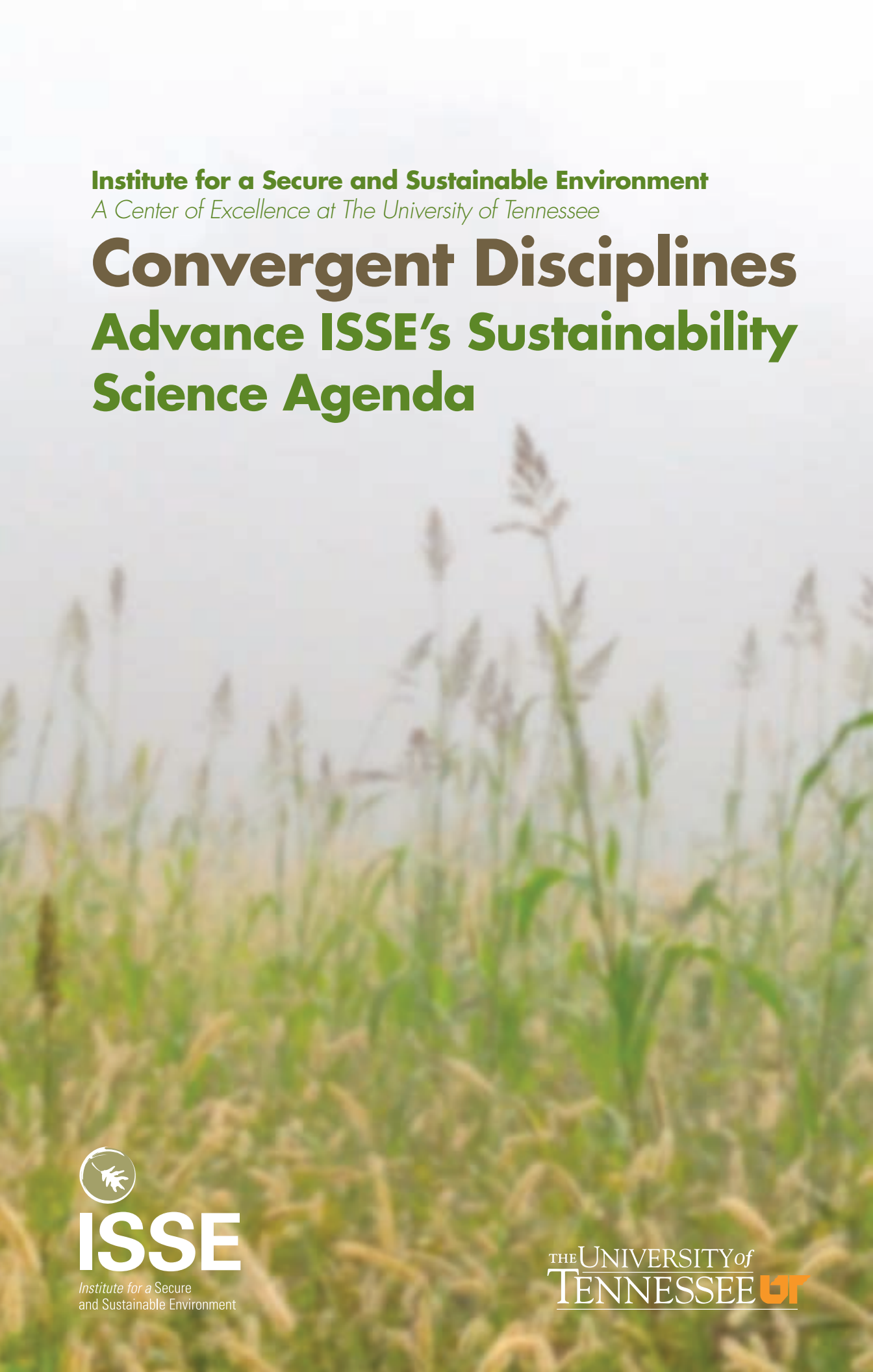

Institute for a Secure and Sustainable Environment

A Center of Excellence at The University of Tennessee

Convergent Disciplines Advance ISSE's Sustainability Science Agenda

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Institute for a Secure and Sustainable Environment

THE UNIVERSITY of TENNESSEE

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THE UNIVERSITY of TENNESSEE

Convergent Disciplines

Advance ISSE's Sustainability Science Agenda

ISSE, whose resident research expertise reflects more than 15 disciplines, continues to respond to challenges that cut across multiple scientific fields.

By ISSE Director
Randall W. Gentry

Sustainability science is an inherently interdisciplinary research realm that requires engaged collaboration across broad areas of science. Nevertheless, many scientific organizations become more and more segmented into strict disciplinary sectors. The result is increasingly columnar research enterprises that may possess significant depth in limited areas but lack sufficient breadth to address issues that range across multiple disciplines. From the beginning, we at ISSE have sought to create a fertile research environment that welcomes the many complementary disciplines that lie at the heart of sustainability science.

Several years ago, within my own discipline of water resources, questions began to arise about whether we had reached a plateau in our research creativity. At the time I was following closely the dialogue among leaders within my field about what lay ahead. I believe it is useful to revisit some of the ideas that were discussed within that context and explore how they apply to the continuing evolution of sustainability science as a truly interdisciplinary field.

Researchers have often struggled to capture quantitative data regarding research productivity and impacts within the state-of-the-science. Schwartz and Ibaraki (2001) used citation rates for groundwater-related manuscripts published in highly respected water resources journals, among them, *Ground Water* and *Water Resources Research*. Their goal was to determine if the publications in these journals were influencing research.

Their findings lead to the cautionary conclusion that the groundwater research field has become commodity driven, aged, and inefficient, "with much produced for little apparent gain." The authors suggest that a paradigm shift is needed to re-energize the field of research, and their findings have spawned a spirited discussion among professionals and in the literature (Belitz 2001, Phillips 2002, Voss 2005).

Interestingly, at the same time, Srivastava (2001) leveled a blistering rebuke at the academic environmental engineering community and, to a lesser degree, at the community of practitioners. Srivastava asked, "is it that all the worthy research that could ever be done and published in the journal has already been done and now we are toying with minutiae? Or is it that 'reality' is too complicated and dirty so people have drifted to mathematical modeling of things inane and banal, with no thought to the practical value of such efforts?" Srivastava's comments were not so much about mathematical modeling as about the scale and novelty of the approach being used.

The literature has suggested that interdisciplinary education lies at the heart of innovation as it pertains to the broad environmental engineering milieu (Hagoel and Kalekin-Fishman 2002). As an example, environmental and water resources engineering and hydrosciences maintain interactions that could spark innovation if the relationship were to be optimized for such creativity. Hagoel and Kalekin-Fishman recognize an urgent need in the scientific literature for boundary crossing and disciplinary cross-fertilization, a need that results from the complex realities present in the research. Even in the distant past, Cohen (1978) recognized that "disciplinary boundaries are temporary and penetrable. Knowledge today is unstable in the sense that it is undergoing an accelerated rate of change."

In the years since, there have been movements in the direction of creating this interdisciplinary framework (Fettig et al. 2000, Semerjian et al. 2004), but creating such a framework is a long-term process that requires continued resource investment and critical evaluation through peer review. The central dilemma today is whether this cross-fertilization is occurring within an optimal framework.

A Merging of Skills

In this magazine, we present ISSE as a broadly interdisciplinary—as well as multinational—research unit devoted to sustainability science and reflective of just the cross-fertilization that Hagoel, Kalenkin-Fishman, Cohen, Fettig, Semerjian, and others have called for.

For instance, ISSE's hydrology and water resources research taps the skills of computer modelers, hydrologists, civil and environmental engineers, planners, biologists, and ecologists, among others. Our toxicology and remediation team reflects backgrounds in soil and earth sciences, modeling, microbiology, engineering, and molecular genetics. Our researchers involved in education and outreach are historians, engineers, vocational and secondary educators, and biologists. Our energy specialists hold degrees in planning, political science, and engineering.

The articles that follow present our institute in terms of prominent research themes. But, as you'll learn, within each theme, scientists with widely varying backgrounds merge their expertise to address some of the pressing

sustainability issues facing our state, nation, and globe.

Each section begins with a short essay that introduces the topic and establishes the context for the information presented in the articles that follow.

The section on hydrology and water resources, "Water, Water Everywhere—But Not for Long," which begins on page 10, explores, among other topics, ISSE's research in the areas of watershed protection and restoration, drought forecasting, water quantity and quality, and the effects of climate change on hydrologic resources.

Beginning on page 19, "Getting the Dirt Out" takes a look at ISSE efforts to clean up Department of Defense and Department of Energy sites, prevent contamination of groundwater systems in East Tennessee and Bangladesh, and promote safe use of wastewater for crop irrigation.

On page 29, "Taking it to the Streets" explores ISSE's education and outreach projects that enhance environmental literacy, restore degraded watersheds, encourage wise resource use, promote use of alternative fuels, create green-sector jobs, and guide distressed East Tennessee communities toward sustainable development.

ISSE is not only interdisciplinary—it's also largely multinational. Indeed, nearly a third of ISSE's research staff members hail from other nations, including Nepal, Taiwan, Korea, India, and China. "International Collaboration," which begins on page 38, presents brief profiles of our international staff members.

On page 44, "Annual China-US Conference Grows, Retains Focus on Climate, Energy, Ecosystems," tells the evolving story of ISSE's China-US Joint Research Center for Ecosystem Change. And "Linking the Global Community," which begins on page 50, provides a look the GLORIAD program, whose network of fiber-optic cables circles the globe and facilitates exchange of information among scientists from more than a dozen nations.

Beginning on page 57, "Engineers of the 21st Century" presents the efforts of ISSE scientists to encourage improved product stewardship in the building-products sector, create a WiFi network in downtown Knoxville that merges high-tech with African-American history, enhance sediment prevention and erosion control on construction sites, develop secondary markets for forest and wood products, bioengineer zebra fish to monitor for estrogens in water supplies, and create living tissue that glows in the presence of cancer cells.

"Making Every Kilowatt Count," which begins on page 69, examines ISSE' range of projects to overcome barriers to improved energy efficiency, promote adoption and use of renewable fuels, control energy waste at truck stops, and create lighter-weight—and more fuel-efficient—vehicles.

As always, I welcome comments and questions about our projects and programs and remain open to new opportunities for collaboration. To learn more about ISSE, I invite you to visit our Web site: isse.utk.edu

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Hydrology And Water Resources

By Marlene Taylor

A Thirsty World Faces A Half-Empty Cup

No substance on Earth—with the exception of the air we breathe—is more precious than water. All living things must have it to sustain life. Yet, in historically water-rich regions like the Southeast, we have treated it as if it were an inexhaustible resource. We pour it wastefully down the drain. Meanwhile, millions of gallons of fresh rainwater cascade through the stormwater system and enter our rivers, carrying with them a host of pollutants. More millions of gallons are used to sustain exotic grasses and plants that can't survive the summer sun without regular watering.

But we have plenty to drink, right? Yes, for a time, but that's changing, even in the Southeast. Just a few years ago, a dispute arose between Georgia and Tennessee. Drought-stricken Atlanta—with its burgeoning and thirsty population—was running short of water, and Georgia pushed to shift the Tennessee-Georgia state border southward to provide the Peachtree State with access to a few miles of the Tennessee River.

The more arid regions of the US Southwest and California have experienced water disputes for decades over rights to the region's waterways, including the Colorado River. The notoriously parched city of Las Vegas, Nevada, recently implemented some wise water-usage strategies when the city, stricken by a seven-year drought, ran out of water in 2001. Water resource officials—albeit just in the nick of time—revamped hotels with low-flow toilets and circulated recycled "gray" water through the city's numerous fountains. Resource managers also offered incentives to suburban residents to opt for natural, xeric—or dry-weather—landscaping instead of exotic grasses that require daily watering in the desert environment. But despite these measures, fears persist that the City of Lights, situated squarely in the desert, will exhaust its available water resources in the next five decades.

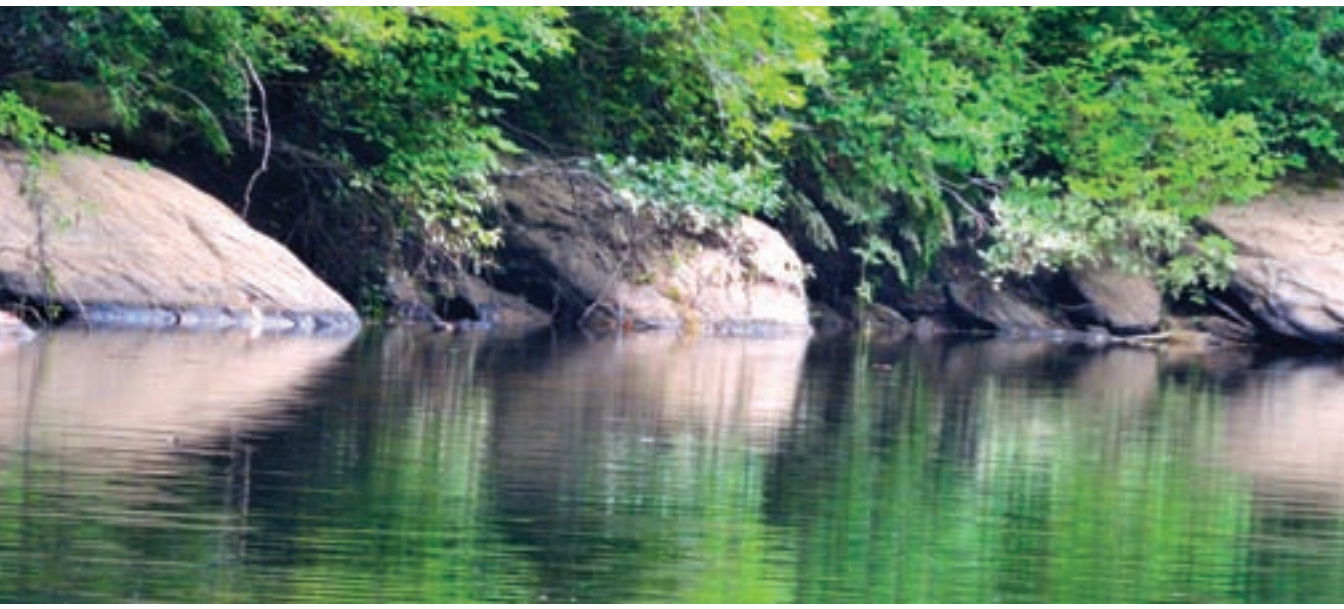
While much of the United States is blessed with abundant rainfall and numerous lakes and rivers, many equatorial nations suffer severe water shortages—and the associated illnesses. The World Health Organization attributes six major parasitic-related diseases that kill about 5 million people a year to unsanitary living conditions often resulting from severely limited water supplies.

Media coverage of the Nashville flood last spring was somewhat overshadowed by the explosion of British Petroleum's offshore drilling rig and subsequent oil spill in the Gulf of Mexico. But hydrologists studied Nashville's disastrous flood with interest, investigating infrastructural

modifications that might have lessened its severity. Cities across the nation face similar problems with stormwater runoff. In fact, the EPA names stormwater runoff as the greatest threat to the nation's water resources.

People in developed countries like the United States, who have convenient access to the faucet, may find it difficult to imagine life without adequate supplies of water. Since 1908, when Jersey City, New Jersey, became the first US city to provide purified water to its citizens, most Americans have had access to cheap, potable water. But water resource specialists are re-thinking how we distribute and use water. In light of population growth, groundwater depletion, and increased evaporation from a warming climate, they are researching ways to retool our infrastructure systems to better contain stormwater runoff and replenish our reserves.

ISSE sustains a broad, multidisciplinary scientific agenda, but water-resources research is one of the institute's dominant foci and ISSE addresses these and other issues facing an increasingly thirsty world.



Water, Water Everywhere—But Not for Long

Climate change, inadequate stormwater-management infrastructure, and failing septic systems threaten water resources in the Southeast, a region once thought to have an inexhaustible supply.

By Marlene Taylor

TENNESSEE WATER RESOURCES RESEARCH CENTER

The Tennessee Water Resource and Research Center (TNWRRC) at ISSE is engaged in numerous projects that seek to protect both the quality and quantity of the state's water resources, including efforts to develop complex hydrologic models to trace the movement of contaminants or investigate the effects of climate change on water resources.

TNWRRC currently supports three US Geological Survey (USGS)-funded projects, each making a considerable contribution to sustainable water resources.

IMPROVED SEPTIC SYSTEMS

John Buchanan from UT's Department of Biosystems Engineering and Soil Science is in his second year of a study on an alternative technology for septic tanks and their drain fields. In traditional systems, wastewater is treated and released into drainage ditches three- to five-feet deep. In many areas of the state, soil conditions prevent these systems from functioning efficiently. Clay soil—common in east Tennessee—doesn't percolate well, and thin soil—common in middle Tennessee—doesn't have the depth needed to cleanse the wastewater before it reaches the groundwater.

Buchanan is looking at the notion of drip irrigation as an alternate method of releasing the wastewater into the soil from single-family septic tanks or from larger subdivision septic systems. After the wastewater is treated in the tanks and the solids settle out, the final product is directed through small hole-filled tubes in a shallow drain field. The treated wastewater is emitted slowly back into the soil via a dosing system, controlled by a pump. The groundwater is protected, the soil's moisture is replenished, and because the wastewater has a farther distance to travel, bacteria in the soil break down the remaining contaminants in the wastewater before they can enter the groundwater system. Buchanan has a number of test sites across Tennessee and is monitoring them for the effectiveness of the new method, determining if the water needs a secondary treatment or other processes before being released back into the ground. Buchanan's results could prevent contamination of groundwater by *E. coli* bacteria migrating from septic systems.

HISTORY IN A TREE RING

Counting rings to determine the age of a felled tree is more than a fun way to interest children in nature. Studying tree rings is also a valuable research method. Tree rings offer up tiny slices of history, telling not only the age of the tree but what conditions were like during each year of its life.

Dendroclimatology is the study of tree rings to determine annual climatic conditions during the tree's growing years. Narrower rings denote years of low moisture or nutrients, while wider rings reflect years of favorable conditions for growth, including ample water.

UT civil and environmental engineer Glenn Tootle is conducting a two-year study to gather historical data on how climatic conditions affect streamflow—particularly during long-term droughts. The year-to-year amount of available water is reflected in the size of the tree rings. Similar research has taken place in the Southeast and other regions of the country, but this TNWRRC project is the first of its kind in Tennessee. Tootle is examining how major climatic events such as the El Nino-Southern Oscillation, the Pacific Decadal Oscillation, and the Atlantic Multidecadal Oscillation affect available water in the state. His findings will aid in developing probabilistic drought forecasts.

A MODEL WATERSHED

A current TNWRRC data-transfer project will come to the aid of researchers who conduct computer modeling on climate and water resources for the Tennessee and Cumberland watersheds in Tennessee. Currently, many of the researchers at UT who conduct modeling use their own computers. Thus, the data they compile are

out of reach of other researchers who may be pursuing similar research tracks. Because the researchers and research teams often use the same data sets to develop their models, a designated geographic information system (GIS) server already populated with those data sets—and available to all—would streamline the modeling process.

"We're in the initial stages of collecting data sets and have started to work with key researchers at UT on how they might utilize that server and how we can best serve their needs," says TNWRRC Director Tim Gangaware. Shesh Koirala, ISSE post-doctoral researcher and principal investigator for the project, is collecting data sets from the National Oceanic and Aeronautic Administration (NOAA), the Environmental Protection Agency (EPA), other state and federal sources. Koirala is also investigating other data sources, like aerial photography and land-use maps, and evaluating software applications that might contribute to the project.

Tim Gangaware

Shesh Koirala

"We want researchers not only to have access to this server but to enter their own data as they conduct their own research," says Gangaware. "They also will be able to store their own data and results on the server." The project is funded by a one-year grant, but Gangaware fully expects it to become a multi-year project.

For more information, contact Tim Gangaware at 865-974-4777, or email: gangwrrc@utk.edu.

THE CENTER FOR WATERSHED SOLUTIONS

The Center for Watershed Solutions—an EPA-designated Center of Excellence for Watershed Management—continues to expand and improve its mission to serve the state and the southeastern region. CWS, a partnership between TNWRRC/UT and the Nashville-based Cumberland River Compact, offers information and resources for budding and existing watershed groups across the state.

Already recognized as leader among watershed organizations in the state, the center was asked to facilitate poster and listening sessions at a Tennessee Department of Environment and Conservation (TDEC) watershed conference in September in Nashville. The event is the first official CWS-TDEC collaboration, and the posters will feature details about on-the-ground watershed improvement projects.

Julie Mawhorter

Year 2010 kept CWS staff busy developing a new Web site. TNWRRC's Julie Mawhorter headed up the effort to populate the Web site, working with the two groups to design a site that can provide guidance and information to watershed groups across the state and to individuals who want to learn about water-quality issues.

The Web site—due to go live in late fall—will provide guidelines for building partnerships, conducting watershed planning and service-learning programs, and engaging the community and K-12 students in educational initiatives. The site will also feature success stories on restoration of neglected streams and abused watersheds, present information on UT faculty research, and promote special events.

CWS surveys of Tennessee residents, governmental agencies, and watershed organizations indicate that many municipalities and local governments are interested in low-impact development (LID) projects but know little about how to pursue them. CWS has responded by collecting data for an online atlas of LID and green infrastructure projects already established in Tennessee. The dataset will be added to the University of Connecticut's Nonpoint Education for Municipal Officials (NEMO) inventory, and will list developers, locations, and types of LID projects in Tennessee. "Not only will this project let other people in the state and across the country see the kind of work that's going on in Tennessee, but it will be a means by which people in Tennessee can learn what other communities are doing and how to get additional information," says Gangaware. The dataset will be accessible through the CWS Web site.

As part of the project, Wyn Miller, a graduate student in landscape architecture, created and sent a Web-based survey to all managers of LID projects in the state to begin collecting data. A three- to five-page write-up submitted by survey participants will provide information on sources of project funding, engineering specifications, costs, and project outcomes. "We want to make sure we represent the breadth of the type of LID practices and the geographic representation across the state," Gangaware says.

Wyn Miller

For more information, contact Tim Gangaware at 865-974-4777, or email: gangwrrc@utk.edu.

IONS IN THE STREAM

ISSE post-doctoral researcher Shesh Koirala thinks in terms of tracers and models, spectral and wavelet analyses, and hydrologic units in his studies on the persistence of chloride ions in various water systems.

Understanding the fate and transport of chemicals in water is essential for those who manage our water resources and establish state and national policies and regulations.

Take *E. coli*, for instance. If it's present in our lakes and streams, how long does it persist, and what happens to it as the water travels downstream? To begin to answer some of these questions, Koirala traced chloride in Walker Branch in Oak Ridge, looking at its concentrations and persistence.

Chloride is chosen as a tracer because it enters the water system through rain, which picks up the chemical as it passes through the atmosphere. It is naturally occurring and is also a conservative tracer, meaning it's relatively stable and remains unchanged in the water. Modeling how chloride behaves in a system can be applied to the behavior of other agents, such as bacteria and nitrates. These models are useful in helping water resource managers and policymakers plan for the future.

For more information, contact Shesh Koirala at 865- 974-1847, or email: skoirala@utk.edu.

THE DRAIN OF CLIMATE CHANGE

Scientists know that climate change—resulting from increased CO_2 concentrations in the atmosphere—affects hydrologic systems. Increased temperatures, evapotranspiration, and changing patterns of vegetation all affect the water cycle.

Global models for predicting how climate change affects the planet's waters have been developed, but they can't easily be applied regionally. Koirala and other researchers are working to scale down the larger models to accurately address individual regions and watersheds. In particular, Koirala is working on a model for the Tennessee and Cumberland watersheds to learn how climate change will affect the region's hydrologic systems—information essential for water

resource planning and policymaking in East Tennessee.

For example, in the Tennessee River, designated quantities of water are diverted for irrigation, power, and water supply, while allowing the river to flow downstream unimpeded. Changes in water availability or rainfall will determine how the Tennessee's waters should be managed to ensure adequate supplies and sustainable flow rates. Koirala is gathering data from different sources, including the National Oceanic and Atmospheric Administration (NOAA), United States Geological Survey (USGS), Tennessee Valley Authority, and the Earth System Grid, among others, to model how water systems will respond to changes in climate. "We have to think of all factors that can influence our rainfall and how much water we will have in the future," says Koirala.

One of the scenarios Koirala is modeling predicts changes in the region's water cycle—including frequency and intensity of rainfall—at twice the current atmospheric concentrations of CO_2. Under such a scenario, will East Tennessee continue to receive 51 inches of rain per year, or will rainfall decline or increase? Will September-November continue to be the driest months, or will that change? Koirala's research will help answer these and other questions and, in the process, provide improved tools for Tennessee's resource managers.

Climate change affects all natural systems, and scientists realize that a warmer climate will inevitably affect water levels in lakes and reservoirs. Koirala's colleague ISSE Research Scientist Ungtae Kim studies surface and ground water and the relationship between the two in exploring ways to sustain adequate access to clean water in the face of reduced supplies and increased demand. Kim also serves as a research assistant professor in UT's Department of Civil and Environmental Engineering.

In arid areas such as North Africa, where

Ungtae Kim

hydrologic monitoring is limited, water resources are extremely valuable, and competition for them is fierce, which creates political instability.

Runoff variability in large basins where water gauges are nonexistent makes management of water difficult, particularly when the basins cross state or national borders. In response, Kim designs reliable, computer-aided hydrologic models to predict runoff, rainfall uncertainty, and other hydrologic phenomena.

"We need to determine if our disaster-prevention systems are flexible enough to adapt to future climate change," says Kim. Further, we should redesign our infrastructure to accommodate changes in climate, population, and urban sprawl. New designs, based on knowledge of how much water is going to flow and when, can help prevent floods, mitigate the effects of drought, and help protect stores of water. Among other engineered solutions, detention basins can help control stormwater runoff in subdivisions, shopping malls, and other large facilities with impervious paved surfaces. These systems direct stormwater into the retaining basins, where it is temporarily stored and slowly re-released once the storm event has ended. Many existing basins are poorly designed and not capable of capturing the extreme stromwater runoff associated with once-in-100-year storm events, such as the one that inundated Nashville this past spring.

For more information, contact Shesh Koirala at 865-974-1847, or email: skoirala@utk.edu. Contact Ungtae Kim at 865-974-4695, or email: ukim2@utk.edu.

MESSAGES FROM A VOLCANO

Environmental engineering PhD candidate Abby Gaddis is comparing observational weather data to climate model data from the time surrounding the 1991 eruption of Mt. Pinatubo in the Philippines. Volcanic eruptions serve as a benchmark for assessing the accuracy and precision of climate models since they provide a sudden impulse to the Earth's climate system.

In particular, the Pinatubo eruption is of interest because it was the largest aerosol perturbation to the stratosphere in this century. The eruption also was the most intensely observed eruption on record. "Volcanic eruptions release both sulfur dioxide (SO_2) and other particulate matter into the stratosphere," says Gaddis. "So you have chemical reactions in the stratosphere with the SO_2 as well as the blocking of sunlight by what is basically dirt."

The enormous amounts of material ejected in an eruption are then spread globally, affecting the Earth's climate for up to a couple of years. "These changes will be seen in precipitation data (typically an increase) as well as surface temperature data (typically a decrease) and in other climate variables," says Gaddis. "If your model follows all those signals correctly over such a short time period, then it's a good model. The model variables that don't track the observations as well might reveal problems in the model." In her study, Gaddis is using weather records from the National Centers for Environmental Protection/University Corporation for Atmospheric Research (NCEP/NCAR) Reanalysis project, consisting of monthly averages of variables like surface air temperature and precipitable water (i.e., the quantity of water contained in a column of atmosphere, if the water were to fall as rain). This will then be compared to data for the same time period from the newest Community Climate System Model, CCSM4, which runs on the Jaguar supercomputer at Oak Ridge National Laboratory.

For more information, contact Abby Gaddis via email: agaddis@utk.edu.

ISSE Director Randall Gentry, associate professor in UT's Department of Civil and Environmental Engineering, currently directs the postdoctoral research of Shesh Koirala and the doctoral research of Abby Gaddis. Both researchers are focusing on climate systems at a basin scale and seek to understand uncertainties and predictabilities at that scale.

Toxicology And Remediation

By Elise LeQuire

The Ambassadors Of Clean

The Greek physician Hippocrates, in his treatise "On Air, Waters, and Places," was among the first to articulate the implications of environmental factors for human health. The ancient Romans, however, with their elaborate network of aqueducts, continued to funnel untreated waste water into sewers that flowed into the Tiber River. Since the days of the Roman Empire, understanding of the myriad ways humans are exposed to contaminants has grown by fits and starts.

Today, large areas of the developing world still have no access even to such basic infrastructure as sewer systems. Humans live in crowded conditions, often in close contact with livestock, and drink from wells that are situated near primitive latrines. Even in East Tennessee, many people in rural areas still depend on wells and springs for drinking water, and pathogens may find their way long distances into family and community water supplies.

Researchers from the University of Tennessee's (UT) Institute for a Secure and Sustainable Environment (ISSE), Department of Earth and Planetary Sciences, and Center for Environmental Biotechnology (CEB) are combining forces to better document the presence of pathogens in streams and groundwater and track their transport through hydrogeologic systems. This line of research can help heighten awareness of the need for public vigilance and testing. It also helps the public-health sector monitor and mitigate chronic contamination in the developing world and occasional contamination that causes sporadic water-borne disease outbreaks in the United States.

In the Gaza Strip, where water is scarce and the aquifer is compromised by overuse, treated wastewater is being used to irrigate agricultural crops. Treatment does not eliminate all pathogens, however, and the risks to public health from consumption of food produced in this manner have been poorly understood. An ISSE researcher with a strong background in statistical analysis and computer programming recently used his expertise to assess the risks involved with this practice.

The findings suggest ways to minimize the potential spread of pathogenic infection to the public through irrigation.

At many US Department of Energy sites, groundwater contamination from highly radioactive materials and heavy metals is the legacy of weapons production during World War II. For ISSE researchers, the proximity of Oak Ridge National Laboratory (ORNL) and its long history of research focused on toxicology and remediation presents unparalleled opportunities for cooperation.

ISSE researchers adept in computer modeling and statistical analysis are involved in basic, interdisciplinary research with ORNL scientists. One study is based in a watershed that is the focus of the most intensive long-term ecological, environmental, and hydrologic study in the world. Another study reports on a method to predict the mobility of uranium and technetium in highly acidic groundwater. Yet another deploys bioluminescent reporters designed by CEB researchers to understand interactions among mercury, soil particles, and biosystems using soil samples from a contaminated site at ORNL.

In August 2010, nearly four months after the explosion at the Deepwater Horizon oil rig, the National Oceanic and Atmospheric Administration published a report indicating that naturally occurring microbes with an affinity for oil are breaking down the leaked oil at a surprising rate. Monitoring and measuring this process in such a large body of water, however, is not an easy task. For more than a decade, researchers at CEB have been designing and tailoring a suite of genetically engineered microorganisms (GEMs) that glow in response to specific toxic substances. Thirteen years ago CEB and ORNL received permission to use these organisms for the first time in a controlled experiment at an ORNL site. For now, these bioluminescent reporters cannot be released into the wild because of concerns over their persistence and safety in the environment.

Current research at the original site, where the GEMs have been maintained in storage tanks, aims to elucidate the long-term fate of these GEMS. The information will be valuable in determining how GEMs may be regulated in the future. If the research proves the organisms are harmless, they could be released in an oil spill. As the organisms consume the oil, they would also emit visible light that could be monitored by satellite to determine where the oil is.

ISSE has a long history of collaborative, interdisciplinary research that spans the UT campus, other US research institutes, and experimental sites around the world. This combined expertise is advancing our knowledge of feasible ways to pinpoint and remediate contaminants of concern at the local, regional, and international scale.

Getting the Dirt Out

ISSE researchers combine forces to detect and remediate contaminants in water, soils, and sediments.

By Elise LeQuire

SEPTIC-SYSTEM SLEUTHS

Water-borne disease is a persistent problem in the developing world, where diarrheal disease is a leading cause of death among children under five years old. In contrast, because of modern sanitation methods and access to quality health care, children rarely die from diarrheal disease in the United States. Although morbidity is low in the United States, fecal contamination of water supplies still remains a serious threat to public health.

"People forget that we have periodic outbreaks of water-borne disease even in the United States," says Larry McKay, leader of the Institute for a Secure and Sustainable Environment's (ISSE) Water Resources Program. In Wisconsin, for example, a restaurant in a semi-rural area with a new well and new septic tank—built to code and designed and installed properly—was the source of a serious water-borne viral disease outbreak.

"The well and septic tank responsible for the outbreak were installed in a rock-fractured limestone aquifer, which is a hydrogeologic environment that is highly susceptible to contamination," McKay says. This type of bedrock aquifer is similar to many aquifers in east Tennessee. "In these sensitive environments our conventional engineering standards for construction and monitoring of septic systems and wells may not be adequate."

Larry McKay

Unlike municipal water systems that require chlorination or disinfection, small water systems that serve venues such as rural restaurants, campgrounds, and churches require no treatment and can be at risk for disease outbreaks. Moreover, rural areas where wells and septic systems were once widely spaced are now being densely developed. "Having a large number of septic fields close together can overwhelm the natural ability of soil and rock to filter out organisms and increase the risk of the spread of infectious microorganisms that could affect large numbers of people," says McKay.

McKay underscores the need to raise

awareness and increase monitoring of water quality. "People don't test their well water often enough." More basic research is needed to determine how prevalent these disease-causing organisms are in well water, and the public needs to be made aware of the importance of on-site, commercially available treatments to disinfect water for households, campgrounds, and other areas where there is no municipal water treatment.

Findings of a study on the Wisconsin outbreak will be published in a special issue of the *Journal of Ground Water* on "Pathogens and Fecal Indicators in Ground Water."

Alice Layton

McKay, who is also the Jones Professor of Hydrogeology and head of the Department of Earth and Planetary Sciences, is guest editor for the issue. The special issue includes papers that he and Alice Layton, a research professor with the Center for Environmental Biotechnology (CEB), have co-authored with their former graduate students Peter Knappett and Trisha Johnson on microbial sampling of groundwater in a village in Bangladesh and on viruses and bacteria in karst and fractured rock aquifers in East Tennessee.

Recent research in watersheds in East Tennessee suggests that routine water-quality testing for *E. coli* may not be sufficient to detect the occurrence of actual disease organisms. "*E. coli*-monitoring is a blunt instrument," says McKay, "It tells you whether fecal bacteria are present in the water, but it doesn't tell you whether microorganisms capable of causing disease are present."

In collaboration with researchers from the University of Dhaka, the University of North Carolina at Chapel Hill, and Columbia University, McKay and Layton are conducting research in an area of

Pictured in the photos on this spread is Larry McKay's research team as they conduct studies in a Bangladeshi village where latrines and bathing ponds act as sources of recharge to the aquifer. Photos provided by Larry McKay

Bangladesh where one of the world's best databases on diarrheal diseases has been maintained since the 1960s from a number of villages. "Research in Bangladesh is relevant to the United States because the frequent occurrence of disease-causing microorganisms makes it a good place to refine microbial sampling and testing equipment, as well as to study the relationship between fecal contamination and human health," McKay says.
For the special issue of the *Journal of Hydrology*, McKay and Layton report on a method of concentrating groundwater samples to determine the presence of bacteria, viruses, and protozoa. "A virus is a thousand times smaller than *E. coli*," says Layton. "Bacteria are much easier to detect because they are so much bigger."

Water samples from the Bangladeshi village were put through a hollow-fiber filtration system that allows water to pass through, but is fine enough to collect particles as tiny as 20 nanometers in diameter. The assays Layton runs on water samples, however, are prohibitively expensive for routine monitoring. "This is not a portable technology," she says, though eventually researchers in Bangladesh could run the tests in their own hospitals.

Layton continues to refine the method she pioneered some 10 years ago to detect pathogens in water samples—real-time polymerase chain reaction (rt-PCR). "With recent improvements in the PCR technology, we are better able to detect animal RNA viruses," she says. Similar assays can also detect a genus of bacteria, *Bacteroides*, which are present in the digestive systems of all mammals and are host specific, so it is possible to determine whether contamination is from humans, wildlife, or livestock.

Fractured rock in Karst terrain allows rapid movement of contaminants.
Photo by Larry McKay

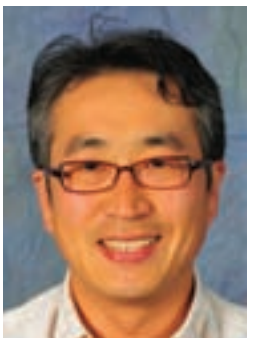
Layton recently used PCR assays to track the concentration and persistence over time of equine-specific *Bacteroides* in stream water where runoff from pastures can introduce fecal matter into the stream. Layton and colleagues found that these *Bacteroides* degrade more rapidly at higher than at lower temperatures, likely because protozoans, which graze on the organisms, are more active in warmer weather. This research may be used to determine the origin of fecal contamination and assist in developing remediation plans for watersheds.

For more information, contact Larry McKay at 865-974-0821, or email: lmckay@utk.edu.

WHERE WATER IS SCARCE

In the Gaza Strip, with its critically limited water resources, overuse of groundwater has led to lowered water tables and an encroachment of sea water into the aquifer. One alternative to agricultural irrigation with groundwater is applying treated wastewater to field crops, but the risks to public health of using recycled water are uncertain. When Ahmed E. Al-Juaidi, a researcher at Utah State University (USU), wanted to assess those risks, he turned for help to Ungtae Kim, an ISSE research scientist and research assistant professor in UT's Department of Civil and Environmental Engineering (CEE). Kim received his doctorate from USU in water resources engineering in 2007.

There are many pathogens that survive the treatment process, and each one has a different probability of infection to humans. "I wrote a short, fairly simple program to evaluate overall annual infection risk when people consume agricultural products from irrigated land," Kim says. By using a computer program to evaluate 10,000 cases of pathogenic infection, Kim discovered that the annual infection risk is a function of wastewater treatment efficiency and exposure time between the last irrigation and consumption. The longer the time since irrigation, the lower the risk to the public. An additional precaution is to switch from surface irrigation to drip or sprinkler irrigation. These practical measures can increase the economic efficiency of water use threefold and at the same time decrease the use of freshwater resources for applications deemed risky, resulting in a significant reduction of groundwater use. Results of this research were published in the *Journal of American Water Resources Association*.



Ungtae Kim

Kim was recruited to ISSE and CEE in

2008 by Jack Parker, ISSE associate director for research, and ISSE Director Randall Gentry, who were impressed by Kim's ability to manipulate large data sets and to model hydrology, statistics, and stochastic—random—processes.

When he joined ISSE, Kim was a self-declared novice at groundwater contamination and remediation. "My previous research was focused on climate change and surface water hydrology," he says. Kim likes to cite the adage that "all models are wrong, but some are useful" to explain the limitations and inherent problems associated with use of models. "If we enter wrong observations or data, we get the wrong results."

Kim was attracted to ISSE by the breadth and depth of the institute. "Randall Gentry has assembled a wide spectrum of talented people in environmental sciences and decision-making protocols so that various research fields produce the maximum synergistic effects," he says.

For more information, contact Ungtae Kim at 865-974-4695, or email: ukim2@utk.edu.

LEGACY OF THE MANHATTAN PROJECT

Parker, who is also a research professor in UT's Department of Civil and Environmental Engineering, has recently used his modeling expertise on a site at the Y-12 National Security Complex of the US Department of Energy's (DOE) Oak Ridge National Laboratory (ORNL). From the early 1950s through the early 1980s, liquid wastes were pumped into holding ponds at the Y-12 complex. Highly radioactive byproducts of the enrichment process to obtain weapons grade uranium, including uranium and technetium, have since leached into groundwater, surface water, and sediments in and downstream of the ponds. Removal of all the contaminated material is not a feasible option, so remediation efforts focus on containment and immobilization. "By changing the geochemical conditions, it is possible to reduce the mobility of radionuclides by converting them to less-soluble forms facilitated by microbial processes," Parker says.

Jack Parker

In an article published in the *Journal of Hazardous Materials*, Parker and colleagues report on a method to predict the mobility of uranium and technetium in highly acidic groundwater. "Some of the water has a pH as low as 3 because nitric acid, used in the uranium enrichment process, was deposited in the waste ponds," Parker says. By manipulating pH and redox conditions in samples taken from wells on the site, geochemists working at the site found that the radionuclides bind to iron and aluminum oxides in the soil. As pH increases to near neutral, more than 90 percent of the uranium and technetium was removed from the solution.

"If you get the pH near neutral and maintain reducing conditions by adding soluble organics that serve as microbial food sources, these contaminants become less mobile," Parker says. "Unfortunately, maintaining these geochemical conditions can require ongoing amendment additions."

For more information, contact Jack Parker at 865-974-7718, or email: jparker@utk.edu.

MERCURY RISING

Mercury is another toxic legacy of weapons production at DOE sites, including Oak Ridge, Hanford, and Savannah River. Jie (Joe) Zhuang, ISSE research director, is working with a multi-institutional research group to better understand the fate and transport of an ionic form of mercury in subsurface water, soils, and sediments. Zhuang's research team includes Alice Layton and Steven Ripp of CEB; Wenjuan Shi, a visiting scholar from China's Xi'an University of Technology; and Tony Zhuang, a science student at Oak Ridge High School.

Sorption and movement behaviors of mercury in soils at the contaminated sites are being examined in the laboratory using a bioluminescent bacterial reporter. The reporter was designed by Joint Institute for Biological Sciences Director Gary Sayler, CEB Managing Director John Sanseverino, and CEB's Layton and Ripp to detect bioavailable mercury. The lab setting mimics real-world hydrologic conditions during alternatively wet and dry periods to quantify the effect of natural environmental conditions on mercury distribution and mobility in complex soils. A non-invasive, high-resolution imaging system is used to visually record the reaction of the reporter to the presence of mercury. "The bioreporter is an excellent tool to understand interactions between mercury, colloidal soil, and biosystems," says Zhuang.

The research team is also pursuing the utility of nanomaterials (such as nanocarbon) as agents in absorbing mercury. "Nanomaterials are easy to deliver to contaminated subsurface locations," says Zhuang. "If we find any nanomaterial that can absorb mercury, we can use it to reduce the mercury's biotoxicity, thus protecting the subsurface bio-environment from contamination." The mercury bioreporter offers a unique way to easily distinguish the bioavailable mercury from its other forms (such as adsorbed or organic) at extremely low concentrations.

Joe Zhuang

Steven Ripp

The group found that the bioreporter's effective detection concentrations of mercury range between 0.001 and 3 microgram per liter. The bioreporter can thus be used to analyze ionic mercury in a liquid sample, but more important, it can rapidly determine how much mercury is potentially toxic to organisms in various environments. This capability is beyond that of any existing mercury analytical instruments. Eventually, the mercury biosensors and nanomaterials could be deployed on mercury-contaminated DOE sites, mercury and gold mining sites, and a coal fly-ash slurry site at the Tennessee Valley Authority's Kingston Fossil Plant, where an accidental spill released fly ash into the Clinch and Emory rivers in 2008.

Mercury contamination also exists widely in China. This integrated research will facilitate collaboration and data exchange on mercury contamination among the scientists of China and the United States. The participation of Tony Zhuang and other high school students will help cultivate growth of the next generation of environmental scientists.

For more information, contact Jie (Joe) Zhuang at 865-974-1325, or email: jzhuang@utk.edu.

STREAM CHEMISTRY

Since the 1970s, the Walker Branch watershed on ORNL's Oak Ridge Reservation has been the focus of the most intensive and long-term ecological, environmental, and hydrologic studies in the world. Shesh R. Koirala, a post-doctoral research associate with ISSE, has recently

applied his background in statistical analysis to 10 years of data from the West Fork of Walker Branch.

In a paper published in the *Journal of Hydrology*, Koirala and colleagues from ISSE, ORNL, and UT's Department of Earth and Planetary Sciences analyzed stream chemistry and long-term persistence of chloride in relation to hydrologic variables such as rainfall and discharge—the flow of water in a stream, groundwater, or river system.

Chloride is in the air and is primarily absorbed in water during rainfall. "We use it to trace and understand the pathways of ground water in a particular hydrologic system," Koirala says. He has applied his expertise in novel statistical approaches to data analysis to understand the short- and long-term persistence of a chloride solute in response to stream discharge and rainfall. The study showed that short-term persistence is caused by rainfall and discharge, while long-term persistence is caused by discharge alone.

This basic knowledge of hydrological processes over long time periods may help researchers understand the effects of climate change and how extreme weather events, from drought to high levels of precipitation, affect hydrology and stream health.

A Gem of a Project

In 1996, researchers at the University of Tennessee (UT) and Oak Ridge National Laboratory (ORNL) were the first to be granted permission by the US Environmental Protection Agency to engage in field studies of a genetically engineered microorganism (GEM) created by fusing a light-emitting (lux) gene into a common bacterium, *Pseudomonas fluorescens*. As this strain, HK44, comes in contact with substances that have certain or potential carcinogenic or mutagenic properties, such as polycyclic aromatic hydrocarbons (PAHs), the GEM glows, indicating the presence of PAHs and at the same time degrading them.

The organisms were placed in large tanks—lysimeters—with several layers of soil and gravel and, in the middle, a mixture of soil, target contaminants, and the GEMs. "The GEMs glowed as they ate the oil," says Steven Ripp, a research assistant professor at UT's Center for Environmental Biotechnology. "We are now going back out to the lysimeters to see if this engineered microbe or remnants of its DNA are still around as a means to explain the persistence or environmental risk of released microbes." The current project, which is funded by the US Department of Agriculture, may help regulators determine whether these organisms are safe to use in real-world remediation efforts.

For now, EPA regulations forbid releasing GEMS into the wild because of the uncertainties surrounding their long-term viability and safety in the environment. If deemed safe, GEMs could, in the future, be deployed in situations such as the Gulf of Mexico oil spill, where they would consume the oil and glow as they do so. The visible light they emit could be monitored by satellite. "If the organism glows, that's where the oil is."

For more information, contact Steven Ripp at 865-974-8080, or email: saripp@utk.edu.

—Elise LeQuire

Education And Outreach

By Marlene Taylor

Toward An Enlightened Citizenry

The philosophers, scholars, and statesmen who shaped our democracy understood the importance of an educated public. Among them was Thomas Jefferson, who believed that education should be government-sponsored and free to everyone. But it wasn't until the end of the 19th century that the institution of public education came into being, when advocates Horace Mann and Henry Barnard advanced the argument that "common schooling could create good citizens, unite society, and prevent crime and poverty."

There's no discounting the value of formal education, but the acquisition of knowledge doesn't end in the classroom; it only begins there. Indeed, education and outreach that extend beyond the schoolhouse gate and benefit the general citizenry are central to the missions of most major universities, the University of Tennessee (UT) included.

In its mission statement, UT pledges to:

- Partner with communities to provide educational, technical, and cultural support to increase the livability of those communities.

- Contribute to improving the quality of life, increasing agricultural productivity, protecting the environment, promoting the well-being of families, and conserving natural resources.

To a large extent, improved quality of life and enhanced educational opportunities go hand in hand and produce benefits in nearly all sectors of the community. More and more, life-long education has sought to bolster environmental awareness and clarify the impacts our decisions and actions have on the planet.

Life on Earth comprises a complex network of interdependent chemical and biological systems that has no regard for the legal boundaries separating states and nations. With the dawn of each new decade, our scientists solve more of the planet's mysteries and gain greater understanding of the flow of energy, the processing of natural cycles, and the integration of the physical systems that sustain life. We are all riders on the same planet, and all of us play a role—for better or worse—in the Earth's overall health.

Take the water cycle, for example. Many factors and processes affect the way surface water is

released into the atmosphere to form rain and the rate at which the water table is replenished. Most of us realize that running tap water down the drain is wasteful and that stormwater runoff alters the water cycle by carrying off large quantities of water from roads and parking lots—much of it tainted with oil and other pollutants—that should, instead, slowly percolate back into the groundwater. Likewise, we now know that increasing concentrations of CO_2 will trap more and more of the sun's heat, prompting temperature rise and disruption of prevailing weather systems. Society's growing awareness of these and other environmental issues and the human behaviors that contribute to them derives, to some extent, from the incorporation of environmental education into the K-12 and college curricula. But the nonformal education sector—including citizen groups, the media, and nonprofit organizations dedicated to sustainability—also has contributed significantly to an increasingly environmentally literate populace.

UT's Institute for a Secure and Sustainable Environment supports a range of educational and outreach projects that target traditional students as well as adult learners. The projects seek to raise environmental awareness and encourage citizens of all ages to adopt sustainable behaviors in the way they live and work, purchase and consume, and travel and play.

Jonathan Overly, executive director of the East Tennessee Clean Fuels Coalition, believes that the message of alternative fuels (alt-fuels) can be shaped for all audiences, from early elementary school children on up. In fact, he often applies the same techniques teachers use in the classroom—art projects, contests, and games—in introducing citizens of all ages to the interlinkages among biofuels, clean air, and reduced dependence on foreign sources of oil.

Research Associate Ruth Anne Hanahan heads up education and outreach for the Tennessee Water Resources Research Center and has numerous programs in place in Knox County schools and the community at large that increase knowledge of water pollution and conservation.

In 2010, ISSE partnered with Self Awareness Consultancy (SAC) International to form a premier source of consultation and training in dealing with threatening behavior in schools and workplaces. Heading up this new endeavor are Sheila Webster, leader of ISSE's Education and Social Perspectives Program (ESP), and Dennis McGowan, vice president of SAC. Meanwhile, Rex Short, ISSE manager of Environment, Safety, and Health Education continues to offer instruction and training to emergency responders, counselors, law enforcement officials, and others who might be called on in the event of mass-fatality events. While ISSE's mass-fatality training has been offered since 2002, the incorporation of training for threatening behavior will help maintain safer workplaces and schools. The new courses will begin in October 2010.

Other ESP projects pursue creation of jobs in the renewable energy field and increased adoption of environmental technologies by community and tribal colleges, technical schools, and industrial work sites.

Tim Ezzell, director of the ISSE's Community Partnership Center, teaches a graduate course on sustainable growth in rural, resource-stressed, Appalachian communities. To him, poverty is the greatest barrier to sustainability and the biggest threat to the environment. "People who can't meet today's needs can't be expected to provide for tomorrow's needs," Ezzell says. "Though the people of Appalachia love their land and want to sustain it, they also face economic realities that make it very difficult to do so."

Taking it to the Streets

ISSE's educational programs and outreach projects spread the message on security, environmental sustainability, and wise resource use to audiences young and old throughout East Tennessee.

By Marlene Taylor

Sustainability science can be as complex as compiling the elaborate data sets and crunching the calculations that undergird climate or hydrologic models, or as simple as placing a rain barrel under a spout to collect runoff for irrigation.

Through a growing range of educational programs and outreach projects, various ISSE initiatives and centers promote the precepts of sustainable living, targeting all segments of the population, from the youngest school children to the retired professional, from the new homeowner to the established farmer.

EAST TENNESSEE CLEAN FUELS COALITION

The East Tennessee Clean Fuels Coalition (ETCFC) promotes production and use of alternative fuels (alt-fuels) from the Tri-Cities to Chattanooga. Over its eight-year existence, the organization has continued to forge new partnerships, expand its scope, and broaden its audience.

In 2004, ETCFC was designated as a member of the Department of Energy's Clean Cities Program, an outgrowth of the Energy Policy Act of 1992. The program seeks to reduce US dependence on foreign oil, improve air quality, and enhance local economic activity by supporting public-private partnerships that spur the use of alternative fuel vehicles and help build supporting infrastructure.

The inclusive ETCFC Web site keeps the clean fuels community informed on the latest innovations from automobile manufacturers, job creation in the alt-fuels sector, and locations of the newest ethanol and biodiesel fueling stations. The Web site's "Basics for Kidz" page contains colorful graphics and questions and answers that explain, among other things, the negative environmental impacts of continued reliance on petroleum products, the natural processes behind production of alt-fuels, and the important differences between renewable and nonrenewable energy sources. AmeriCorps volunteers help maintain the ETCFC Web site.

The TN Clean Fuels Advisor, accessible online and in hard copy, is a quarterly publication covering news from the partnering Clean Cities coalitions in East, Middle, and West Tennessee. The newsletter, in its seventh year and published by ETCFC Executive Director Jonathan Overly, keeps readers abreast of current clean fuel topics. For instance, the winter/spring 2010 issue announces the installation of electric-vehicle charging stations for municipal vehicles in Nashville and a new processing unit for converting cooking oil into biodiesel in Clarksville. The publication also provides information on grant and loan opportunities and local events that display or demonstrate alt-fuel technologies.

ETCFC AmeriCorps volunteer Emily DeVillers talks with students about clean fuels. Photo by Nikki Bumgardner

ETCFC volunteers introduce clean-air concepts to elementary school students. Photo by Wenny Ng

With the aid of social media tools like Twitter, Facebook, Linked In, and You Tube, Overly keeps ETCFC's outgoing message current and accessible.

The Kids for Clean Air program is ETCFC's traveling classroom presentation, tailored for first-12th graders. "Our presentations relay facts about our current oil predicament (e.g., how much we use and where it comes from), what alternatives are in use today, and why reducing our petroleum consumption and carbon footprint is important," Overly says. In the 2009-2010 school year, AmeriCorps volunteer Emily DeVillers made presentations to more than 5,000 students. That's up from 700 in the 2006-2007 school year, the first year the program was offered. DeVillers also coordinates The Clean Fuels School program, which takes the message further by recruiting middle- or high-school teams to take the alt-fuel message to citizens in their neighborhoods. "The Clean Fuel School program is a great way for dedicated students to come together to create real change in their communities and help the country and the planet at the same time," says DeVillers.

The coalition holds quarterly public meetings throughout East Tennessee to provide updates and increase availability and use of alt-fuels in the Tri-Cities area, Knoxville, and Chattanooga. Overly also holds quarterly meetings for municipal and industrial fleet managers in East Tennessee who have made or are considering the switch to alt-fuels.

The ETCFC Annual Run for Clean Air in April bolsters air quality awareness in East Tennessee and helps raise funds for ETCFC. WBIR television co-sponsors the 5K run/walk, which offers brief environmental workshops, live music, and information on clean fuels. This year's run drew 340 participants. "The run is an event to celebrate the wonderful outdoor environment we have in East Tennessee and raise awareness of ETCFC's efforts to improve our air quality and increase use of alternative fuels," says AmeriCorps Volunteer Wenny Ng.

ETCFC has a presence at nearly all regional events that focus on alt-fuels. At the recent Electric Vehicle Show in Knoxville, Overly

and staff entertained and informed at the same time. “At the information tent, people could answer trivia questions to obtain bean bags to play cornhole and a chance to win a prize,” says Overly. “The event successfully increased EV visibility, allowing people to inspect and learn about electric vehicles, all while having fun.”

For more information, contact Jonathan Overly at 865-974-3625, or email: jgoverly@utk.edu. Visit the ETCFC Web site: http://eerc.ra.utk.edu/etcfc/.


Jonathan Overly

TENNESSEE WATER RESOURCES RESEARCH CENTER

As the Tennessee Water Resources Research Center (TNWRRC) grows and expands its efforts to establish water preservation and conservation practices, its education and outreach initiatives increase in scope.

Adopt-A-Watershed, Adopt-A-Stream, Tennessee Yards & Neighborhoods, Kids in the Creek, and county-wide cleanups are just a few of the programs and events TNWRRC Senior Research Associate Ruth Anne Hanahan helps coordinate with local community partners. Hanahan and the seven-member CAC AmeriCorps Water Quality Team also continue to maintain an educational presence at Knox County’s annual EarthFest and Water Fest.

Photos down right side of page: students from various Knoxville schools investigate a stream, plant vegetable and flower gardens, install a green roof, and plant trees for an arboretum. Photos by CAC AmeriCorps Water Quality Team

Adopt-A-Watershed classroom activities include building bird houses and establishing a rain garden. Photo by CAC AmeriCorps Water Quality Team

At the 2010 Water Fest, held at Ijams Nature Center in Knoxville, the AmeriCorps Water Quality Team members combined their imaginations with their scientific backgrounds to entertain and inform 750 elementary school children in attendance. "Pirates" in creative costumes aboard a life-sized "ship" performed a science show that demonstrated the utility and value of abundant clean water.

At the April EarthFest, which drew 9,000 people, the team sponsored the Green Living Tent, which featured 12 expert speakers on topics like green roofs, native plants, and pervious asphalt that allows stormwater to pass through. Three additional set-ups provided information on the Tennessee Yards and Neighborhoods program, rain gardens, and nonpoint source pollutants and preventive measures.

ADOPT-A-WATERSHED

Service learning involves both a teaching and learning strategy that integrates meaningful community service with instruction and reflection to enrich the learning experience, teach civic responsibility, and strengthen communities.

TNWRRC embraces the place-based learning concepts of Adopt-A-Watershed as an educational outreach tool. The program involves teachers and students in efforts to improve the health of their school's watershed using the concept of a living laboratory and a multidisciplinary hands-on approach. Teachers learn principles and activities they can incorporate into their classes that satisfy state requirements, instill awareness of watershed issues, and fulfill a need within their communities. In the end, children reflect on new ways to view their local surroundings and learn to better respect its limited resources.

Ruth Anne Hanahan

This year Adopt-A-Watershed hands-on learning projects involved 1,758 middle and high school students in educational activities lasting from 60 to 90 minutes, says Hanahan. "And 1,363 middle and high school students worked on projects that had real results in improving the health of 10 local watersheds." Forty-two mile long Beaver Creek, which runs along the Emory Road corridor of north Knox County, continues to be the focus of restoration work and public

A mulched walking path at Gibbs High School's outdoor classroom.

awareness campaigns. Passing through five communities—Gibbs, Halls, Powell, Karns, and Solway—the creek and its watershed provide living laboratories for five schools and 13 classes.

Examples of class projects for the 2009-2010 school year include design and installation of two rain gardens on the Powell Middle School campus; a sculpture, photographic exhibit, and paintings of aquatic-themed subjects at Powell High School; a creek investigation and presentation of findings by Karns environmental science students to Water Quality Forum members; and the construction of a storage shed with a green roof by Gibbs High School carpentry students.

Other watersheds in the region also benefit from Adopt-A-Watershed projects, including Knox County's Baker, First, Third, Love, Lyons, Stock, Ten Mile, and Turkey creeks. The Tennessee River watershed also was the site of a recent clean-up.

During the 2009-2010 school year, elementary, middle-, and high-school students in Knox County—with assistance from the CAC AmeriCorps Water Quality Team—planted vegetable, herb, and butterfly gardens; built bird houses and bat boxes; constructed a compost bin; removed invasive plants; planted more than 200 native trees and shrubs; wrote and recorded public service videos on protection of air, land, and water; and created thematic works of art on water.

RAINY DAY BRUSH-OFF

This year's third annual Rainy Day Brush Off event received a 2010 Governor's Environmental Stewardship Award from Tennessee Governor Phil Bredesen for showing "exceptional voluntary actions that improve or protect our environment and natural resources." The project invites artists to paint and decorate 55-gallon rain barrels, turning them into functional works of art.

Thirty "barrels of art" placed in busy areas around town and accompanied by informational signage increased awareness that an average rain event can fill a 55-gallon barrel to the brim. With use of the barrels, water that might otherwise have flowed into storm drains can be used for irrigation. More than 2000 rain barrels are in place and saving water in Knox County.

"Rainy Day Brush Off is a win-win idea for those groups working to protect and conserve our water resources and for residents who are looking for ways to cut their bills and be better stewards of their environment," says Hanahan. "It is also a way to build partnerships, with members of the Water Quality Forum all coming together to make this event happen."

TENNESSEE YARDS & NEIGHBORHOODS

The Tennessee Yards and Neighborhoods (TYN) pilot program, initiated in 2007, is nearing completion, and TNWRRC is preparing to launch the program into an expanded phase. "We now have of a state-wide advisory board assembled that will bring new talents and skills to the TYN program," says Hanahan. "And we are looking at new and innovative ways of delivering the program, including on-line training and providing a range of landscaping modules that meet the diverse interests of the Tennessee homeowner." Hanahan says the program also plans to tap the expertise of the Tennessee Master Gardeners. A TYN workshop was presented at the Master Gardeners 2010 Winter School held in Murfreesboro, Tennessee, and attended by 70 master gardeners. Many expressed considerable interest in helping to move this program forward.

The Master Gardener training program, facilitated by the Department of Plant Sciences of UT Extension, currently has

about 2000 trained and certified Master Gardeners across the state. "We're looking into developing a home certification program for TYN participants that Master Gardeners would help to implement," says Hanahan.

The TYN program received additional financial support from the EPA to expand its program into two more communities. A CAC AmeriCorps volunteer will fill a new position to expand TYN's marketing tools, enhance its statewide partnerships, and help Extension and Water Resource staff develop new TYN training modules on topics such as integrated pest management and rain gardens.

EDUCATION AND SOCIAL PERSPECTIVES PROGRAM

ISSE's Education and Social Perspectives Program (ESP), led by Sheila Webster, supports research and application of emerging technologies for environmental, energy, and science education training. The organization has developed energy-conservation programs for high school students and teacher-training to improve students' science and mathematics skills and promote environmental literacy. ESP's other initiatives support preparation for mass-fatality incidents, prevention of acts of violence in schools and workplaces, creation of jobs in the renewable energy field, and increased adoption of environmental technologies by community and tribal colleges, technical schools, and industrial work sites.

Sheila Webster

ENERGY SECTOR AND GREEN JOBS

ESP supports Tennessee initiatives that seek to create jobs from renewable energy and renewable energy products. With funding from the Tennessee Department of Labor (TDL), ESP collaborated with institutions throughout the state, including TDL, Oak Ridge Associated Universities, community colleges, institutions of higher learning, and private-sector companies to identify labor demand, necessary skills, and training requirements for new jobs in the energy and green jobs sectors. ESP researched and compiled a summary of current labor market data and current training initiatives and developed a plan for solar energy training at the community college level.

NATIONAL PARTNERSHIP FOR ENVIRONMENTAL TECHNOLOGY EDUCATION

The ESP program recently received a five-year grant from the National Institute of Environmental Health Sciences and the Department of Energy to administer training for the National Partnership for Environmental Technology Education (PETE). Serving all 50 states, US territories, and Tribal Nations, PETE is a 501(c)3 nonprofit organization that targets education and training in community and tribal colleges, technical schools, and in government and industrial work sites.

PETE's aim is to build a global workforce that is in harmony with global environmental stewardship, sustainable practices, and sustainable workforce technologies; science, technology, engineering, and math literacy; and safety and health issues.

SELF-AWARENESS CONSULTANCY

The newly formed ISSE-Self Awareness Consultancy (SAC) International program helps businesses and organizations of all types plan for and manage threatening behavior in the workplace and in schools. Situations involving disgruntled or angry employees and customers and misguided students bent on violence fall into the areas of SAC training. SAC tries to head off such incidents by providing training to recognize threatening behaviors and avoid worse-case scenarios.

The ISSE-SAC training courses qualify for continuing education unit (CEU) credit, an added bonus to those who are committed to protecting their businesses, schools, and communities.

Most of us proceed through life without much thought about tragic incidents—plane crashes, school shootings, or factory explosions, for instance—that may occur at any time in our community, resulting in many deaths and injuries. ISSE-SAC offer specialized training for emergency-response personnel, law enforcement, coroners, grief counselors, clergy, and others who are often called on in the wake of such events.

Rex Short

With the confusion that attends these tragedies, business administrators and public authorities need to have a practiced and as-best-as-can-be known plan of action. Questions that need to be answered ahead of time are, among others: who to notify, how to deal with the families of victims—by phone and in person—and where to find grief and support counseling.

When Rex Short, ISSE manager of Environment, Safety, and Health Education, goes to a group of medical or mental health professionals or educators to help them prepare for the unthinkable, he first looks at their existing plans. "Many times I find they have a good plan in place for tending to the injured, but they haven't addressed steps for dealing with the dead," he says. "I help them round out their plan with information such as preserving evidence, who to call, how to accommodate the families, and treatment of the deceased with respect and dignity."

For more information, contact Sheila Webster at 865-974-1985, or email: swebster@utk.edu. Visit the Education and Social Perspectives Web site: http://isse.utk.edu/program_areas/education/education.html.

APPALACHIAN TEACHING PROJECT

Southern Appalachia is a region that historically evokes images of destitute families beset by poverty, poor education, and even poorer health.

That's only one side of the story. The people of the mountainous region are tough and resourceful, with practical know-how and a centuries-long relationship with the land. In fact, more than 40 percent of the region's population is rural, compared with only 20 percent of the national population, according to the Appalachian Regional Commission (ARC).

Nevertheless, problems persist in Appalachia. The ARC reports, further, that 2007 per-capita personal income in Appalachia was 80 percent of the national average, while the proportion of the region's adults with college degrees is about two-thirds that of the nation.

In recent months, the White House announced the Obama-Biden Plan, in which rural communities are the focus of support for economic development, economic opportunity for family farms, and an improved quality of life.

Pairing nicely with this plan is the Appalachian Teaching Project (ATP), which seeks to build a sustainable future for Appalachian communities. Sponsored by

the ARC, a regional economic-development agency, and begun in 2001, the ATP involves 15 universities and colleges along the Appalachian mountain chain from Mississippi to Maryland.

UT is one of those participating universities, and ISSE's Community Partnership Center (CPC), directed by Tim Ezzell, sponsors an annual ARC educational project. Ezzell and ISSE Sustainability Program Leader Bruce Tonn facilitate a graduate ATP class consisting primarily of students in planning, political science, and sociology. Tonn also serves as director of UT's Urban and Regional Planning Program and professor in the UT Department of Political Science.

Tim Ezzell

In some cases, Ezzell and Tonn research East Tennessee counties to identify communities that might benefit most from the class's input. In other cases, the researchers respond to requests from communities for assistance in shaping growth plans. In reviewing candidate communities, Ezzell and Tonn examine communities' assets and their potential for pursuing sustainable economic development.

"There are all kinds of barriers for rural communities—economic and educational barriers, as well as lack of cohesive leadership," says Ezzell. "The communities we work with are often isolated and have few resources for economic sustainability. In some cases they also carry a stigma of being both 'poor' and 'Appalachian.'"

As a form of service-learning, students develop skills by organizing and facilitating community meetings and gathering ideas from residents in community workshops. After evaluating ideas suggested at the workshop, the students present their findings and recommendations to the community in a follow-up meeting. Through the process, the community receives a concrete and viable strategy for achieving sustainable economic growth while preserving its unique cultural and recreational assets.

In past years, the class has targeted Copperhill in Polk County, Wartburg in Morgan County, and Hartford in Cocke County. In a relationship between UT and Shanghai University, which shares similar development goals for its surrounding rural areas, ATP students investigated ideas that would benefit rural communities in both countries. Tim Headrick, a UT master's candidate in planning, traveled to China with the ATP group and benefitted from the opportunity to "operate in a professional capacity" prior to graduation.

For the 2010 class, students organized and facilitated a workshop at the Baker Center on the UT campus for county mayors and economic developers from Cocke, Hancock, and Monroe counties. The Appalachian Regional Commission classifies Hancock and Cocke counties as economically distressed. The discussions covered globalization, sustainable economic development, and import and export opportunities with China. Later in November, UT hosted several MBA students from Shanghai University.

"The Chinese students visited these rural, Appalachian communities," says Ezzell. For many of them, it was their first experience in a "natural"—nonurban—environment. In fact, for some, says Ezzell, "it was the first time they had ever experienced things like silence or darkness."

The students also visited Chattanooga, once regarded as among the most-polluted cities in America. Today, Chattanooga is among the nation's cleanest cities and earliest adopters of sustainable community development.
"Learning about Chattanooga's dramatic turn-around demonstrated to the students what is possible in terms of sustainability,"

says Ezzell. “They also came to understand that small cities can thrive and be competitive on a global scale.”

At its best, the ATC creates vibrant communities and opportunities for mutually beneficial relationships—some of which stretch half-way around the world. The community of Sweetwater, in Monroe County, for instance, has an abundance of dairy farms and once sustained a huge dairy industry. China, by contrast, lacks adequate grazing land to support cattle, yet its citizens need dairy products. This year’s ATP class responded by exploring the feasibility—and profitability—of creating a powdered-milk facility in Sweetwater to sell its product to communities in China’s Shanghai Province, providing benefits to both communities.

The Appalachian region is renowned for its mountainous landscape, natural beauty, and outdoor recreation. Cosby, in Cocke County, Tennessee, is an ARC distressed community, but it’s also a gateway to the Great Smoky Mountains National Park and Cherokee National Forest. Like many gateway communities, Cosby is facing significant development pressure that could negatively affect the area’s rural and rustic charm.

UT’s ATP class has responded by working with the community to develop sustainable tourism that would provide jobs, bolster economic development, and preserve the community’s natural character and charm. “Globalization is here to stay,” says Ezzell. “Small communities have to adapt to that fact. But there are huge opportunities available to allow them to adapt and prosper without losing the attributes that make them unique.”

For more information, contact Tim Ezzell at 865-974-9036, or email: tezzell@utk.edu. Visit the CPC Web site: http://isse.utk.edu/cpc/.

Top two photos below: UT ATC students and faculty visit the Forbidden City and the and a steel factory in Shanghai. Bottom two photos: Shanghai University students visit various sites in East Tennessee, including the UT campus and Great Smoky Mountains National Park. Photos by Tim Ezzell

International Collaboration

Compiled By George Brock Scott

ISSE's core staff comprises numerous scientists from foreign nations. All contribute substantially to the institute's cultural diversity and research depth.

ISSE's multidisciplinary staff reflects a broad range of scientific backgrounds and research emphases, ranging from hydrology to history, from political science to planning, from computer science to sustainable agriculture.

Adding further depth to ISSE's research enterprise, more than a third of the institute's core staff hail from other nations; the percentage increases substantially if we include student researchers in the count. Each brings a unique, international perspective and contributes to a culturally diverse and vibrant workplace.

Here we introduce ISSE researchers with ties beyond US borders, and we encourage you to visit the staff pages on the ISSE Web site to learn more about them and their research interests: http://isse.utk.edu/staff/staff.html.

RACHEL J.C. CHEN,

Director of ISSE's Center for Sustainable Business and Tourism and Associate Professor in UT's Department of Retail, Hospitality, and Tourism Management

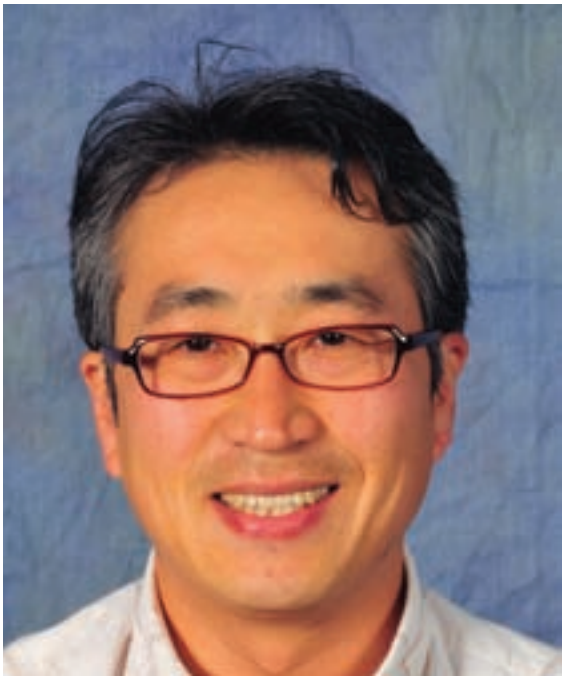
Home Country: Taiwan

Degrees

- PhD, North Carolina State University
- MS, North Carolina State University
- BA, National Cheng-Chi University, Taiwan

Research Focus

- Tourism and hospitality, service management.
- Sustainable development, economic impact assessments, forecast model evaluations, tourist behavior analyses, and geographic information system (GIS) applications in business development.
- Provides operational solutions to improve the quality of life and to develop sustainable business models and green tourism via interdisciplinary research, community collaboration, leadership, and education.



UNGTAE KIM,

ISSE Research Scientist and Research Assistant Professor in UT's Department of Civil and Environmental Engineering

Home Country: Korea

Additional International Experience

- Doctoral dissertation on regional impacts of climate change on water resources in Ethiopia.

Degrees

- PhD, Water Resources Engineering, Utah State University
- MS, Water Resources Engineering, Korea University, Seoul, Korea
- BS, Civil and Environmental Engineering, Korea University, Seoul, Korea

Research Focus

- Hydrology and water resources, including stochastic and deterministic hydrologic modeling, model evaluation, drought and flood analysis, subsurface hydrology, contaminant transport in groundwater, and climate change impacts on water resources.
- Strategic Environmental Research and Development Program (SERDP) develops solutions to environmental challenges facing the US Department of Defense to reduce the costs, environmental risks, and time required to resolve environmental problems while enhancing and sustaining military readiness.

SHESH RAJ KOIRALA,

ISSE Post-doctoral Research Associate

Home Country: Nepal

Degrees

- PhD, Civil Engineering, The University of Tennessee, Knoxville
- MA, Geography, Western Illinois University, Macomb, Illinois
- BE, Civil Engineering, Pulchowk Campus, Tribhuvan University, Nepal

Research Focus

- Temporal persistence of pollutants in streams, scaling behavior in hydrologic systems, multifractal modeling of hydraulic properties, climate-change impacts on hydrology, and climate-change-induced extreme events.
- Analyzing of tools and techniques such as fractals, wavelets, GIS, and statistics for use in modeling hydrology and tracking pollution in hydrologic systems.

LARRY MCKAY,

Leader of ISSE's Water Resources Program, Professor and Department Head, UT's Department of Earth and Planetary Sciences

Home Country: Canada

Additional International Experience

- Geological survey of Denmark

Degrees

- PhD, Earth Sciences (Hydrogeology Program), The University of Waterloo, Canada
- BS, Geological Engineering, University of British Columbia, Canada

Research Focus

- Opportunities for UT students in the growing fields of hydrogeology and environmental geology.
- Assists UT faculty and staff in projects that advance understanding of the scientific, social, and political issues affecting water resources and provides educational opportunities for students and service to the broader community.

PREDRAG RADULOVIC,

Chief Network Engineer, Center for International Networking Initiatives/ GLORIAD

Home Country: Yugoslavia (now Serbia)

Degrees

- PhD, Chemistry, University of Tennessee, Knoxville
- MS, Computer Science, University of Tennessee, Knoxville
- BS, Physical Chemistry, University of Belgrade, Yugoslavia

Research Focus

- Engineering an international data exchange network for research institutions worldwide
- Development and implementation of networking projects—using next-generation Internet capability—that are designed to tie scientists, educators, and students together in countries around the globe.

HARIKA TANDRA,

Software Engineer, Center for International Networking Initiatives/ GLORIAD

Home Country: India

Degrees

- MS, Computer Science, University of Tennessee
- BS, Computer Science, Osmania University, Hyderabad, India

Research Focus

- Network performance measurement and analysis, data visualization, and databases; creation of automated systems to debug under-performing flows in wide area networks; development of a diagnostic tool to locate end-to-end performance losses in wide area networks.
- Development and implementation of networking projects that tie scientists, educators, and students together in countries around the globe.

FORBES WALKER,

Leader of ISSE's Agriculture and Natural Resources Program, Associate Professor, UT Institute of Agriculture's Department of Biosystems Engineering and Soil Science

Home Country: Scotland

Degrees

- PhD, Soil Science, North Carolina State University
- MS, Seed Technology, University of Edinburgh, Scotland
- BS, Plant Science, University of Aberdeen, Scotland

Research Focus

- Sustainable agriculture practices.
- Development and adaptation of technologies that minimize soil erosion, reduced-tillage management practices that increase carbon sequestration, and alternative, more sustainable forms of bio-based fuels.

JIE (JOE) ZHUANG,

ISSE Research Director, Coordinator of the China-US Joint Research Center for Ecosystem and Environmental Change (JRCEEC)

Home Country: China

Additional International Experience

- Served as research fellow in Japan at the Japanese Society for the Promotion of Sciences

Degrees

- PhD, Environmental Soil Physics, Shenyang Agricultural University, China
- MS, Soil Science, Shenyang Agricultural University, China
- BS, Soil Science and Agrochemistry, Shenyang Agricultural University, China

Research Focus

- Promotion of US-China collaboration in the areas of global environmental change, bioenergy sustainability, and international education.
- Management of the JRCEEC, which occupies research facilities at UT/Oak Ridge National Laboratory and the Chinese Academy of Sciences. JRCEE addresses the combined effects of climate change and human activities on regional and global ecosystems and explores technologies for restoration of degraded environments.

Annual China-Us Conference Grows, Retains Focus On Climate, Energy, Ecosystems

The China-US Joint Research Center for Ecosystem and Environmental Change held its third annual workshop, on the "Climate-Energy Nexus," in November at Oak Ridge National Laboratory (ORNL).

Sponsored by the National Science Foundation and the Department of Energy, the workshop convened more than 100 Chinese and US leaders in climate, ecosystem management, energy, and green technology to exchange perspectives and findings, identify opportunities, and shape action plans for promoting bilateral research collaboration in climate and energy.

Thirty-five Chinese participants attended the workshop, representing the Chinese Academy of Sciences (CAS), Chinese Embassy in the United States, University of Science and Technology of China, Tsinghua University, Sichuan University, Chinese Academy of Social Sciences, East China University of Science and Technology, and the municipal government of Huaibei City.

US participants represented the ORNL Climate Change Institute, National Energy Technology Laboratory, National Renewable Energy Laboratory, Purdue University, University of Tennessee (UT), ORNL Center for Bioenergy Sustainability, ORNL Computational Earth Sciences Group, UT Institute for a Secure and Sustainable Environment, UT Center for Environmental Biotechnology, ORNL Environmental Sciences Division, ORNL Biosciences Division, ORNL Center for Computational Sciences, Genera Energy LLC, Climate Institute, Springer Science and Business Media, and LR Shugart and Associates.

France's Laboratory for Climate Sciences and the Environment was also represented at the conference.

The annual conference, which is hosted reciprocally by UT/ORNL/Purdue and CAS, provided a platform for communication among leading Chinese and US scientists in advance of the United Nations Framework Convention on Climate Change, held in Copenhagen, Denmark, this past December.

"This conference is addressing one of the most—if not the most—pressing challenges of our time," said ORNL Director Thom Mason, in welcoming participants to ORNL. "China and the United States are the world's two largest emitters of CO_2, so we have the greatest stake in finding the right solutions for our energy needs and [exploring] constraints on our energy choices that are placed by our deepening understanding of the environmental impacts of those choices."

At the same time, said Mason, our populations are demanding energy in ever-increasing amounts, particularly in China

because of rapid development. "So we have the simultaneous and sometimes conflicting demands of increasing needs for energy and also increasing understanding of the impacts of our energy use, distribution, and generation patterns."

GROWING NUMBERS, EXPANDING SCOPE

The invitation-only annual China-US workshop has nearly tripled in size since the China-US Joint Research Center hosted its first workshop at UT in 2007. The growth will continue with the 2010 annual conference, which will convene in September in Beijing and feature nearly 100 presentations and engage more than 200 leading scientists, governmental leaders, and representatives from private corporations.

"The dramatic growth in the number of participants and the scope of presentations reflect both the vitality of the China-US Joint Research Center and the urgency with which scientists from China and the United States regard the issues of sustainable energy production and ecosystem restoration," said Gary Sayler, director of the ORNL-UT Joint Institute for Biological Sciences (JIBS) and Beaman Distinguished Professor in the UT Department of Microbiology.

The conference opened on Wednesday with presentations on climate change and ecosystem management, and concurrent sessions took place throughout the day. Bioenergy impacts and energy technology provided the organizing themes for Thursday, and Friday's presentations focused on ecological modeling and climate change mitigation.

"As the world's leading emitters of carbon dioxide, China and the United States have a great deal at stake in responding to climate change and devising systems for sustainable energy production and use," said Randall Gentry, director of UT's Institute for a Secure and Sustainable Environment (ISSE) and president of the UT Research Foundation. "This annual conference provides a valuable forum for

the exchange of views and perspectives and has produced significant opportunities for increased collaboration among the scientific communities of the two participating nations."

ISSE and JIBS are founding members of the China-US Joint Research Center. (For more information on the partnership, see "A Durable Collaborative Framework" on page 47.)

"In the Chinese research community, the China-US Joint Research Center continues to grow in prominence and impact," said Gui-Rui Yu, director of China Fluxnet and the Synthesis Center of the Chinese Ecosystem Research Network and deputy director of CAS's Institute of Geographic Sciences and Natural Resources. "The center has played a pivotal role in linking scientists and program leaders from the two nations and spurring collaboration on a broad range of interdisciplinary projects."

The China-US Joint Center also has created an exchange program to encourage students and scientists from the two nations to collaborate directly on research projects that explore shared challenges. (See "Visiting Scholars from the East" on page 49.)

"The exchange of students as well as junior and senior scientists will contribute directly to research and education for the partnering institutions," said ISSE Research Director Jie (Joe) Zhuang, coordinator of the China-US Joint Research Center and research associate professor in UT's Department of Biosystems Engineering and Soil Science. "We expect that the exchange program will produce valuable findings, particularly in the areas of ecosystem management and climate change."

FACILITIES TOURS: NEW AND OLD

The three-day workshop culminated with a field tour of a new, commercial-scale, cellulosic bioethanol production facility in Vonore, Tennessee. The facility is part of the Tennessee BioFuels Initiative, a public-private partnership among the University of Tennessee Research Foundation, the UT Institute of Agriculture, Genera Energy LLC, and DuPont Danisco Cellulosic Ethanol LLC.

The 74,000-square-foot plant produces ethanol and will develop low-cost technology for commercial production of the fuel from agricultural residue and bioenergy crops, including corncobs and switchgrass. Chinese scientists also toured the ORNL campus and visited the Oak Ridge Leadership Computing Facility, which houses the Cray XT5 Jaguar supercomputer, recently ranked as the world's fastest. ORNL also houses UT's Kraken supercomputer (also a Cray XT5), which ranks as third fastest in the world.

The Chinese scientists later visited the historic X-10 graphite reactor at ORNL. The reactor, which is a National Historic Preservation Landmark, became operational in November 1943 and contributed to the production of plutonium from uranium. As part of the top-secret Manhattan Project, the reactor paved the way for creation of the world's first atomic bomb. The reactor continued operation until 1963, producing the world's first electricity from nuclear energy and contributing to applications for radioisotopes in industry and medicine, among other civilian uses.

For more information on the China-US Joint Research Center for Ecosystem and Environmental Change, contact center coordinator Jie (Joe) Zhuang at 865-974-1325, or email: jzhuang@utk.edu.

To access video presentations and accompanying PowerPoint slides, presentation abstracts, and presenters' biographies, visit the China-US Joint Research Center Web site: http://jrceec.utk.edu/workshops/AnnualWorkshop2009/2009AnnualWorkshop.html.

Access information on past workshops, including proceedings from the 2007 and 2008 workshops, here: http://jrceec.utk.edu/workshops/AnnualWorkshop2009/2009AnnualWorkshop.html.

A Durable Collaborative Framework

The UT-ORNL Joint Institute for Biological Sciences (JIBS) and UT Institute for a Secure and Sustainable Environment (ISSE) signed an agreement in 2006 to establish the China-US Joint Research Center for Ecosystem and Environmental Change (http://jrceec.utk.edu) with two Institutes of the Chinese Academy of Science (CAS): the Institute of Geographic Sciences and Natural Resources Research and the Research Center for Eco-environmental Sciences.

The China-US Joint Research Center's primary collaborative themes include: (1) ecosystem processes and management, (2) environmental sustainability of bioenergy production, (3) ecological foundations of water resources and quality, and (4) technologies for improvement of eco-environmental systems.

"We established the China-US Joint Research Center with the goal of increasing communication, collaboration, data exchange, personnel exchange, and joint research projects—all of which will lead to better understanding of climate, bioenergy, environmental change, and ecosystem restoration issues," said JIBS Director Gary Sayler, Beaman Distinguished Professor in the UT Department of Microbiology.

The first annual China-US workshop convened in September 2007 at UT to address the environmental aspects of bioenergy production and sustainability.

The 2008 workshop, sponsored by the US National Science Foundation, CAS, and the Natural Science Foundation of China and held in Beijing, focused on bioenergy consequences for global environmental change. The gathering also saw induction of two new members into the China-US Joint Research Center: the University of Science and Technology of China and Purdue University.

—David Brill

Sowing Seeds

Projects and activities generated by the China-US Joint Research Center are uniting researchers from the two nations in addressing shared environmental challenges and issues. Since its creation in 2006, the China-US Joint Research Center for Ecosystem and Environmental Change has grown in size and scope and spawned a number of related activities.

"One of the exciting opportunities for our China-US Joint Research Center is to spin off and develop other parallel activities that relate to continuing interactions with China at the science level, at the social level, and potentially even at the commercial level," said Gary Sayler, director of the ORNL-UT Joint Institute for Biological Sciences (JIBS) and Beaman Distinguished Professor in the UT Department of Microbiology.

More than 100 Chinese and US scientists gathered in Oak Ridge for the third annual workshop of ISSE's China-US Joint Research Center for Ecosystem and Environmental Change.

JIBS and UT's Institute for a Secure and Sustainable Environment are founding partners of the China-US Joint Research Center.

As part of one such spin-off, researchers from China and the United States convened in November 2009 in Knoxville for a topical workshop, "Biotechnology of Bioenergy Plants." (See "Fueling the Future" on page 79.) The meeting came on the heels of the third annual workshop of the China-US Joint Research Center, held November 11-13 at ORNL.

The China-US Joint Research Center convened a second topical workshop, "Sustainable Management of Soil and Water Resources," in January 2010 in Shenyang, China. Jack Parker, ISSE associate director for research, co-chaired the workshop, which drew more than 70 scientists and students.

The mayor, developers, and municipal planners from Huaibei City, situated in Anhui Province in East China, attended the annual China-US Joint Research Center's workshop in November to explore collaborative opportunities for green community development. Huaibei City, whose economy was built on coal mining, seeks to restore its degraded environment and redevelop as an eco-city.

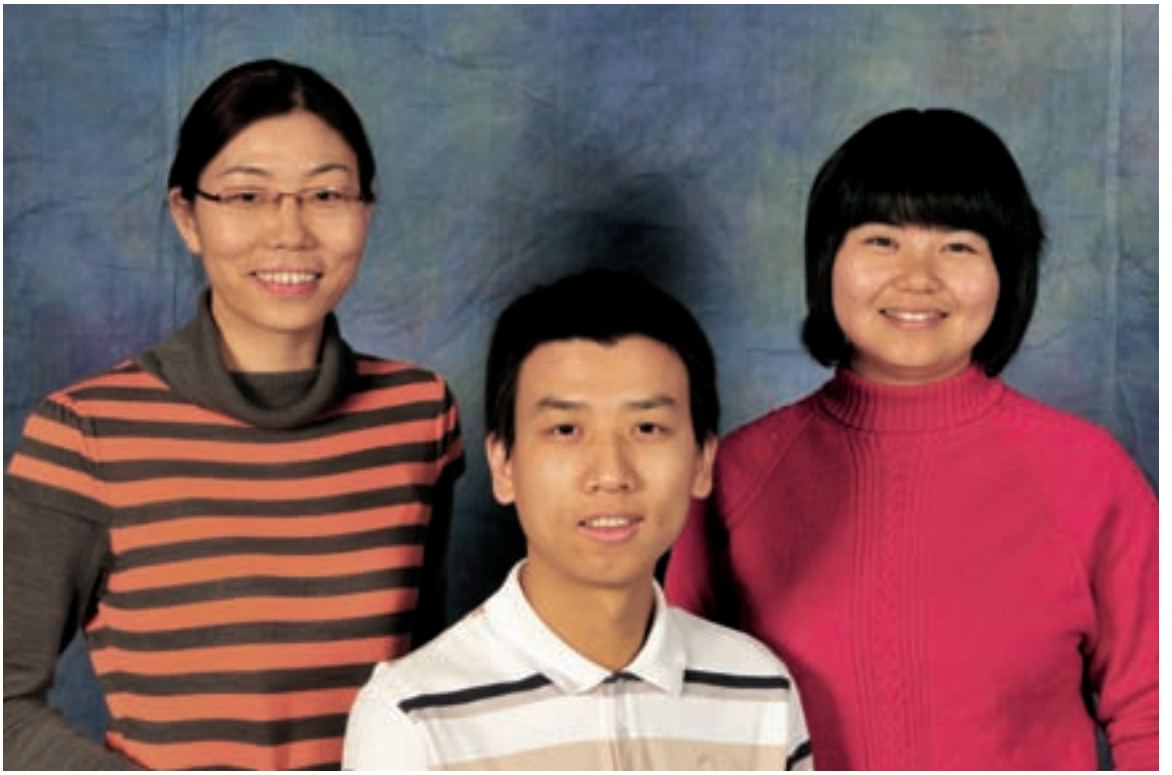
To that end, the Huaibei City contingent met with East Tennessee green development experts, including representatives of Quietlands Development Group, who are working with Huaibei officials to shape a sustainable redevelopment strategy.

Samuel Jackson, vice president for Feedstock Operations of Genera Energy LLC, a subsidiary of the UT Research Foundation, presented an overview of the Tennessee Biofuels Initiative, a farm-to-fuel business plan developed by the state of Tennessee and the UT Institute of Agriculture. "Through these meetings and presentations, we've begun to learn from each other and identify opportunities for jointly addressing many of our shared issues and challenges," said Saylor.

—David Brill

For information on Quietlands Development Group, visit the Web site: http://quietlandsdevelopmentgroup.com/.

To learn more about the Tennessee Biofuels Initiative, visit the Web site: http://www.utbioenergy.org/TNBiofuelsInitiative/.



Visiting Scholars From The East

Among its key goals, the China-US Joint Research Center for Ecosystem and Environmental Change seeks to promote academic and scientific exchange among senior researchers as well as graduate students and post-doctoral scientists.

In the fall, ISSE welcomed three scholars from the Chinese Academy of Sciences (CAS) who spent a year at ISSE.

Yuling Fu, a CAS associate professor (left), is collaborating with researchers from the Environmental Sciences Division of Oak Ridge National Laboratory. Mi Zhang (right), a CAS fourth-year PhD candidate, and Chao Fu (center), a CAS third-year PhD candidate, are advancing their research on ecosystem response to climate change.

Wenjuan Shi, an associate professor of soil physics with the Institute of Water Resources and Hydro-electric Engineering at Xi'An University of Technology, began a residency at ISSE in April. During her stay, Shi will collaborate with UT soil scientists and study techniques for measuring the distribution and transport of mercury and cadmium in soils.

Xiuli Dang, a lecturer in agricultural environmental engineering at Shenyang Agricultural University, began a year-long residency at ISSE in June. During his stay, Dang will study carbon sequestration in soil amended with biochar and will collaborate with scientists at the soil biochemistry laboratory of the UT Department of Biosystems Engineering and Soil Science (BESS). BESS professor Mike Radosevich and ISSE Research Director Jie (Joe) Zhuang are hosting Dang during his visit.

GLORIAD

Linking The Global Community*

By Dennis McCarthy

Imagine transmitting all 20 million books in the New York Public Library to, say, Amsterdam, in a second. Impossible? At the moment, yes, but only because the books aren't all digitized. Google is digitizing many of the library's holdings, along with the holdings of other major libraries around the world, and expects to scan 32 million volumes within 10 years. When this work is finished, libraries can be beamed across continents at the speed of light, and our contact with the printed word will be forever changed. Move over, Gutenberg; make room for Google.

Or suppose you're a surgeon performing a delicate operation in Chicago and you need the help of a specialist in Hong Kong. You can videoconference him in and have him talk you through the operation, just as if he were standing over your shoulder. Or better yet, he can perform the operation, manipulating levers robotically across the Pacific Ocean.

To Greg Cole, director of ISSE's Center for International Networking Initiatives, none of these ideas sounds like the plot for a Star Trek movie.

Greg Cole

The capability of transmitting a library of data already exists. Real-time videoconferencing with super-high-definition quality is also a reality, with imagery so clear you'd think the person on the far side of the globe was actually in the room with you. And while telesurgery is still in its infancy, it's here to stay.

Cole is the creator and director of GLORIAD, a high-speed research network that could allow the transmission of an entire library or the performance of an operation over fiber optic cables.

GLORIAD—an acronym for Global Ring Network for Advanced Applications Development—is a fiber optic network directly connecting scientific and education communities in the United States with 10 partnering nations and indirectly connected to almost every other nation in the world. Today, virtually every university in the United States, as well as every federal agency, is connected to the network.

When universities or federal agencies send huge files to sister organizations in partnering nations, GLORIAD is the charioteer. GLORIAD joined ISSE in 2010.

ORIGINS

"GLORIAD started out in an early incarnation as an example of social networking between the United States and Russia," Cole says. "The Cold War was over, and a Russian friend—Natasha Bulashova—and I wanted to explore use of the then-new Internet to help build communications and trust between our two countries.

"I've had a lifelong interest in Russia, ever since I was 10 and got a short-wave radio and listened to Radio Moscow," Cole says. "As I got older I read Tolstoy and Dostoevsky and other great works of Russian literature. I've learned the language. Russia fascinates me."

"Natasha and I set up a Web site, a Web-hosting service, e-mail listservers, and a chat room, and called the project Friends and Partners. It was not a dating service, despite some humorous early misunderstandings.

Its purpose was—and is—to promote better cultural awareness and understanding among participants and to provide an avenue for communication."

Within two days of the project's launch in 1994, Cole received over 360 e-mails—mostly offers of help—from around the world. And soon he had funding—from NATO, the US Department of State, and Sun Microsystems—and a new center for the international program.

Friends and Partners started out as a hobby. Cole says he never intended it to become a job, but it grew so large that he didn't have a choice.

KORRNET

"At about the time we started Friends and Partners, I also helped start a community network in East Tennessee, called KORRNET, which stands for Knoxville Oak Ridge Regional Network," Cole says. "This was back in the early days of the Internet and we were trying to help the community engage with the new technology. We hosted Web sites, provided public access and training, and created user accounts. The project grew into something much larger, however. It got people throughout the region talking with one another and cooperating on all kinds of activities that had nothing to do with KORRNET.

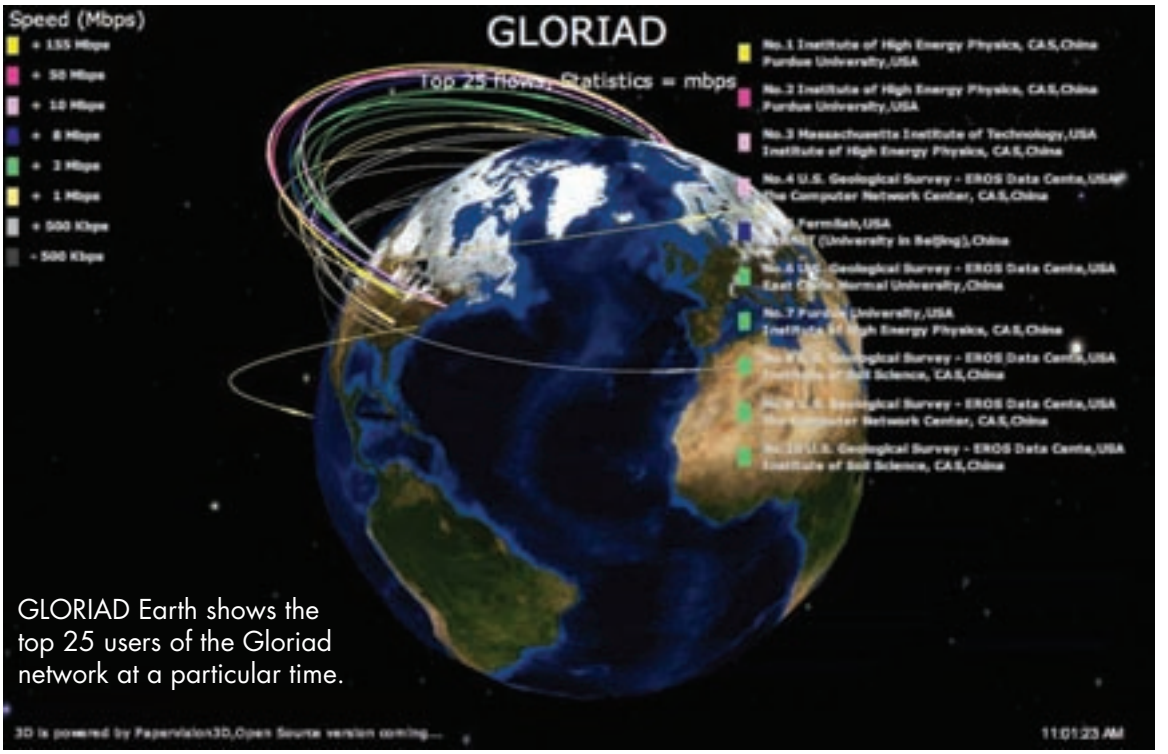
"When we realized the community networking aspects of the project, we thought similar networks could work in Russia, too," Cole continues. "The Ford Foundation, the Eurasia Foundation, and other funders interested in democratic institution building in Russia gave us support. We started KORRNET-type projects—modified, of course, for Russian communities—in six Russian cities. Those networks are still running today."

THE RUSSIAN CONNECTION

With these successes under way, Cole and Bulashova decided to build a high-performance network between Russia and the United States. At that time it took much too long to send files of any size between the countries. For instance, it could take all weekend to send a 50-megabyte file to Russia. There was no way to do a videoconference; you couldn't make a telephone call through the Internet.

So Cole and his team submitted a $4-million proposal to the National Science Foundation to establish MIRnet, the first high-performance network between Russia and the United States. NSF funded the proposal, and the Russian Ministry of Science provided substantial support as well.

Before that time, there was no practical advanced Internet connection for research



GLORIAD Earth shows the top 25 users of the Gloriad network at a particular time.

and education between the two countries. MIRnet allowed the major universities and science facilities in Russia and the United States to communicate with one another. The network was begun in 1998 and completed three years later.

"When we started out, we could transmit up to six megabits per second," Cole says. "Upgrades in 2001 and 2002 brought the transmission up to 155 megabits per second. "The initial route to Russia was across the Atlantic and through Stockholm. We realized that if we could get a network link across the Pacific to Hong Kong, we could increase access to existing cables elsewhere and, in effect, complete a ring around the world. We would also then have a high-speed research and education connection to China.

"There was a fiber optic cable between Russia and China that was essentially unused at the time, and we got the two countries to agree to interconnect across their border. GLORIAD, the first ring around the Earth for science and education, was launched at a ceremony in Beijing in 2004."

GLORIAD TODAY

The new GLORIAD network continues to grow. Cole and his colleagues have partnership agreements, not only with Russia and China, but with Canada, Korea, the Netherlands, and the five Nordic countries—Norway, Sweden, Finland, Denmark, and Iceland.

The partner nations fund the network. The National Science Foundation, which has already provided over $10 million, is the primary funder of the US partnership. Each US dollar invested in GLORIAD leverages about 15 non-US dollars.

Cole's most immediate goal now is to create a high-speed network from Hong Kong to Singapore to Mumbai to Cairo and back to Europe. GLORIAD can then provide improved research and education services between the United States and Southeast Asia and India and will have an exchange point for future US-Africa network development.

Cole is also trying to establish an interdisciplinary research center, the Center for International Networking Initiatives,

to further integrate GLORIAD and other networking projects into research and education programs at UT-Knoxville. Although GLORIAD has only 11 partner nations, it has nonetheless served almost every country in the world at one time or another. For political reasons, the network does not facilitate transmissions with Cuba, Iran, and a few other nations, but Cole hopes those barriers eventually will come down. He sees the network's role as one of connecting people and building trust through open communications—not erecting walls to isolate us from one another.

IN BRIEF

"If I had to sum up GLORIAD in a few words," Cole says, "I'd say it's a community-networking project, using next-generation Internet capability, designed to tie scientists, educators, and students together in countries where we haven't traditionally had strong science and education links.

"While GLORIAD is one of the most advanced cyber-infrastructure systems in the world, at its core, it's about human networking—it's about people talking with one another."

For more information, contact Greg Cole at 865-974-1262, or email: gcole@gloriad.org. Visit the GLORIAD Web site: http://www.gloriad.org/.

*This article first appeared in in the May 6, 2009 edition of *Quest* (http://quest.utk.edu/).

A TRULY GLOBAL NETWORK

Members of the GLORIAD staff visit Cades Cove in Great Smoky Mountains National Park. GLORIAD's multinational staff traces roots to, among other nations, Korea, Egypt, Denmark, the Netherlands, India, Canada, Russia, China, Yugoslavia, and the United States.

Engineered Solutions

By Elise LeQuire

Designs for a Sustainable Future

The Brooklyn Bridge, the Hoover Dam, and the Empire State Building all represent breakthroughs in engineering that still serve useful functions. These monuments to human ingenuity continue to draw visitors as much for their awe-inspiring scale as for their utility. Feats of environmental engineering may not have the visual appeal of massive construction projects, but they do meet practical needs in terms of environmental health, safety, and sustainability for present and future generations.

During a housing boom in the southeastern United States, new home owners found out the hard way that international standards for building materials are either nonexistent or insufficient to safeguard public health. Tainted drywall imported from Asia made the homes virtually uninhabitable. Standards in the chemically intensive building-products industry currently vary widely from country to country and between developed and developing countries. ISSE's Center for Clean Products (CCP) has been chosen from a large pool of candidates by the United Nations Environment Programme, Chemicals Branch, to create international standards of communication within the industry. CCP researchers bring their expertise in chemical engineering and background in life-cycle analysis of manufacturing processes to the task.

The speed of technological development in wireless devices and applications is increasing at warp speed, and ISSE's Community Partnership Center (CPC) is keeping pace. CPC is lending technical support to a community-based economic-development effort. A Wi-Fi network in Knoxville connects visitors with historic African-American culture from the city's past as they take a walking tour of downtown aided by Web-enabled hand-held mobile devices that link them to the past. The project is part of a broader effort to use high-tech networking capabilities as an engine to drive economic development in urban environments.

Runoff from construction sites causes increased turbidity in streams and rivers, raising water temperatures, lowering oxygen levels, and suffocating fish. The US Environmental Agency has issued stricter standards for runoff from construction sites of 20 acres or more, which typically

include all road and subdivision projects. ISSE's Tennessee Water Resources Research Center (TNWRRC) has been asked by the Tennessee Department of Environment and Conservation to totally revamp its Tennessee Erosion and Sediment Control Handbook and to add more training programs for people involved in land-disturbing activities. The training program will assist the regulatory community in meeting the new EPA requirements.

In summer 2010, an ISSE affiliate, the Tennessee Forest Products Center (TFPC) at UT's Institute of Agriculture (UTIA), and three other UTIA programs were incorporated into a larger entity, the Center for Renewable Carbon, reflecting the new emphasis on agriculture and forestry resources as an alternative to fossil fuels. The TFPC has worked to realize a concept currently promoted by the wood products industry: the integrated biorefinery. Unlike the petroleum refinery, which creates fuels and chemicals from a finite, nonrenewable resource, the integrated biorefinery capitalizes on a renewable resource—forest products and byproducts—to create fuel, chemicals, and wood products with significantly reduced environmental impacts.

Natural and synthetic estrogenic compounds found in water represent a potential threat to fish and humans. Researchers at the Center for Environmental Biotechnology's (CEB) Zebrafish Research Facility (ZRF) have explored the response of the fish to natural and synthetic hormones. The end goal is to engineer a transgenic reporter fish that will fluoresce when exposed to these substances and provide early detection of hormone-disrupting substances in aquatic environments. Ted Henry, who established the facility, has accepted an appointment as an academic fellow at the University of Plymouth, UK, where he is collaborating on further research he began at CEB on the potential toxicity of the nanoparticle C60 on zebrafish. He continues to maintain his affiliation with UT and to oversee research in the ZRF.

Despite advances in medical imaging over the past decades, tracking tumor formation in cancer patients remains an inexact science. Researchers at CEB have been working for more than 10 years to genetically engineer a mouse model that will one day allow precise pinpointing of disease progression. By inserting a genetically altered cell line into laboratory mice, CEB researchers created a mouse that produces bioluminescent light, on its own, in the visible spectrum, overcoming a number of presumably impossible barriers in the process. In the near future, investigators can use this laboratory model to advance understanding of disease progression. In the distant future, people could, at an early age, have cells implanted in the body that would always be looking for a cancer signature.

Whether creating international bridges to understanding chemically intensive building products, meeting the demand for stricter monitoring of stormwater runoff, creating renewable fuels and co-products from forest materials, or creating designer genes for environmental and biomedical research, ISSE researchers are engineering the immediate and distant future.

Engineers Of The 21St Century

ISSE researchers are putting a new spin on the term engineering, meeting environmental challenges at multiple scales.

By Elise LeQuire

GLOBAL STANDARDS IN BUILDING PRODUCTS

The Center for Clean Products (CCP) has been awarded a grant by the United Nations (UN) Environmental Programme to help industry adapt to a national and global trend toward greener manufacturing and product stewardship in the building-products sector.

The first phase of the Chemicals in Products (CiP) project consisted of an international survey conducted in 2009. The survey revealed that stakeholders in the UN's Strategic Approach to International Chemicals Management (SAICM) identified the building-products sector as one of the top priority areas among all chemically intensive product types with the potential for adverse environmental or health effects. CCP's task is to understand and identify the type of information and the manner in which it is communicated to manufacturers around the world.

Standards vary widely from country to country. In Europe, there is a good amount of regulatory information, but much less in the United States.

"If an American company creates a new chemical, the only information it has to disclose is how it was created, what it is used for—such as carpet backing—and whether the company is aware of any human or environmental adverse effects," says Jack Geibig, director of the Institute for a Secure and Sustainable Environment's (ISSE) CCP. In developing countries, there is even less oversight.

Jack Geibig

Through its Globally Harmonized System of Classification and Labeling of Chemicals, the UN is encouraging standardization of the ways health and environmental effects are communicated. "Depending on the country, there are many different test results and different ways of measuring the chemical impacts," says Geibig. "If we harmonize a system, the whole world could agree on how to evaluate materials." This is increasingly important in a marketplace that is global

in scope. Just a few years ago, for example, contaminated drywall imported from Asia during a housing boom in the Southeast was installed in a number of new homes. "These homes are now virtually uninhabitable," says Geibig.

CCP was well qualified for the internationally competitive grant in part because of its participation in Pharos, an international effort to assess the life cycle and human health impacts of building materials. "The UN could have chosen anyone in the world to conduct this project," Geibig says, "but they funded us."

These efforts require engineering-based knowledge about chemicals and human health in addition to insight about manufacturing processes and chemicals. "My engineering background is important because I can analyze a manufacturing process," says Geibig. "We have to help the manufacturer find a better way, such as using alternative chemicals that perform the same job while being safer, or working with them to modify the process."

For more information, contact Jack Geibig at 865-974-6513, or email: jgeibig@utk.edu. Visit the CCP Web site: http://isse.utk.edu/ccp/.

TWENTY-FIRST CENTURY TOURISM

By fall 2010, anyone with a Web-enabled mobile handset will be able to get a glimpse of old Knoxville while taking a walking tour of downtown. A Wi-Fi network connects users within a 2.5-square-mile radius in downtown Knoxville to archived and digitized images and videos of African-American culture preserved since 1975 by the Beck Cultural Exchange Center. At 10 of the 15 stops on the one-mile itinerary, a professional ensemble company based in Knoxville, The Carpetbag Theatre, provides digital storytelling to bring history to life.

Eric Ogle

ISSE's Community Partnership Center (CPC) is providing technical support to the community-based partners who participate in the Knoxville African American Tours of Cultural Heritage (KAATCH). Initially funded by the US Department of Housing and Urban Development through its Empowerment Zone program, the concept is the brain child of Eric Ogle, CPC program coordinator. "This is a concept I started thinking about in the late 1990s to build community and economic development opportunities around technology."

Ogle knew early on that, in the near future, wireless networks would be everywhere and that technology would advance at a rapid pace. "When we proposed the project in 2004, Wi-Fi devices were primarily limited to laptops and Pocket PCs," says Ogle. Less than five years later, smartphones like the iPhone and Droid have revolutionized mobile end-user devices. "These portable devices will usher in a new era for mobile content, sparking an increased demand for localized tourism-based content."

Though technology seems to move at the speed of light, the underlying principles of KAATCH transcend technological platforms. Web-based community networks typically feature information about local non-profit organizations, libraries, churches, and local business directories. "I have a background in tourism, so I focus my research on developing interfaces to promote local attractions and tourism-dependent businesses," says Ogle.

A pilot project Ogle launched in 2003 in downtown Newport, Tennessee, led to the proposal to the City of Knoxville to develop the historic walking tour. "The idea was to get people off the interstates and into downtown to take a walking tour of historic and culturally significant sites," Ogle says.

Communities and municipalities, including

Photos on the left are scenes from Knoxville's African-American cultural history. These images, preserved by the Beck Cultural Exchange Center, are now part of a Wi-Fi enabled walking tour of the city.

Knoxville, however, have grappled with the cost of operating and maintaining a network on such a large scale. Because downtown areas are mostly pedestrian retail environments, tourism portals could be a key component in the support of multi-use city-wide Wi-Fi networks and allow users to pool resources to operate the infrastructure. "A city could derive additional tax revenue from the increased sales such a network could drive into local business by keeping visitors in the community for longer periods of time," says Ogle.

To successfully replicate this model, a community needs three things: the network, the content, and the interface, and content is perhaps the most critical piece of the model. "Content is what creates demand," Ogle says. "Every community has a story to share."

For more information, contact Eric Ogle at 865-974-4562, or email: eogle@utk.edu. Visit the CPC Website: http://isse.utk.edu/cpc/.

STRICTER REGULATIONS ON STORMWATER RUNOFF

The US Environmental Protection Agency has issued stricter guidelines for water flowing off construction sites during a storm event. Starting in 2011, construction sites of 20 acres or more will be required to monitor runoff during a storm event.

Tim Gangaware

"Most subdivisions and road projects affect areas that size or greater," says Tim Gangaware, assistant director of ISSE's Tennessee Water Resources Research Center (TNWRRC). "The EPA's Effluent Limitation Guidelines set higher standards

for turbidity at construction sites." The new limits will be set at 280 NTU (nephelometric turbidity units), a measure of how turbid the water is, based on how much light can pass through water affected by sediment. By comparison, in the United States, drinking water may not exceed 0.3 NTU.

Since 2002, in collaboration with the Tennessee Department of Environment and Conservation (TDEC), Gangaware has helped design and implement two levels of training courses aimed at people involved in land-disturbing activities, including planners and inspectors responsible for maintaining best management practices to control sediment runoff from construction sites (Level 1) and at engineers and other professionals who design Stormwater Pollution Prevention Plans (Level II).

"The new permit requirements put a higher level of responsibility on the construction industry to improve sediment control on site," says Gangaware. TDEC, which is charged with enforcing EPA regulations, has requested the assistance of the TNWRRC in totally revamping the Tennessee Erosion and Sediment Control Handbook used in the training sessions. "We are overhauling the training program and adding training courses on top of that so we can inform the regulatory community on ways to meet the new requirements."

Gangaware says that, at times, industry hopes that new regulations will go away. "These new regulations are achievable," he says, "but industry has to use due diligence in making sure everything is designed, installed, and maintained in a timely fashion."

For more information, contact Tim Gangaware at 865-974-4777, or email: gangwrrc@utk.edu. Visit the TNWRRC Web site: http://isse.utk.edu/wrrc/.

The top three photos depict sediment-laden stormwater runoff, evidence of land disturbance without erosion-control practices. The bottom photo shows one engineered method for keeping soil in place and sediment out of the water. Photo credit: TNWRRC

The top three photos demonstrate how silt fences and ground cover can prevent erosion during the construction process.
Photo Credit: TNWRRC

In the photo to the bottom, a major stormwater detention basin at Turkey Creek Shopping Center shows a nice blend of landscaped aesthetics and engineered stormwater control. Not all engineered structures of this type need be a local eyesore or negative. We're beginning to see more attention paid to aesthetics, while being accountable to local drainage control requirements.

THE INTEGRATED BIOREFINERY

The South has been known as the "fiber basket" of the United States for some decades now and is a major producer and exporter of a wide range of forest and wood products, from pulp and paper to lumber, from composite materials to whiskey barrels. In addition to these products, the forest industry generates various sources of biomass, including waste from harvest operations and manufacturing processes.

A concept recently advanced by the wood products industry to capitalize on these residues is the integrated biorefinery. Tim Rials and other researchers at UT's Institute of Agriculture (UTIA) are furthering the concept in the lab, experimenting with ways to use byproducts from the wood manufacturing process to produce ethanol while extracting high-value chemical co-products.

Tim Rials

"We like to use the analogy of the petroleum refinery, which manufactures massive amounts of gasoline and a smaller amount of more valuable byproducts," says Rials. "The main difference is that petroleum is a limited resource whereas woody biomass is a source of renewable carbon."

In summer 2010 Rials was named director of the Center for Renewable Carbon, which incorporates four programs of UTIA: the Tennessee Forest Products Center—an affiliate of ISSE—the Office of Bioenergy Programs, the Sun Grant Initiative, and the Carbon Sequestration Program.




Wood biomass produced in the South—the US fiber basket—can provide feed stocks for integrated biorefineries capable of producing ethanol, a renewable transportation fuel, as well as high-value chemical co-products.

"With the integration of these centers and the name change, we are providing a stark contrast to fossil carbon systems and casting a broader net over agriculture and forestry resources for materials, chemicals, and fuels," he says.

Among the larger timber companies in the South there has been a trend toward divesting their land and timber holdings. To small forest landowners, the integrated biorefinery could offer real advantages in a highly competitive international forestry products industry. "It provides a market and establishes a demand for low-quality or small-diameter timber, enabling better management practices," says Rials. "Landowners don't have to absorb the costs of a stand reaching pulp wood stage, and smaller wood-processing industries in Tennessee and the region can find an outlet for their residues."

The concept also allows new perspectives for more efficient use of renewable resources. In laboratory experiments, composite materials were pretreated to extract sugars. Rials, who has a background in wood science and technology, was surprised to find that the treated composite material was mechanically stronger, less likely to absorb water and swell, and more resistant to mold and mildew. The extracted sugars can be converted to ethanol or value-added chemicals.

The integrated biorefinery provides substantial reductions in the overall footprint of the manufacturing process. "The material for this process comes from renewable carbon," Rials says. "As we develop these durable materials, they become a valuable tool for sequestration of carbon beyond conventional approaches."

For more information, contact Tim Rials at 865-946-1129, or email: trials@utk.edu. Visit the Forestry Products Center Web site: http://wood.tennessee.edu/.

CEB RESEARCHER CROSSES THE POND

When Ted Henry left the University of Tennessee (UT) for a position at the University of Plymouth, UK, he kept one foot firmly planted in the Zebrafish Research Facility (ZRF) he had established at the Center for Environmental Biotechnology (CEB). CEB is an ISSE research affiliate.

In 2007, Henry, a research assistant professor in CEB and UT's Department of Forestry, Wildlife, and Fisheries, accepted an appointment as an academic fellow of the Research Councils of the United Kingdom in the School of Biomedical and Biological Sciences at the University of Plymouth (UP). At the time, he put several research assistants and post-doctoral research associates in charge of maintaining the lab and continuing its work.

Steve Ripp

At the ZRF, Henry and his team have investigated gene expression responses in zebra fish (*Danio rerio*) in response to estrogenic environmental contaminants, with the ultimate goal of engineering a transgenic zebrafish that is responsive to these substances. The transgenic fish will fluoresce when estrogenic substances are present in the water and thereby provide an early indicator of these endocrine disrupting compounds that can cause harmful changes in the reproductive systems of animals and, potentially, humans. Further research is being conducted to engineer fish to bioluminesce in response to external stimuli based on genetic constructs developed by CEB's Steven Ripp.

Henry is also collaborating with researchers at UP to expand work he began at CEB on the potential toxicity to laboratory zebrafish of insoluble nanoparticles known as buckminsterfullerenes, or C60. The next step is investigating how these particles behave in environmentally relevant media, particularly in wastewater or effluents, and what the bioavailability will be to fish after the particles have passed through wastewater plants.

"Researchers on both sides of the Atlantic are trying to determine whether regulations should be imposed on these nanoparticles already used in products such as paint and personal care products," says Henry.

Henry returns to UT on a quarterly basis, communicates with students and researchers by Skype each week, and is planning international student exchanges, discussion courses or formal courses at UP and UT, and remote lecturing "With our overlapping focus on nanotechnology, we are keen on enhancing the collaboration between the two universities," he says.

For more information, visit the CEB Web site: http://www.ceb.utk.edu/.

A Diagnostic Glow

CEB researchers have created a mouse that could radically alter medical imaging. Biomedical researchers are always seeking improved means of tracking tumor formation and disease progression in laboratory animal models and eventually in humans. Scientists with the Center for Environmental Biotechnology (CEB) have created a mouse containing a genetically engineered cell line that represents a major breakthrough in reaching a higher level of imaging. The mouse produces bioluminescent light in the visible spectrum on its own.

Dan Close

Currently, most animals genetically engineered to glow, such as zebrafish and mice, have a green fluorescent protein (GFP) inserted. "GFP is an old technology," says Steven Ripp, a research assistant professor at CEB, "you can't pinpoint what you want to see because everything in the background also glows. Dan Close tried another approach to create a mouse that would glow by substituting GFP with bioluminescent genes."

Close, a doctoral candidate and graduate research assistant at CEB, says that bioluminescent systems, unlike fluorescence, produce their own light. "Bacterial bioluminescence produces its own substrate and can maintain it over a longer period of time, and we don't have to hit the cell with any excitation to get the result." Close is the lead author of an article appearing in *PLoS ONE*, a Public Library of Science online, peer-reviewed journal.

There are many bacteria that bioluminesce, but the vast majority are marine bacteria. "They just light up and are happy to produce light on their own, thanks to a couple of different genes they contain," says Close. Humans and other mammals, however, are not the same temperature as sea water. To create a mouse model that glows on its own, the researchers used proteins that are stable at higher temperatures, around 37° C (98.6° F). "We used genes from *Photorhabdus luminescens*, the only known terrestrial bacteria that live on land and express these genes to glow," says Close.

A major hurdle was finding a way to introduce the luminescent gene, bacterial luciferase, into mammalian cells. Close says this was accomplished by performing a bit of high-tech translation, modifying the DNA without altering the amino acids it codes for. "Basically, we used the language preferred by mammalian cells rather than the language preferred by bacterial cells."

Using genetically engineered nude mice and mice with fur, Close tried three forms of injection: subcutaneous (subQ), intraperitoneal, and circulatory. "No one has ever attempted this before, so we have to characterize everything," says Close. For the research published in the *PLoS* article, the mice were injected subcutaneously.

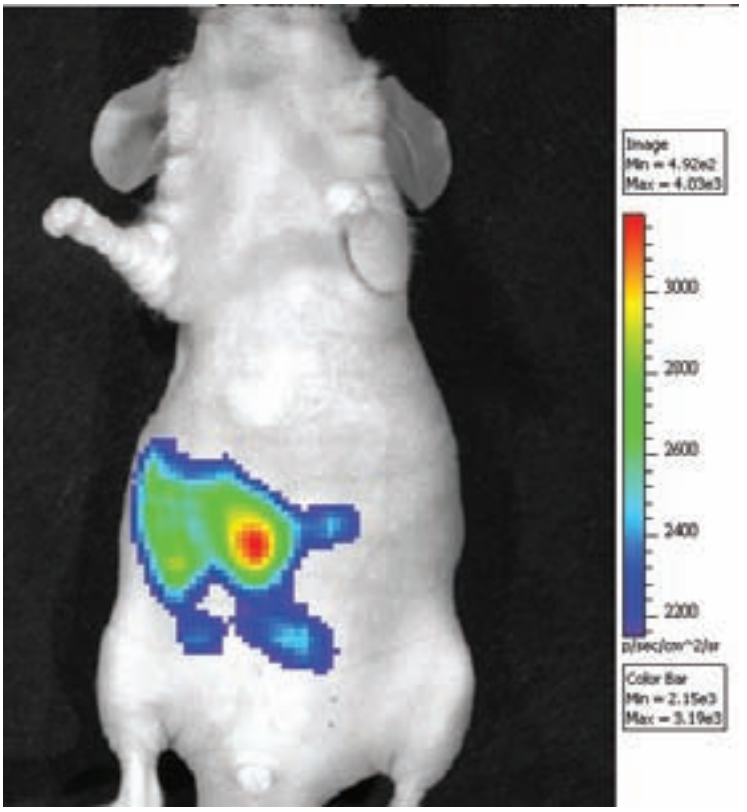
"SubQ is the more popular route in biomedical research," says Close. "It allows you to mimic evidence of cancer and how tumors grow without disturbing the animal."

Close says that this project has all the elements one could hope for. "People said it wasn't possible; it has a potentially huge impact on scientific and medical communities, and it has that great sci-fi aspect of getting things to glow that aren't supposed to."

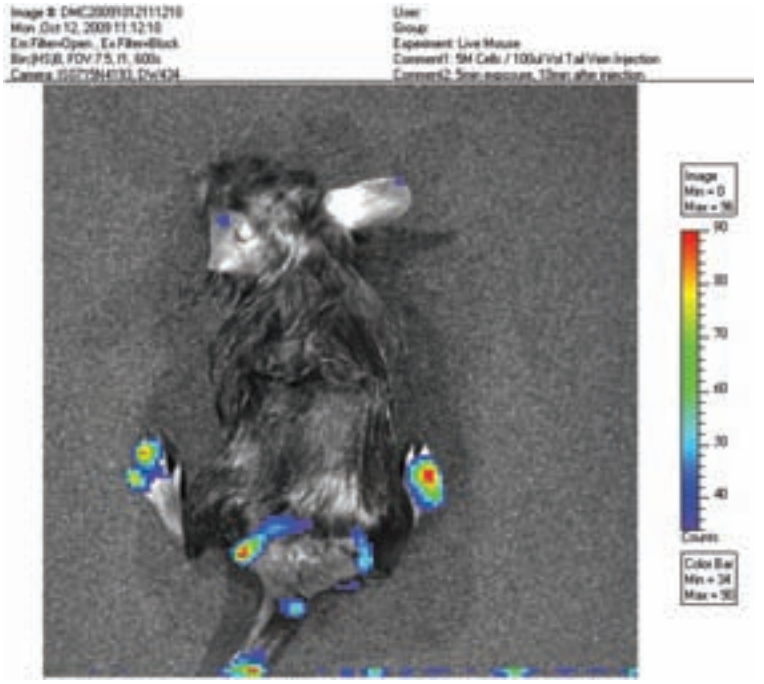
"Most of what we try in the lab doesn't work the first few times," says Ripp. "It takes someone with special talent to persevere when things don't go quite right, and Dan just kept plugging away days, nights, and weekends to make this work."

This line of research could radically alter medical imaging. Currently, surgeons use results of scans such as MRIs to locate a tumor, but during actual surgery, they are operating in the dark. "They have to poke around and find a tumor and hope they get it all," says Ripp. In the future, they will be able to see all the glowing parts of a tumor. "In the far future, people at an early age might have cells implanted and resident in the body that would always be looking for a cancer signature."

For more information, contact Dan Close at 865-974-8075, or email: dclose@utk.edu. Visit the CEB Web site: http://www.ceb.utk.edu/.



Pictured here is a nude (hairless) mouse that was injected in the body cavity with human cells containing CEB's mammalian-adapted lux constructs. The cells have dispersed within the body cavity and are producing a large signal area. This technology may one day help doctors detect cancer growing in the human body.



This mouse with dark fur also was injected in the tail vein with human cells containing CEB's mammalian-adapted lux constructs. The fur makes light detection more difficult, but the image clearly shows that the injected cells have traveled via the blood to the extremities and within the major venous structures of the mouse's hindquarters.

Energy

By George Brock Scott

Powering The World, Protecting The Planet

The earth is like a spaceship that didn't come with an operating manual. ~R. Buckminster Fuller

Energy surrounds us, in the breeze, the sunlight, the food we eat. Just a few centuries ago, families wrested energy from the environment by cutting wood for heat, rendering fat for illumination, designing machines to leverage muscle power, catching wind and falling water to turn a shaft, or simply preserving food in the sun. As technology advanced, modern society developed an ever more ravenous appetite for energy.

With the invention of the steam engine, the curtain went up on the industrial age, and large-scale manufacturing became practical and profitable. The concentrated energy of coal turned the wheels of mills and inspired industrial-scale mining, and Western society became dependent on this fuel.

Demand for the easy energy of coal and petroleum creates many of the problems we see reported in the daily news. The accident at Massey Energy's Upper Big Branch Mine in West Virginia claimed 29 lives in April of this year. The 11 oil workers who died and the 17 others who were injured in the explosion of a British Petroleum drilling platform in the Gulf of Mexico in the same month marked only the beginning of that tragedy.

The recent oil pipeline explosion at China's northeastern port of Dalian, which triggered the largest oil spill in China's history, only reinforces the global nature of problems associated with petroleum extraction and use.

The world now seeks new energy sources that won't harm workers, foul the air and water, and increase global unrest. And several of ISSE's researchers are engaged in this search for clean—or

at least much cleaner—sources of energy.

America's power generation system is still built on a mountain of coal. The United States digs up over 1 billion tons per year, according to the US Energy Information Administration, 90 percent of which is burned to boil water, which, in turn spins turbines and makes electricity.

America is coming to the realization that its reliance on coal is not sustainable in its present form. Clean coal technologies will not be used on a major scale for many years, though $800 million is dedicated to the 2010 Clean Coal Initiative.

Recent polls by Reuters and others show growing support for atomic power—even among some former anti-nuke activists—as America searches for a way to transition from overreliance on coal for electric generation. Though disposal of radioactive waste remains an issue, nuclear power does not produce greenhouse gases and, thus, does not contribute directly to global climate change.

In a time of growing concern over greenhouse gases and rising global temperatures, reliance on nuclear fission will likely increase. In that regard, France and Korea are leading the way. Nuclear power produces 74 percent of France's and 34 percent of Korea's electricity. However the two nations' overall nuclear power production (418 billion kilowatt hours [BkWh] for France and 143 BkWh for Korea) is far less than the cumulative amount produced by US nuclear plants (806 BkWh, or 20 percent of US total).

Nuclear power is but one part of an increasingly complex—and sustainable—US energy portfolio. Other power sources—cleaner and more sustainable to produce and burn—are being cultivated right here in East Tennessee.

Making Every Kilowatt Count

ISSE researchers are operating on several fronts to promote increased efficiency and development and use of renewable sources of energy.

By George Brock Scott

Billions of dollars in grants, contracts, and loans from the federal government's American Recovery and Reinvestment Act (ARRA) are funding development of wind, solar, and other green power sources. The UT/Oak Ridge National Laboratory (ORNL) Tennessee Solar Institute, for instance, received $31 million to improve efficiency and affordability of solar panels. Although development of less-polluting energy sources is part of the supply-side challenge, increased energy efficiency remains the chief target on the demand side.

Bruce Tonn, a professor in UT's Department of Political Science and a senior researcher at Oak Ridge National Laboratory (ORNL), has spent years studying ways to reduce energy demand, as well as barriers to adoption of energy-efficient behaviors. (See "Barriers to Energy Efficiency" on page 73.) Tonn also serves as leader of ISSE's Environmental Sustainability Program.

Bruce Tonn

Since passage of ARRA in 2009, $50 million of existing federal funding for housing weatherization has been increased to $5 billion, according to Tonn, and some of that money has found its way to low-income housing in Knoxville.

Petroleum products burned in vehicles account for two-thirds of total petroleum use in the United States, according to the Energy Information Administration. One way to increase fuel efficiency is to reduce the overall weight of vehicles, and to that end, since 2002, Tonn has worked with the Department of Energy's (DOE) Automotive Lightweighting Materials Program. The decade-long project develops and adapts technologies for manufacturing lighter-weight vehicle components and improving manufacturing technologies. Lighter weight aluminum parts—which require stamps and dies heated to specific temperature ranges—are more difficult to make than traditional steel components.

Other lightweighting materials in Tonn's arsenal include carbon fiber and composites. The program, which draws funding from DOE and private auto makers, also develops

environmentally responsible manufacturing techniques for these lightweight components.

The lightweighting program is part of the FreedomCAR initiative and forecasts potential levels of fuel savings, market penetration, manufacturing savings, and reduction in pollution that would result from reducing the weight of vehicles.

For more information, contact Bruce Tonn at 865-974-4552, or email: btonn@utk.edu.

TANKING UP WITH GREEN

ISSE's East Tennessee Clean Fuels Coalition (ETCFC) is a nonprofit group working to reduce dependence on foreign sources of petroleum and improve environmental quality in East Tennessee. In 2004, ETCFC was designated as a member of the Department of Energy's Clean Cities Program, an outgrowth of the Energy Policy Act of 1992.

Jonathan Overly, ETCFC executive director, believes the end is near for peak world oil production. "We're not sure if we've passed the world oil peak, but even if the peak will be in 2030, waiting until 2020 to address the many problems associated with continued reliance on petroleum products is a bad idea," says Overly.

Jonathan Overly

One way to reduce petroleum imports is to reduce fuel waste. With that in mind, ETCFC is currently working on a project that could save millions of gallons of fuel each year. The truck drivers who transport goods over America's highways are required by law to take rest breaks. While asleep in their cabs, the drivers often use the air-conditioning and heating systems of their rigs to stay comfortable, which burns considerable amounts of fuel while the truck's wheels sit idle. In the 1990s, some companies began offering truck stop electrification (TSE) services that provide heat, air-conditioning, and electricity to power truckers' televisions, computers, and other in-rig appliances.

ETCFC is currently collaborating with a truck service plaza in Crossville, Tennessee, on a pilot TSE program. A federal ARRA grant has funded installation of photovoltaic panels to demonstrate how solar power can meet part of the electricity demand. The end result is reduced energy demand as well as reduced air and noise pollution.

Another ARRA grant, facilitated by ETCFC, is powering vehicles at Tri-Cites Airport with cleaner-burning propane. Nearby, in Kingsport, propane fuels police cruisers, in collaboration with the Virginia Clean Cities program.

ETCFC holds regular meetings with vehicle fleet operators in East Tennessee to demonstrate return on investment for conversion of cars, trucks, and utility vehicles to propane, biodiesel, ethanol, and other alternative fuels.

Continued reliance on petroleum—much of which comes from outside the United States—is an environmental, economic, and national security issue, according to Overly. "Sixty to 70 percent of the money the United States spends on oil goes to foreign countries," he says. Mexico and Canada sell us fuel, but so do other less-stable nations, including Venezuela and countries of the turbulent Middle East.

"Two-thirds of our trade deficit is money spent on petroleum," says Overly. "The way to build American jobs is largely based on producing and using American fuels"—preferably fuels that are cleaner to produce and use.

Rapidly growing woody crops and waste plant products represent a real possibility for the production of fuels that can create income for farmers and cleaner air and water for the rest of us. Fueling the push for home-grown fuels, petroleum produced in America


SUMMER/FALL 2010

TENNESSEE
Clean Fuels Advisor

Biannual publication from the partnership between the Clean Cities coalitions in Tennessee and the state of Tennessee.

Bringing alternative fuels, higher fuel economy vehicles and advanced transportation technologies to the forefront in Tennessee.

Propane: Catching on in Tennessee

While propane has been used as an alternative fuel for over 20 years, many people are still learning about its benefits. Propane, a nontoxic by-product of natural gas processing and oil refining, can be used as a fuel in both light and heavy-duty vehicles and off-road machinery. Propane costs less and that is a significant attraction for many fleets. Because of its versatility and low price, it is the third most commonly used fuel in the U.S. There are many political and economical benefits because propane is 85 percent domestically produced. Other benefits of propane include 20 percent less greenhouse gas emissions and reduction of hydrocarbon emissions by 70 percent, when compared to gasoline.

Two fleets in northeast Tennessee are working on using propane in their vehicles. Due to ETCleanFuels winning a state grant, two tugs and one belt loader were converted to run on propane at the Tri-Cities Regional Airport in early 2010, and later this year Kingsport is converting three police cruisers. Additionally, through the grant, the city is receiving funds to offset its capital costs with the purchase and installation of an above ground tank and dispensing pump. This will allow them to begin using propane in even more vehicles including lawn mowers.

Although the average cost of converting a light-duty vehicle from gasoline to propane is $4,000-$6,000, according to the Department of Energy (DOE) the payback period is very reasonable for fleets that are high-mileage and heavy fuel consuming vehicles. The city recently received an additional grant through DOE to fund two vehicle conversions.

Also there are several projects focusing on converting off-road vehicles, such as lawn mowers, to propane. Clean Cities of Middle Tennessee partnered with Jim Coker of Heritage Propane/ Metro Lawn this past April to educate 45 people about the advantages of using propane, and ETCleanFuels held a similar event in Blount County in June (a Cub Cadet is pictured). Attendees were able to test drive various mowers and speak with dealers and manufacturers. ETCleanFuels is currently working on holding more propane events in other counties. For more information on switching your fleet to propane, contact Emily DeVillers at 865-974-9665.

Twenty-Three Hybrids on the Market Today

Hybrid electric vehicles were once a rare novelty, and only a couple of car manufacturers produced them. However, as technology has improved and people have become more conscientious of the environment, several car manufacturers are now offering vehicles as hybrids.

Hybrids combine an internal combustion engine with an electric motor that captures energy lost through braking. They use regular gasoline and do not need to be plugged in for charging. Instead of using only gas to power the engine the battery assists the primary engine during acceleration. (on some vehicles, the battery provides all the power at low speeds). Thus, by using battery power, it reduces fuel consumption and produces fewer tailpipe emissions.

Hybrids are not only better for the environment, but they can also save its owner money. Owners stand to benefit from their capital investment as gas prices rise, which is what the U.S. Energy Information Administration predicts in the comin years.

The chart below lists a sampling of hybrid vehicles available today. Manufacturers are offering more vehicles as hybrids, and over 30 new hybrids are scheduled for release in the next three years. For the most up to date information regarding hybrids, nonhybrids, and to compare their fuel economy, visit

www.fueleconomy.gov

Inside this Issue

This newsletter was made possible by the Tennessee Department of Environment & Conservation and Innovation Drive. THANK YOU!

is getting harder—and more expensive—to extract, never mind the oil leak in the Gulf of Mexico and other environmental disasters.

"Replacing a significant percentage of oil with energy crops grown by local farmers makes economic sense," says Overly. "If you stick with oil you're going to be paying more over the long run," as the cost of finding and extracting petroleum increases.

ENERGY CROPS

ISSE scientists work with researchers and universities here and across the globe in exploring ways to supply new crop-based fuels—chiefly biodiesel and ethanol—to sate an increasing global demand for energy. The UT/ORNL Joint Institute for Biological Sciences (JIBS) and the UT Institute of Agriculture are investigating biofuel crops at the genetic and cellular level to increase yield and reduce cost. This research includes development of biofuel plant varieties that break down more quickly into sugars for fermentation into biofuels, and for growing better microorganisms for plant processing and fermentation. (See "Fueling the Future" on page 79.)

Meanwhile, the China-US Joint Research Center for Ecosystem and Environmental Change explores ways to increase production of biofuels while protecting and restoring degraded ecosystems in China and the United States. The China-US Joint Research Center is a partnership among ISSE, JIBS, ORNL, Purdue University, the Chinese Academy of Sciences, and the University of Science and Technology of China. (See "China-US Workshop Explores Sustainable Management of Soil and Water Resources" on page 81.)

The UT Biofuels Initiative is demonstrating how alternative, homegrown sources of plant material can make a considerable contribution to domestic fuel production. The pilot production site, located southwest of Knoxville in Vonore, Tennessee, is funded by DuPont Danisco Cellulosic Ethanol LLC, and the University of Tennessee Research Foundation through Genera Energy. (For more information on the Biofuels Initiative, see the section "From Hay Field to Highway" in "Fueling the Future" on page 79.)

"It's meant to be a research plant," says Overly, and eventually projected to produce 250,000 gallons of biofuel a year when the plant is completed and in full operation.

Currently the most promising biofuel grown in East Tennessee is switchgrass, a native fast-growing plant capable of thriving on marginal agricultural lands. Corn stover—the leaves, stalks, and cobs remaining after harvest of the grain—also shows promise.

While switchgrass is suited to East Tennessee, Overly points out that other plant-based feedstocks are more economical and appropriate for other regions. In Brazil, for instance, sugar cane provides the world's cheapest supply of ethanol. Floridians are experimenting with fuels produced from orange peel waste, and Georgians are using pine tree slash.

"This kind of decentralized fuel production will likely be the way of the future," says Overly. Local production of the fuel feedstock reduces demand for imported oil, and local demand for fuel crops can support new farming enterprises. Fuel production from smaller, more distributed refineries, says Overly, means less vulnerability to weather and other disruptions and creates a more flexible production stream.

ETCFC also is part of a clean-fuels initiative that traces the Federal Interstate Highway System from the Upper Peninsula of Michigan to the southern tip of Florida. The I-75 Green Corridor Project will install more than 20 public biofuel pumps at intervals along the route.

The goal is to replace 10 percent of America's automotive fuel supply with biofuels by 2020 and to grow the feedstocks on land where no food is produced.

Are we there yet? "No," says Overly, "but we're definitely moving in the right direction."

For more information, contact Bruce Tonn at 865-974-4552, or email: btonn@utk.edu. Contact Jonathan Overly at 865-974-3625, or email: jgoverly@utk.edu. Visit the ETCFC Web site: http://eerc.ra.utk.edu/etcfc/.

Barriers To Energy Efficiency

Tools and technologies to reduce energy consumption at home and on the road are readily available, but a report identifies multiple barriers that stand in the way of their widespread adoption.

By Noa Davidai and Marlene Taylor

SCENARIO 1:

You wake up in the morning; make your coffee with water from your Brita purifier; spend 2-3 hours a day in your car braving rush-hour traffic; hop in and out from car to home, work, and stores that are 5-10 miles or more from each other; minimize outdoor time because the radio announced an air quality advisory this morning; spend $200 on gasoline and an additional $200 or more on your home energy bill every month.

SCENARIO 2:

You wake up in the morning to a cool breeze coming through your open window; make your coffee with pure tap-water; read your newspaper on your way to work on public transportation; take a nice stroll from your office to a nearby coffee shop to meet a friend before heading to the local store for some organic groceries; spend $40 on gasoline and $80 on your home energy bill each month.

If presented with a choice of realities, while ignoring cost or availability, who among us would not pick the second scenario? But, when faced with the actions and decisions necessary to convert the first scenario into the second, we confront a set of barriers, both real and perceived.

IS THERE A BLOCK IN THE ROAD?

With a new, energy-conscience administration in the White House, access to the most advanced technology in the world, and growing mainstream awareness of environmental issues, now seems to be the perfect time to embrace such environmentally sustainable technologies and behaviors. So why are we still encountering barriers that prevent us from doing more to reduce our nation's energy consumption?

WHY REDUCE ENERGY USE?

Before we can begin to break down barriers, we must first describe, quantify, and understand them. With that goal in mind, Bruce Tonn and Jean Peretz, researchers with the University of Tennessee's (UT) Institute for a Secure and Sustainable Environment (ISSE), published the report "Barriers to Reducing Energy Consumption at Home and on the Road."

The report was conceived when Dye, Van Mol, and Lawrence (DVL), a Nashville-based public-relations and advertising company, contacted William Fox at the UT Center for Business and Economic Research about writing such a paper for a general audience. For assistance, Fox approached Tonn and Peretz, both of whom have researched and

Bruce Tonn

Jean Perez

published extensively on energy issues.

Tonn, a professor at UT's Department of Political Science, a senior researcher at Oak Ridge National Laboratory, and leader of ISSE's Environmental Sustainability program, explains that "the larger idea for the project was a desire to change people's energy behaviors. To achieve that goal, DVL wanted to evaluate barriers that people face in pursuing energy efficiency, and based on these results, to launch a campaign consisting of television commercials and public service announcements."

Peretz, an ISSE research leader, felt the timing was ideal for such a project. "Bruce and I had just published a paper [in *Energy Policy*] on state-level benefits of energy efficiency, and this was a chance to summarize the academic literature in lay terms to be used as background material for a future campaign." Peretz also saw an opportunity to promote ISSE's energy-related research.

Based on extensive research and ideas drawn from a survey conducted by the Department of Energy's Weatherization Assistance Program, Tonn and Peretz completed a seven-chapter, 20-page report on the economic, technological, and social/psychological barriers to reducing energy consumption at home and on the road.

The report states that "the combined consumption of energy in our homes and cars represents almost half of the energy consumed in the United States." The report further asserts that, although Americans can take numerous actions to reduce their energy consumption, "many barriers seem to prevent households from adopting these technologies and practices."

The report discusses the multiple wide-ranging benefits of decreased energy consumption for global climate change, US energy independence, the food market, and many more. But it also stresses that households themselves would benefit directly and states, "They can see home energy bills and costs at the gas pump reduced, weatherizing homes can lead to better health and improved safety, all drivers would benefit from reduced traffic congestion, and all citizens would benefit from improved air quality.

"The transportation sector, which is dominated by private vehicles, is almost wholly dependent on liquid fossil fuels, and the effects of urban sprawl are clearly seen in the growth of the length of an average trip," the report continues. "Most of the energy used in the residential sector is for space heating and cooling." And most of the fossil fuel used for transportation and the fuel oil used to heat homes in the United States is imported. The report shows that "US energy consumption has steadily increased over the years and is forecasted to continue to increase," alongside increasing worldwide energy consumption.

These worldwide increases will primarily affect the United States through world oil markets, and based on these forecasts and the current energy consumption numbers, Tonn and Peretz predict that "it is likely that oil prices will remain high for many years into the future."

WHAT'S HOLDING US BACK?

The report provides a comprehensive list of actions that households can take to reduce their energy consumption at home and on the road, based on three categories: changing the use of existing technology, changing behavior, and investing in new energy-efficient technology. The actions are further organized by ease of personal adoption.

Certain actions are "simple and involve minimal cost," such as closing off rooms, turning off lights, running the dishwasher in the mornings during low peak demand, and maintaining recommended air pressure in tires. These kinds of actions "generally do not involve major changes in behavior and are not typically related to perceptions of reductions in quality of life."

On the other hand, there are more dramatic changes that "may be associated with impacts on quality of life" and may therefore be harder to implement. These changes include taking shorter showers, taking mass transit to work, downsizing a home, or moving closer to work.

The report found that adoption of these changes, big or small, by the general public is compromised by the following three barriers:

Economic Barriers. For many people, "first costs dominate their decision making for purchasing energy-efficient appliances and fuel-efficient cars." Energy-efficient products often have higher initial costs than conventional products. But since these products have lower operation and maintenance costs, their total costs are often much lower over the lifetime of the products. Even so, people are hesitant to take that leap of faith toward future savings.

A 2009 *New York Times* article titled "Why Isn't the Brain Green" by Jon Gertner describes research funded by the National Science Foundation and conducted by the Center for Research on Environmental Decisions showing that "we are not always adept at long-term thinking; experiments have shown a frequent dislike for delayed benefits, so we undervalue promised future outcomes. (Given a choice, we usually take $10 now as opposed to, say, $20 two years from now.)" This type of barrier clearly makes many people hesitant when faced with the higher initial cost of energy-efficient products, especially high-cost items such as large appliances or cars.

An additional cost described by the ISSE report is sometimes referred to as "hassle cost." To reduce one's driving, an individual might need to merge trips and coordinate schedules with others in or out of the household, which may entail a certain degree of complexity. Taking alternative modes of transportation would also reduce driving but might be associated with a "psychological barrier to giving up the freedom of driving."

Following this presentation of each type of economic barrier, the report describes the need for programs that provide rebates, incentives, and resources to help reduce costs and assist home and car owners in making these transitions.

Technology Adoption. Even if new technology is available, there are often barriers associated with adopting it into regular use. Overcoming these barriers is a multi-step process. Awareness is step one. If people have not heard of residential geothermal heat pumps, how can they make the decision to adopt this technology?

But, even "after awareness is established, information needs to be available that describes the costs and benefits," states the report. And this information must be obtained, in part, through an evaluation process. At this step, the process slows down significantly because "most people would rather take a wait-and-see attitude and let others suffer the errors." An example of this is the hybrid automobile. For many years, hybrid cars were used only by a "small set of early adopters or risk takers." And it was only after the product proved its long-term

quality and durability that it began to take off and become more trendy and common on the roads.

Many psychological barriers that may influence energy consumption could result from misconceptions and a lack of feedback. For example, a common misconception about household energy use is that "leaving on lights, computers, televisions, etc., uses less energy than shutting them off and turning them on again." And since, typically, energy bills do not provide a detailed breakdown of consumption for heating, lights, kitchen appliances, and such, households get no feedback to indicate any energy-savings that might have resulted from certain behavioral changes.

There also tends to be an association between energy use and social status, good health, comfort, and convenience. As the report states "energy use is intimately interwoven with lifestyles and quality of life." When people face the decision of, for example, using mass transit, they struggle with barriers such as "loss of freedom, fear of crime (threat to good health), stigma associated with using mass transit (threat to social status), and crowded conditions (threats to comfort and convenience)."

An additional psychological barrier is one referred to as "moral disengagement." The report suggests that though "many people know deep down that they should consume less energy, they simply refuse to do so, usually out of pure self-interest and then justify their actions using other moral arguments," such as "it has not been proven that humans are causing global warming" and "global warming may not be that bad."

Gertner's *New York Times* article reinforces this theory by describing research in which around 50 percent of Alaskans, now living in a state that is experiencing easily perceived climate changes, "considered climate change a long-term problem that required more study before acting." In fact, Gertner states that for many people the "experience of climate change is a relative thing: something happening to another part of their state, or to a different cultural group, and doesn't necessarily warrant a change in their own response."

THE ENERGY-EFFICIENT LIGHT AT THE END OF THE TUNNEL

Following grim assessments of energy consumption in the United States and the barriers standing in the way of real change, Tonn and Peretz conclude the ISSE report with several inspiring "success stories" of communities, and even entire states, banding together to significantly reduce energy consumption in the home.

At the turn of the 21st century, California experienced an energy crisis. Following a government-funded media campaign called Flex Your Power, which appealed to a feeling of community service and altruism, the average California household "reduced its consumption by 10 percent during peak summer hours in the summer of 2001."

In an attempt to restructure its electric power industry, New York initiated a state-wide Energy Smart Program™ in 1998. The initiative consists of more than 40 programs that focus on business, residential, low-income, and research and development. As of 2004, "the program's annual electricity savings are estimated to be 1,400 GWh, peak demand has been reduced by 860 MW, and state energy customers are saving $195 million on their energy bills annually." And with eyes to the future, "more than 18 percent of new residential homes are being built to ENERGY STAR® specifications."

WHAT ABOUT THE VOLUNTEER STATE?

Is Peretz and Tonn's report relevant to Tennessee? The researchers answer with an emphatic "yes." "Tennessee is the 13th largest consumer of energy in the United States," Peretz points out. "In fact, Tennessee has the largest watt-per-capita consumption in the country. We have a long way to go to achieve energy efficiency and to improve public education, state energy policies, and implementation."

Adds Tonn: "The State Energy Program of the Tennessee Department of Energy recently saw its annual budget jump from $40 million to $3 billion, and they have to figure out how to spend it. If they understood the barriers to energy efficiency, they could develop programs and apply for additional grants from the national Energy Efficiency and Conservation program that has $3.3 billion allocated for such purposes."

The task in Tennessee is a big one, but there are already groups and organizations working hard to make a difference. At UT-Knoxville, the Make Orange Green (MOG) program has been hard at work since 2006 in promoting and coordinating environmental stewardship activities on campus and developing a campus-wide energy conservation policy.

Gordie Bennett, MOG's sustainability manager, says that a major barrier he regularly encounters is the lack of "education about the need for energy conservation." Bennett adds that although the organization regularly gives "presentations to students, faculty, and staff groups concerning the importance for energy conservation," there are a couple of issues that MOG continuously encounters.

First, there are always questions about comfort. The current energy policy on campus dictates that when heating, the temperature be kept at 68°F, and when cooling, the temperature be kept at 76°F. "But," says Bennett, "it remains to be seen how people will react to warmer indoor temperatures during the summer." Also, the current policy does not allow any individual heating devices in offices. "A lot of people got used to having heating blankets and space heaters," notes Bennett. "The new policy bans those, and there has been some resistance. We hear rumors that people continue to use them."

The second challenge is the yearly turnover of several thousand students. This makes energy conservation education an on-going task. "It is a continuing battle," says Bennett, "because we have students graduating and new ones coming in every year."

"On the whole," Bennett says, "response to the MOG program has been positive. We expected a lot of opposition coming into the program, but haven't encountered much here on campus. Make Orange Green is becoming a strong organization."

BABY STEPS TOWARD ENERGY EFFICIENCY

Following the publication of ISSE's "Barriers to Energy Consumption" report, DVL conducted a survey asking around 1,000 people a variety of questions about their knowledge of general energy conservation issues as well as about their own energy-consumption habits. Based on both the report and the survey, DVL's future goal is to utilize the project's findings as background information in creating a public campaign.

From an ad-agency standpoint, DVL was looking for a clear message to send as to which barrier is most relevant to tackle. But to Tonn's surprise, "there was no clear answer in the research as to which area of energy consumption one should focus on." Tonn believes that the "biggest barrier is to change people's driving habits." But there are no simple solutions because "it's not just a matter of changing people's habits," says Tonn, "it's that they don't have options because of urban sprawl and the lack of public transportation. That's a huge barrier compared with changing light bulbs, turning

down the thermostat, or even buying an energy-efficient washer."

Still, what clearly is necessary is to educate the general public. "I think the most important thing is that a lot of these items are easy behavioral changes that we can adopt and that make a difference," says Peretz. "Some of it is easy and some of it, like carpooling, could require a bit more planning. But it's so important when you look at the state's energy consumption. Just a little bit of work can make a difference."

For more information, contact Bruce Tonn at 865-974-4552, or email: btonn@utk.edu.

Access the report here: isse.utk.edu/pdf/issepubs/2008_02EnergyBarriers.pdf

Fueling The Future

A topical workshop on the biotechnology of bioenergy plants brings top Chinese and American scientists together to explore improved feedstocks for alternative fuels.

By Elise LeQuire

The United States has set an ambitious goal of displacing 30 percent of its petroleum consumption with biofuels and other renewable energy sources by 2030. The government of China has set similar goals. Achieving these goals will require careful use of marginal lands and optimizing the agricultural markets while ensuring that food security is maintained.

Researchers from China and the United States convened in November 2009 in Knoxville for a topical workshop to explore strategies for breakthroughs in the field of biotechnology of bioenergy plants. During the two-day workshop, consensus emerged that to reach the benchmarks, research must aim to increase crop yield per unit of land, improve the conversion rate from biomass to fuel, and improve biomass sources that thrive on marginal lands.

It is not clear whether the goals realistically can be met, cautions Neal Stewart, Racheff Chair of Excellence in Plant Molecular Genetics in the University of Tennessee's (UT) Department of Plant Sciences. "We can't do everything toward meeting those goals," says Stewart, "but we can do the cutting-edge science." Further, he says that without the science we have no chance to meet ambitious bioenergy goals.

Stewart chaired the workshop, held November 16-17 in Knoxville and funded by the National Science Foundation. UT's Institute for a Secure and Sustainable Environment (ISSE), the UT Institute of Agriculture, the Southeastern Sun Grant Initiative, UT's Office of Bioenergy Programs, and the Joint Institute for Biological Sciences of UT and Oak Ridge National Laboratory (ORNL) co-sponsored the workshop. The meeting came on the heels of the third annual workshop of the China-US Joint Research Center for Ecosystem and Environmental Change, held November 11-13 at ORNL.

"Neal Stewart's group was interested in using contacts from the China-US Joint Research Center as well as his contacts within UT's Institute of Agriculture to explore the most meaningful ways for building international collaboration," said Randall Gentry, director of ISSE.

Eight scientists from the Chinese Academy of Sciences (CAS) and eight scientists from UT, ORNL, and Purdue University presented keynote or plenary addresses to about 50 participants at the workshop, including a number of Chinese and American students. Thirteen poster presentations were displayed at the event. One of the goals of the workshop was to develop a professional network of student scientists to promote future scientific collaboration.

FROM HAY FIELD TO HIGHWAY

Converting from fossil fuels to biofuels requires a number of transitional stages. "We can't flip a switch and go from one paradigm to another," says Gentry. There are scientific, logistical, and cultural challenges to meet. UT's Biofuels Initiative, with strong support from the state of Tennessee and in partnership with Dupont Danisco, is leading the nation in bringing biofuels to the

marketplace. A pilot-scale bio-refinery plant in Vonore, Tennessee, began production in December 2009, using switchgrass and corn products provided by Tennessee farmers to create ethanol.

"This partnership is perceived as a leader in the country in getting next-generation biofuels to the market," says Gentry. "We are focused on the social, environmental, and economic perspectives." This includes providing $8 million in incentives to farmers to replace traditional crops with switchgrass grown on marginal farmland.

BIOENGINEERING OF PHOTOSYNTHESIS

While genomics research and field testing of bioenergy plants are advancing, a professor in UT's Department of Biochemistry and Cellular and Molecular Biology is looking beyond biofuels, engaging in what Stewart terms "high-risk, futuristic research." Barry D. Bruce's research is focused on the bioengineering of photosynthesis. "What are we going to do when we have consumed all accessible biofuels?" he asks. "The solution rises every day."

Not only are fossil fuels a finite resource, the earth's capacity to produce enough biomass to meet future needs is also limited.

Plants harness the sun's energy through photosynthesis at a highly efficient rate—95 percent— but converting that energy into plant biomass reduces the conversion efficiency of photons to a usable form to well below 1 percent. Bruce is exploring shortcuts to produce usable energy by bypassing the production of crop-derived—brown—biomass and mined petrochemical—black—biomass such as coal and oil. This research, termed P2V (photosynthetic photovoltaics), lies at the intersection of biologic and materials science. P2V allows simple plants such as spinach and algae to become biofactories that build and assemble a renewable source of nanoscale-photovoltaic solar cells. Bruce is collaborating in this research with engineers and chemists from other institutions in the United States and France.

CHINA'S LOESS PLATEAU GROWS SWITCHGRASS

The Loess Plateau in central China is a highly degraded, arid to semi-arid region with steep gradients that make mechanized agriculture difficult. Chinese researchers are engaged in rehabilitation efforts to restore the land through the use of more drought-resistant native crops and through germplasm exchange with American scientists—plantings of switchgrass—which is one of the few plants that can survive the harsh conditions.

Yong-Qing Ma, with the CAS Institute of Soil and Water Conservation, has investigated the adaptability of switchgrass (*Panicum virgatum L.*) to the arid conditions on the Loess Plateau. Here, farmers highly skilled in animal husbandry face shortages of forage during the long dry season, which runs from December through April. In drought conditions, there are few species of domesticated grass and grain species suitable for cultivation on the plateau. At the CAS Ansai and Guyuan field stations, Ma and his colleagues are experimenting with drought-tolerant cultivars of switchgrass to determine the best varieties that thrive under serious drought conditions.

China-US Workshop Explores Sustainable Management Of Soil And Water Resources

By Xu-Dong Zhang and Jack Parker

A workshop hosted by the Chinese Academy of Sciences (CAS) Institute of Applied Ecology convened in Shenyang, China, January 5-8, to discuss current research on the sustainability of soil and water resources and to promote bilateral collaboration in research and graduate education between US and Chinese institutions.

The organizing committee included faculty from the University of Tennessee's (UT) Institute for a Secure and Sustainable Environment, the Chinese Academy of Sciences' (CAS) Institute of Applied Ecology and Northeast China Institute of Geography and Agriculture Ecology, China Agricultural University, Liaoning Academy of Agricultural Sciences, and Shenyang Agricultural University.

More than 80 participants represented 14 Chinese institutions, UT, Purdue University, Argonne National Laboratory, and Oak Ridge National Laboratory. Pre- and post-conference visits to Liaoning Academy of Agricultural Sciences, Shenyang Agricultural University, CAS Northeast Institute of Geography and Agriculture Ecology (Harbin), China Agricultural University (Beijing), and CAS' Institute of Geographic Sciences and Natural Resources Research (Beijing) further extended the impact of the conference.

The meeting was co-sponsored by the China-US Joint Research Center for Ecosystem and Environmental Change (http://jrceec.utk.edu/), which was established in 2006 to promote research collaboration, academic exchange, student education, and technology training and transfer in areas of environmental concern.

Population growth and rapid urbanization in China have intensified competition for land use, with consequences for agricultural productivity, water-use allocation, and soil and water quality. Sustainable management and effective remediation technologies are needed in all regions of China. Similar problems exist in the United States because of urban sprawl and pressures to increase biofuel production driven by government subsidy programs. As globally dominant contributors to greenhouse gas emissions, China and the United States also share a mutual interest in understanding the consequences of these emissions.

Workshop participants presented and discussed recent research development of strategies for use of soil and water resources based on models that take into account uncertainty; effects of land use and management practices on water-use efficiency; fate and transport of contaminants in soil, groundwater, and surface water; effects of land use and management on soil carbon balance and nutrient cycling; and molecular techniques for studying mechanisms of soil biochemical processes.

With financial support from the Institute of Applied Ecology, US and Chinese researchers will partner on developing proposals in these research areas.

Participants discussed mechanisms for research collaboration and graduate student exchanges, and the director of the Institute of Applied Ecology offered letters of appointment to US participants as affiliated research faculty to facilitate joint proposal development, student mentoring, and a faculty/student visiting program.

For more information, contact Jack Parker at: jparker@utk.edu.

Xu-Dong Zhang, Institute of Applied Ecology of the Chinese Academy of Sciences, and Jack Parker, associate director of research for UT's Institute for a Secure and Sustainable Environment, co-chaired the organizing committee for the workshop.

The Sunshine Boys

The co-directors of the newly formed Tennessee Solar Energy Association forecast a bright future powered by renewable energy from the sun.

By Marlene Taylor

Steve Levy and Jim Hackworth have created the Tennessee Solar Energy Association (TSEA) to help provide affordable solar power for businesses and families of all income levels in Tennessee.

The co-directors bring complementary technical and "people" skills to the venture. Levy, a Massachusetts native, has a background in electrical engineering and materials science. Hackworth, a Tennessean and former owner of a successful publishing business, contributes marketing savvy and networking skills.

TSEA is the official Tennessee chapter of the 50-year-old American Solar Energy Society. Levy and Hackworth requested that the charter for their organization become official July 4, 2009, at noon—a fitting symbol for an organization determined to declare Tennessee's independence from electricity provided primarily by coal-fired power plants.

"Our goal is to figure out how to reduce the cost of solar power in Tennessee so it can be affordable for use in residential and commercial facilities," says Hackworth. "Using solar could significantly reduce our nation's dependence on foreign sources of oil and improve our air quality."

"Governor Bredesen has done a fantastic job

of recruiting industry to make the panels in our state, and so the governor is the first person to receive TSEA's Pioneer Award," says Levy.

In 2008 and 2009, two solar technology firms, Wacker Chemie AG and Hemlock Semiconductor LLC, announced plans to build plants in Tennessee. Wacker Chemie makes highly pure polycrystalline silicon, the raw material used to make solar panels, and Hemlock makes semiconductors for the panels. Confluence Solar Inc., which transforms silicon into the crystals used in solar cells, plans to build a $200 million solar manufacturing plant in Clinton, Tennessee. And Sharp Electronics has based its solar module operations in Memphis since 2003.

"Manufacturing in the state will make solar much cheaper than if we have to buy panels from overseas," says Levy.

The production of photovoltaic (PV) cells is the world's fastest-growing energy technology, and the cost is decreasing proportionally.

TSEA currently is developing a magazine on solar and other forms of renewable energy to disseminate information throughout the state. The publication will cover both environmental and business topics.

"We're going to be the market of the future," says Levy, "and the future is closer than you think."

For more information, contact Steve Levy or Jim Hackworth at 865-974-9218. Visit the TSEA Web site at: http://tnsolarenergy.org.

Tennessee Solar Energy Association's Steve Levy (left) and Jim Hackworth.

Staff Citings

Compiled by Sherry Redus

THOMAS BURLEY

Research Reports:
Liem T. Tran and Thomas E. Burley. 2009. An Analysis of Spatiotemporal Variations of Water Quality in the Little River and the Harpeth River Watersheds and their Connection with Land-Cover Patterns. ISSE Working Paper 2009-01.

GREG COLE

In the media:
Tennessee Today, UT's online news and information magazine, posted a video titled "UT-based Fiber Optic Network Expands Global Reach." The video discusses GLORIAD (Global Ring Network for Advanced Applications Development) and its mission through an interview with GLORIAD Director Greg Cole.

Presentations:
Greg Cole participated in SingAREN Fest 2010 on June 28, 2010, in Singapore. This year's conference theme, "Global Network Connectivity- Making the Difference," highlighted Ipv6, Singapore Internet Exchange (SGIX), Future Internet Testbed, and the Global Ring Network for Advanced Applications Development (GLORIAD) and also included a hands-on demonstration. Cole delivered a presentation titled "Global Ring Network for Advanced Applications Development (GLORIAD) Federated Model of Community-focused Cyberinfrastructure."

Cole participated in the US-India Joint Commission Meeting on Science and Technology Cooperation held on June 24-25, 2010, at the Smithsonian Museum of Natural History in Washington, DC. He delivered a presentation titled "The Cross Cutting Impact of Advanced Broadband Telecommunications on Science and Technology Cooperation between the United States and India."

MARY ENGLISH

Awards, appointments, and other honors:
Mary English was appointed to a National Research Council study committee on uranium mining in Virginia.

In the media:
An article featuring the work of Mary English and other social scientists will be published in the August 13 edition of *Science Magazine*. "Nuclear Waste: Knowledge Waste?" which will appear in the Policy Forum section of the magazine, discusses the societal challenges of disposing high-level nuclear wastes and possible policy efforts.

TIMOTHY EZZELL

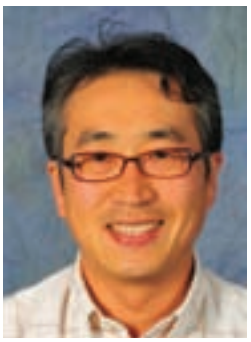
Awards, appointments, and other honors:
Tim Ezzell was named an Honorary Research Fellow by the Appalachian Regional Commission.

RANDALL GENTRY

Awards, appointments, and other honors:
Randall Gentry and Jie Zhuang were appointed to the editorial board of *Journal of Resources and Ecology*, which is published seasonally by Science Press, China.

Presentations:
The paper "Hurst Analysis of Hydrologic and Water Quality Signals" (S.R. Koirala and R. W. Gentry) was presented by Shesh Koirala at the ASCE-EWRI World Environmental and Water Resources Congress 2010, held in Providence, Rhode Island, from May 16-20, 2010.

The paper "Using Wavelets to Evaluate Persistence of High Frequency Hydrologic and Hydrochemistry Signals" (S. R. Koirala and R. W. Gentry) was presented by Shesh Koirala at the American Geophysical Union (AGU) Fall Meeting, December 14-18, 2009, San Francisco.



UNGTAE KIM

Presentations:
Ungtae Kim was co-author (with A. Al-Juaidy and J. J. Kaluarachchi) of a presentation titled "Decision Analysis to Minimize Agricultural Groundwater Demand and Salt Water Intrusion Using Treated Wastewater," delivered at the 7th IAHS International Groundwater Quality Conference (GQ10), June 13–18, 2010 in Zurich, Switzerland.

The following papers, co-authored by Ungtae Kim, were presented by Jack Parker at the DoD Strategic Environmental Research and Development Program (SERDP) meeting in Washington, DC, on December 2-4: "Practical Cost-Optimization of Characterization and Remediation Decisions at DNAPL Sites with Consideration of Prediction Uncertainty" (Jack Parker, Peter Kitanidis, Michael Cardiff, Ungtae Kim, Xiaoyi Liu, Dave Becker, and Aleisa Bloom), and "Estimating DNAPL Source Depletion Time Model Formulation, Calibration and Uncertainty" (Jack Parker, Ungtae Kim, Mark Widdowson, Peter Kitanidis, Frank Chapelle, Carmen Lebron, Xiaoyi Liu, and Michael Cardiff).

Ungtae Kim presented the following papers at the US Department of Defense Strategic Environmental Research and Development Program (SERDP) Annual Meeting, Dec 1-3, 2009, Washington DC: "DNAPL Source Strength vs. Time Model Formulation, Calibration, and Uncertainty" (J. Parker, P. Kitanidis, U. Kim, X. Liu, M. Cardiff, and M. Widdowson) and "Cost Optimization of DNAPL Site Remediation with Consideration of Prediction Uncertainty" (J. Parker, P. Kitanidis, U. Kim, X. Liu, and M. Cardiff).

SHESH KOIRALA

Presentations:
Shesh Koirala presented the following paper at the ASCE-EWRI World Environmental and Water Resources Congress 2010, held in Providence, Rhode Island, from May 16-20, 2010: "Hurst Analysis of Hydrologic and Water Quality Signals" (S. R. Koirala and R. W. Gentry).

Shesh Koirala made the following presentation at the American Geophysical Union (AGU) Fall Meeting, December 14-18, 2009, San Francisco: "Using Wavelets to Evaluate Persistence of High Frequency Hydrologic and Hydrochemistry Signals" (S. R. Koirala and R. W. Gentry).

LARRY MCKAY

Awards, appointments, and other honors:
McKay was named as a Fellow of the Geological Society of America in 2009.

McKay was the keynote speaker at the Tennessee Junior Science and Humanities Symposium at the University of Tennessee on February 26, 2010.

In the media:
WATE-TV's Kristen Farley interviewed Larry McKay about a recent study that found viruses and bacteria in East Tennessee drinking water.

A University of Tennessee press release, based on one of McKay's recent publications on viruses and bacteria linked to human feces found in community water sources in East Tennessee, appeared on more than 30 websites, including *Medical News Today, Medilexicon, Science Daily, USA Today, Science Blog, Topix, PhysOrg, Technobahn, Infection Control Today, WaterTech Online, Nashville Herald, TreeHugger, FirstScience, NewsGuide, EScienceNews, RDMag, and ResearchGate*.

ERIC OGLE

Presentations:
Eric Ogle presented and moderated a panel discussion on April 27, 2010 at the annual Broadband Properties Summit in Dallas, Texas. Ogle's session was titled "Sustaining Rural Broadband," which highlighted emerging models of rural broadband networks and applied traditional environmental sustainability principles to the discussion of sustaining rural network ecosystems.

JONATHAN OVERLY

In the media:
Executive Director of the East Tennessee Clean Fuels Coalition, ISSE's Jonathan Overly, was quoted in the June 21, 2010, issue of *Blount Today* in the article "Powered by propane" about propane lawnmowers.

JACK PARKER

Presentations:
Jack Parker made the following presentations at the Goldschmidt 2010: Earth Energy and Environment Conference held June 14- 18, 2010 in Knoxville: "Simulating reactive transport of cobalt-EDTA complexes through large intact sediment cores" (G. Tang, M. A. Mayes, J. C. Parker, and S. C. Brooks), "Quantifying nitrate migration and natural attenuation in a shale/saprolite pathway from a former waste disposal site" (D. B. Watson, G. Tang, J. C. Parker, and S. C. Brooks), and "Subsurface pH controls for the immobilization of uranium and technetium" (B. Gu, D. Watson, G. Tang, K. M. Kemner, W-M. Wu, C. Schadt, J. Kosta, J. Zhou. J. Parker, and S. Brooks).

Jack Parker made the following presentation at the GeoShanghai International Conference, Shanghai, held June 3-5, 2010: "Simulation of groundwater composition change due to deposition of uranium minerals in dolomite gravel fill" (F. Zhang, J. C. Parker, D. B. Watson, D. Phillips, and P. M. Jardine). *Geoenvironmental Engineering and Geotechnics* (GSP 204): Geotechnics, p. 181-187.

Jack Parker co-chaired a China-US topical workshop on "Sustainable Management of Soil and Water Resources" (convened by ISSE's China-US Joint Research Center as

a follow-up to its 2009 annual conference) held Jan. 6-7, 2010 in Shenyang, China. Parker also made a presentation on "Models, Uncertainty and Cost Optimization of Water Management Decisions."

Jack Parker gave the following presentations at the DoD Strategic Environmental Research and Development Program (SERDP) meeting in Washington, DC, on December 2-4: "Practical Cost-Optimization of Characterization and Remediation Decisions at DNAPL Sites with Consideration of Prediction Uncertainty" (Jack Parker, Peter Kitanidis, Michael Cardiff, Ungtae Kim, Xiaoyi Liu, Dave Becker, and Aleisa Bloom), and "Estimating DNAPL Source Depletion Time Model Formulation, Calibration, and Uncertainty" (Jack Parker, Ungtae Kim, Mark Widdowson, Peter Kitanidis, Frank Chapelle, Carmen Lebron, Xiaoyi Liu, and Michael Cardiff).

The following papers, co-authored by Jack Parker, were presented by Ungtae Kim at the US Department of Defense Strategic Environmental Research and Development Program (SERDP) Annual Meeting, Dec 1-3, 2009, Washington D.C: "DNAPL Source Strength vs. Time Model Formulation, Calibration and Uncertainty" (J. Parker, P. Kitanidis, U. Kim, X. Liu, M. Cardiff, and M. Widdowson) and "Cost Optimization of DNAPL Site Remediation with Consideration of Prediction Uncertainty" (J. Parker, P. Kitanidis, U. Kim, X. Liu, and M. Cardiff).

JEAN PERETZ

In the media:
Jean Peretz and Bruce Tonn were quoted in UT's *Daily Beacon* on April 20, 2010, in an article titled "Research suggests state energy inefficient."

BRUCE TSCHANTZ

Awards, appointments, and other honors:
Bruce Tschantz was named as a member of the on-going Governor's TDEC (Tennessee Department of Environment and Conservation) Advisory Board for reviewing the December 2008 TVA Kingston Steam Plant Ash Spill Accident.

Research Reports:
The Governor's Advisory Board's report to TDEC, "Lessons Learned from the TVA Kingston Dredge Cell Containment Facility Failure: TDEC Advisory Board Recommendations for Safe Performance" (L. Bentley, S. Jacoby, G. Pugh, S. Qualls, K. Shell, & B. Tschantz), dated November 24, 2009, was released by TDEC December 2009.

Presentations:
Bruce Tschantz gave a presentation on a peer-reviewed paper, "Wanted! More Dam Engineers" (S. McCubbin-Cain and Bruce A. Tschantz) at the American Society for Engineering Education's (ASEE) 2010 ASEE Annual Conference, Louisville, Kentucky, June 20-23, 2010.

BRUCE TONN

Awards, appointments, and other honors:
Bruce Tonn is Consulting Editor of the journal *Futures*.

Tonn is a member of the editorial board of the journal *Social Science Computing Review*.

Tonn is a member of the editorial board of the journal *Sustainability*.

In the media:
Jean Peretz and Bruce Tonn were quoted in UT's *Daily Beacon* on April 20, 2010 in an article titled "Research suggests state energy inefficient."

Presentations:
Bruce Tonn made the following presentation at the Affordable Comfort 2010 conference held in Austin, Texas, on April 21-23, 2010: "National WAP Evaluation: What You Need to Know" (B. Tonn, D. Carroll, and J. Berger).

CATHERINE WILT

Presentations:
Catherine Wilt served as an invited speaker at the Tennessee Green Business Summit, held at David Lipscomb University on April 14, 2010. She participated in a session titled "Green Credentials, Certifications, and Standards."

Catherine Wilt spoke at the Tennessee Solid and Hazardous Waste Conference held April 29, 2010. She discussed planning pharmaceutical waste collection projects in conjunction with K-12 schools.

In the media:
Catherine Wilt was quoted in a December 1, 2009, Knoxvillebiz.com article "Shopping online gets greener." The article also has a link to ISSE's TNSWEP (Tennessee Solid Waste Education Project) Web page, "Green Holiday Tips."

JIE (JOE) ZHUANG

Awards, appointments, and other honors:
Jie Zhuang was appointed as Adjunct Research Professor at the Institute of Applied Ecology, Chinese Academy of Sciences, Beijing, China.

Zhuang and Randall Gentry were appointed to the editorial board of *Journal of Resources and Ecology*, which is published seasonally by Science Press, China.

In the media:
The China-US Joint Research Center for Ecosystem and Environmental Change (JRCEEC) hosted a topical workshop (coordinated by Zhuang) on "Sustainable Management of Soil and Water Resources," held January 6-7, 2010 in Shenyang, China. A summary of the workshop appeared in the March 16, 2010 edition of *EOS, Transactions American Geophysical Union* 91(11): 103 (doi:10.1029/2010EO110004).

In his 2009 report, the UT Chancellor references JRCEEC.

Presentations:
Jie (Joe) Zhuang made a presentation titled "A Non-Steady State Simulation of Root Water Uptake" at the International Workshop on Water-Saving Modern Agriculture in an Oasis of Arid Region. The conference was held in Urumqi, Xinjiang Autonomous Region, China, on August 8-10, 2010.

Zhuang gave a presentation of the paper, Organic Matter Preservation due to Pore-Scale Interactions between Organic Matter and Water in Soil Microaggregates (J. Zhuang, J. McCarthy, and E. Perfect) at the Goldschmidt 2010 Conference "Earth,

Energy and the Environment" held June 13-18, 2010 in Knoxville.

Zhuang helped organize a China-US topical workshop on "Sustainable Management of Soil and Water Resources" (convened by ISSE's China-US Joint Research Center as a follow-up to its 2009 annual conference) held January 6-7, 2010, in Shenyang, China. Zhuang also made a presentation titled "Transport of Colloid-Associated Contaminants in Porous Media."

Zhuang made the following presentation: "Bioenergy in China: A grand challenge for economic and environmental sustainability" (J. Zhuang and G.R. Yu., 2009) in Proceedings of the International Seminar on Planetary Emergencies: Energy Permanent Monitoring Panel, 42nd Session, Erice, Italy, August 19-24, 2009.

PUBLICATIONS

THEODORE M. BESMANN

Theodore M. Besmann. 2010. Projections of US GHG reductions from nuclear power new capacity based on historic levels of investment. *Energy Policy* 38: 2431–2437 (doi: 10.1016/j.enpol.2009.12.036). [Note: ISSE provided the funding for this project.]

DAVID BRILL

Books:

Cumberland Odyssey: A Journey in Pictures and Words along Tennessee's Cumberland Trail and Plateau (Mountain Trail Press). With photographer Bill Campbell, the author explores the natural and cultural history of the Cumberland Trail and Plateau. August 2010.

Articles:

"Wild Game, Wild Times on Hooper Bald," *Smokies Life*. Article about the alien invader *Sus scofa*, the Russian wild boar, which escaped its confines in North Carolina and began to colonize Great Smoky Mountains National Park 60 years ago. Forthcoming.

"H.C. Wilburn, the Smokies' Premier Historian," *Smokies Life*. A study of the life and times of Hiram Wilburn, the Smokies' first historian and the individual most responsible for preserving many of the park's enduring artifacts. Forthcoming.

"A Reluctant 'Ultra' Tackles the Smokies' Mountains to Sea Trail," *Smokies Life*. Narrative account of the author's marathon (15-hour, 27-mile) trek of the Mountains to Sea Trail in the Smokies, much of it at night. Spring 2010.

"A Time of War; A Time of Peace," *Smokies Life*. Story on the conscientious objector (CO) camp situated near the current Sugarlands Visitor Center that housed more than 100 COs during World War II. Fall 2009.

"Nocturnal Missions," *Metro Pulse*. Essay on the joys of exploring the wilderness under the cover of darkness. October 8, 2009.

"Hiking the Smokies' AT," *Smokies Life*. Narrative account of the author's trek of the 72 miles of the Appalachian Trail through Great Smoky Mountains National Park. Spring 2009.

RANDALL W. GENTRY

Shesh R. Koirala, Randall W. Gentry, Patrick J. Mulholland, Edmund Perfect, John S. Schwartz. 2010. Time and frequency domain analyses of high-frequency hydrologic and chloride data in an east Tennessee watershed. *Journal of Hydrology* 387: 256-264.

Neal Stewart, Lee Shugart, Gong-she Liu, Jie Zhuang, Yong-qing Ma, Gerald A. Tuskan, Richard Meilan, Randall W. Gentry, and Gary S. Sayler. 2010. China-US workshop

on biotechnology of bioenergy plants. *Ecotoxicology* 19: 1-3 (doi:10.1007/s10646-009-0448-5).

UNGTAE KIM

Jack Parker, Ungtae Kim, P. K. Kitanidis, M. Cardiff, and X. Liu. 2010. Stochastic cost optimization of multi-strategy DNAPL site remediation. *Groundwater Monitoring & Remediation* (doi: 10.1111/j.1745-6592.2010.01287.x, online published in Jun 2010).

A. E. Al-Juaidi, J. J. Kaluarachchi, and U. Kim. 2010. Multi-criteria decision analysis of treated wastewater use for agriculture in water deficit regions. *Journal of American Water Resources Association* 46(2): 395-411 (doi: 10.1111/j.1752-1688.2009.00409.x, April).

M. Cardiff, X. Liu, P. K. Kitanidis, J. Parker, and U. Kim. 2010. Cost Optimization of DNAPL source and plume remediation under uncertainty using a semi-analytic model. *Journal of Contaminant Hydrology* 113(1-4): 25-43 (doi:10.1016/j.jconhyd.2009.11.004, April).

SHESH R. KOIRALA

Shesh R. Koirala, Randall W. Gentry, Patrick J. Mulholland, Edmund Perfect, John S. Schwartz. 2010. Time and frequency domain analyses of high-frequency hydrologic and chloride data in an east Tennessee watershed. *Journal of Hydrology* 387: 256-264.

LARRY D. MCKAY

Larry McKay. 2010. Concentrations of viruses and bacteria linked to human feces found in community water sources in East Tennessee. Published online at *Medical News Today and MediLexicon*.

Jie Zhuang, Nadine Goeppert, Ching Tu, John F McCarthy, Edmund Perfect, and Larry D. McKay. 2010. Colloid transport with wetting fronts: Interactive effects of solution surface tension and ionic strength. *Water Research* 44: 1270-1278 (doi:10.1016/j.watres.2009.12.012).

S. G. Driese, G. A. Ludvigson, J. A. Roberts, D. A. Fowle, L. A. González, J. J. Smith, V. M. Vulava, and L. D. McKay. 2010 (in press). Micromorphology and stable isotope geochemistry of historical pedogenic siderite formed in PAH-contaminated alluvial clay soils, Tennessee, USA. *Journal of Sedimentary Research*.

P. A. Knappett, A. Layton, L. D. McKay, D. Williams, B. Mailloux, Md. R. Huq, Md. J. Alam, K. Matin Ahmed, Y. Akita, M. Serre, G. Sayler, and A. van Geen, 2010. Effectiveness of ultrafiltration for sampling microorganisms in ground water. *Ground Water* (doi: 10.1111/j.1745-6584.2010.00712x).

T. Johnson, L. D. McKay, A. Layton, G. S. Fout, S. Jones, G. Johnson, J. Cashdollar, D. Dahling, L. Villegas, D. Williams, and G. Sayler. 2010. Viral and bacterial contamination in karst aquifers in eastern Tennessee, U.S.A. *Ground Water* (doi: 10.1111/j.1745-584.2010.00698.x).

JACK C. PARKER

Jack Parker, Ungtae Kim, P. K. Kitanidis, M. Cardiff, and X. Liu. 2010. Stochastic cost optimization of multi-strategy DNAPL site remediation. *Groundwater Monitoring & Remediation* (doi: 10.1111/j.1745-6592.2010.01287.x, online published in Jun 2010).

M. Cardiff, X. Liu, P. K. Kitanidis, J. Parker, and U. Kim. 2010. Cost Optimization of DNAPL source and plume remediation under uncertainty using a semi-analytic model. *Journal of Contaminant Hydrology* 113(1-4): 25-43 (doi:10.1016/j.jconhyd.2009.11.004, April).

F. Zhang, J. C. Parker, S. C. Brooks, D. B. Watson, P. M. Jardine, and B. Gu. 2010. Prediction of uranium and technetium sorption during titration of contaminated acidic groundwater. *Journal of Hazardous Materials* 178: 42-48.

F. Zhang, W.-M. Wu, J. C. Parker, T. Mehlhorn, S. D. Kelly, K. M. Kemner, G. Zhang, C. Schadt, S. C. Brooks, C. S. Criddle, D. B. Watson, P. M. Jardine. 2010 (in press). Kinetic analysis and modeling of oleate and ethanol stimulated uranium (VI) bio-reduction in contaminated sediments under sulfate reduction conditions. *Journal of Hazardous Materials.*

G. Tang, M. A. Mayes, J. C. Parker, and P. M. Jardine. 2010. CXTFIT/Excel–A modular adaptable approach for parameter estimation and uncertainty/sensitivity analysis. *Computers and Geosciences* (doi: 10.1016/j.cageo.2010.01.013).

F. Zhang and J. C. Parker. 2009. An efficient modeling approach to simulate heat and mass transfer between fracture and matrix regions for oil shale retorting. *Transport in Porous Media* (doi: 10.1007/s11242-009-9495) (published online November 13).

JEAN PERETZ

B. Tonn and J. Peretz. 2009/2010. Demographic and economic trends. *World Future Review* 1(5): 5-22.

GARY S. SAYLER

Neal Stewart, Lee Shugart, Gong-she Liu, Jie Zhuang, Yong-qing Ma, Gerald A. Tuskan, Richard Meilan, Randall W. Gentry, and Gary S. Sayler. 2010. China-US workshop on biotechnology of bioenergy plants. *Ecotoxicology* 19: 1-3 (doi:10.1007/s10646-009-0448-5).

BRUCE TONN

B. Tonn and J. Peretz. 2009/2010. Demographic and economic trends. *World Future Review* 1(6): 5-22.

B. Tonn and J. Berger. 2010. Evaluating DOE's Weatherization Assistance Program. *Home Energy*, July/August: 22-26.

B. Tonn. 2010. Book review: *Energy for the Future: A New Agenda* (eds. Ivan Scrase and Gordon MacKerron, Palgrave Macmillan: New York, 2009) in *Futures* 42: 504-508.

B. Tonn. 2010. Intervention in countries with unsustainable energy policies: Is it ever justifiable? *Futures* (doi:10.1016/j.futures.2010.02.001).

B. Tonn. 2010. What's in a name: Reflections on Ziauddin Sardar's "The Namesake." *Futures* 42(3): 195-198.

B. Tonn, 2009. Preventing the next mass extinction: Ethical obligations. *Journal of Cosmology* 2: 334-343.

B. Tonn and D. MacGregor. 2009. Are we doomed? *Futures* 41(10): 673-675.

B. Tonn and J. Tonn. 2009. A literary human extinction scenario. *Futures* 41(10): 760-765.

B. Tonn and D. MacGregor. 2009. A singular chain of events. *Futures* 41(10): 706-714.

B. Tonn. 2009. Beliefs about human extinction. *Futures* 41(10): 766-773.

B. Tonn. 2009. Book review: *Year Million: Science at the Far Edge of Knowledge* (Ed. Damien Broderick, New York: Atlas & Co, 2008) in *Futures* 41(9): 663-664.

CHRISTIAN A. VOSSLER

Jordan F. Suter, Kathleen Segerson, Christian A. Vossler, and Gregory L. Poe. 2010. Voluntary-threat approaches to reduce ambient water pollution. *American Journal of Agricultural Economics* (June 10).

Paul J. Ferraro and Christian A. Vossler. 2010. The source and significance of confusion in public goods experiments. *BE Journal of Economic Analysis & Policy* 10(1): article 53.

Kent D. Messer, Gregory L. Poe, Daniel Rondeau, William D. Schulze, and Christian A. Vossler. 2010. Social preferences and voting: An exploration using a new preference revealing mechanism. *Journal of Public Economics* 94(3-4): 308-317.

JIE ZHUANG

Gui-Rui Yu, Zemei Zheng, Qiufeng Wang, Yuling Fu, Jie Zhuang, Xiaomin Sun, and Yuesi Wang. 2010. Spatiotemporal pattern of soil respiration of terrestrial ecosystems in China: The development of a geostatistical model and its simulation. *Environmental Science Technology* 44(16): 6074–6080 (doi: 10.1021/es100979s)

Tailong Guo, Quanjiu Wang, Dingqiang Li, and Jie Zhuang. 2010. Effect of surface stone cover on sediment and solute transport on the slope of fallow land in the semi-arid Loess Region of Northwestern China. *Journal of Soils and Sediments* 10: 1200-1208 (doi: 10.1007/s11368-010-0257-8).

Neal Stewart, Lee Shugart, Gong-she Liu, Jie Zhuang, Yong-qing Ma, Gerald A. Tuskan, Richard Meilan, Randall W. Gentry, and Gary S. Sayler. 2010. China-US workshop on biotechnology of bioenergy plants. *Ecotoxicology* 19: 1-3 (doi:10.1007/s10646-009-0448-5).

Jie Zhuang, Nadine Goeppert, Ching Tu, John F McCarthy, Edmund Perfect, and Larry D. McKay. 2010. Colloid transport with wetting fronts: Interactive effects of solution surface tension and ionic strength. *Water Research* 44: 1270-1278 (doi:10.1016/j.watres.2009.12.012).

Jie Zhuang, John S. Tyner, and Edmund Perfect. 2009. Colloid transport and remobilization in unsaturated porous media during transient flow. *Journal of Hydrology* 377:112-119 (doi:10.1016/j.jhydrol.2009.08.011).

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