graves	BS/ Civil and Environmental Engineering	
Joey Henry	BS/ Civil and Environmental Engineering	
William M. Hines	JD/Law	Spring 2013
Julie Hipp	BS/Chemical and Biomolecular Engineering	
Maria Hunter	JD/Law	Spring 2013
Jason Kauffman	MS/Geography	Spring 2013
Ben Keck	Post-Doc/Forestry, Wildlife and Fisheries	
Jimmie Jones	MS/CEE	2014
Jessica Linville	PhD/Civil Engineering	Spring 2013
Casey Martin	BS/Biochemistry and Cellular and Molecular Biology	
Margo Meeks	JD/Law	Spring 2013
Ramsey Morton	JD/Law	Spring 2014
Keil Neff	Post-doc/Civil and Environmental Engineering	NA
Logan Nester	BS/Civil Engineering	2015
Costyl Njiojob	Post-doc/Chemistry and Center for Renewable Carbon	NA
Kenna Rewcastle	BS/College Scholars	2015
Alexandra Rogers		
Joseph Rungee	MS/Civil and Environmental Engineering	2014
Seunghyun Ryu	Post-doc/Chemical and Biomolecular Engineering	NA
DeAnna Walker	BS/ Civil and Environmental Engineering	
Robby Woockman	PhD/Civil and Environmental Engineering	2015