tx H2O

A Publication of the Texas Water Resources Institute

Spring 2018

GLOBAL IMPACTS OF TEXAS WATER RESEARCH

Inside: Former, current Texas scientists and students push water research internationally

Texas A&M AgriLife Research | Texas A&M AgriLife Extension Service | Texas A&M University College of Agriculture and Life Sciences

Working to make every drop count

The Texas Water Resources Institute (TWRI) is one of 54 academic centers and institutes that make up the U.S. Geological Survey (USGS) Water Resources Research Institute (WRRI) Program, with each state and territory within the United States designating an institution to participate in this program. The mission for the WRRI Program is succinctly stated on its website as:

Plans, facilitates, and conducts research that helps resolve State and regional water problems; promotes technology transfer; promotes the dissemination and application of research; trains scientists through participation in research; and awards competitive grants under the Water Resources Research Act.

Our previous issues of *txH2O* have highlighted our research and extension programs for a wide range of water resource challenges, from aiding agricultural and municipal water conservation to addressing water security, and the impact that these programs have had on improving the condition of water resources throughout Texas and the United States.

However, one of the most enduring impacts of the WRRI Program's mission is the training of scientists, who will ultimately serve as the future workforce and leaders in the water resource professions. The lead article in this issue of *txH2O* focuses on the role that TWRI has played in helping to develop future water resource leaders with support provided through the WRRI Program to students pursuing their degrees in water resource graduate programs at Texas universities. The impact that these students are having throughout Texas, across the United States and even globally is truly impressive. I hope you enjoy catching up with some of our former students and learning how they have used their education and training to advance the water resource professions and to improve the safety and reliability of our water resources in many different ways.

Along with the USGS article, this issue highlights other university water programs that focus on the global impacts of Texas water research. Stories include Texas A&M researchers studying evapotranspiration processes in the tropical forests of Costa Rica, Texas Tech University's research on wastewater technology for use in space and the international work on environmental modeling at the Texas A&M AgriLife Research and Extension Center at Temple.

As always, please join us in "making every drop count."

John C. Tracy, Ph.D.
Director

tx | H_2O

Published by
Texas Water Resources Institute

Editor
Kathy Wythe
Texas Water Resources Institute

Art Direction
Audrey Guidry
Texas A&M AgriLife Communications

Assistant Editors
Danielle Kalisek
Sarah Richardson
Texas Water Resources Institute

Student Writer
Claire Corley
Texas Water Resources Institute

On the cover:
Current and former Texas university researchers and students are conducting water resources research throughout the world.

For more information and to subscribe to *txH2O*, visit our website at
twri.tamu.edu/txH2O

TEXAS A&M UNIVERSITY

TEXAS A&M AGRILIFE RESEARCH | EXTENSION

Texas Water Resources Institute
make every drop count

Volume 12, number 2, Spring 2018

Farmers in South Korea traditionally flood their rice paddies as a means of irrigation. Photo courtesy of Korea's Rural Development Administration National Institute of Agricultural Sciences.

txH$_2$O *is published two times a year by the Texas Water Resources Institute (TWRI), which is part of Texas A&M AgriLife Research, the Texas A&M AgriLife Extension Service and the Texas A&M University College of Agriculture and Life Sciences. TWRI is funded in part by the U.S. Geological Survey and authorized by the Water Resources Research Act. To subscribe to txH$_2$O or Conservation Matters, TWRI's monthly email newsletter, visit* twri.tamu.edu.

Story by Claire Corley

Where in the WORLD Are They Now?

From USGS and Mills scholarship recipients to leaders in the water industry

Texas water research is more than focusing on the here and now; it is about fostering the next generation and giving them resources to become leaders in the water industry.

Each year, the Texas Water Resources Institute (TWRI) helps graduate students by funding research through two programs, the U.S. Geological Survey (USGS) Graduate Student Research Program and the Mills Scholars Program.

Both programs allow students studying hydrology, water management or any other water-related field at Texas universities to receive extra help to finish their graduate degree. The USGS Graduate Student Research Program is supported by funding through the Water Resources Research Act of 1984, which provides federal funding to support water resources research, education and outreach activities of importance for the state, region and nation.

TWRI is one of 54 institutes in the National Institutes for Water Resources supported by USGS. Because TWRI is Texas' water institute, the USGS grants are available to students at any university in Texas, not just Texas A&M University.

"Nationally, when we get together as directors and organizations, one of our talking points is how this program has created the next generation of water leaders in this country and beyond," said Dr. John C. Tracy, TWRI director.

Tracy said the USGS grant program is important to each state across the nation and is a unique program, giving states flexibility to address the most important water resource issues in their area.

"The real brilliance of the program, and I think one of the reasons it still exists, is that it recognized that water resources issues tend to be specific to regions and locations," Tracy said.

TWRI also funds students through the Mills Scholars Program. This program is a permanently endowed fund at Texas A&M that was established in 1967 by Mills Cox, former chairman of the Texas Water Development Board.

The endowment is in memory of his great-grandfather, W. G. Mills. Mills helped prepare the site for Gathright Hall, the original student dormitory and dining hall on the Texas A&M campus, in 1875.

The Mills program awards students scholarships to complete their studies in water-related fields. Unlike the USGS grants, students are only eligible if studying at Texas A&M, Texas A&M at Galveston or Texas A&M at Qatar.

TWRI has awarded many scholarships and grants since both programs were established. The current programs began in 2001 by then Director Dr. Allan Jones and Associate Director Dr. Bill Harris. Since 2001, TWRI has awarded 126 USGS grants totaling $677,979 and 188 Mills scholarships totaling $353,770.

Some scholarship recipients have continued to study water research in Texas, some have left Texas for other locations across the United States, and others have taken their research internationally. Here are highlights from a few of these past recipients.

Karen McNeal: Geoscientist and Geoscience Education Researcher

Dr. Karen McNeal received the Mills scholarship in 2004-2005 while studying geology for her doctorate at Texas A&M.

McNeal said the scholarship allowed her to travel to Laguna Atascosa National Wildlife Refuge in South Texas to complete her studies looking at the soil and water content and how that varies in different soil types.

After completing her doctorate, McNeal became an assistant professor in biogeochemistry at Mississippi State University's Department of Geosciences. She conducted research on soil and sediment profiles along the Gulf Coast where she investigated the impacts of coastal hypoxia, sulfide and mercury, and wetlands after the Deepwater Horizon oil spill.

McNeal said she became successful with getting a variety of geoscience education projects funded while at Mississippi State and that ultimately took her to her next position.

"It led me to North Carolina State University, where I decided to go 100 percent in the disciplinary geoscience education research," McNeal said.

She took a position in global change education in the Department of Marine Earth and Atmospheric Sciences at North Carolina State.

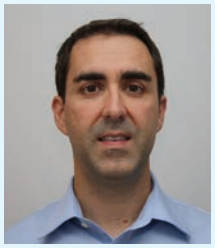
McNeal has since moved to Auburn University where she leads a discipline education-based research initiative in the College of Sciences and Mathematics.

"We are hiring disciplinary experts in all of the STEM departments within the College of Sciences," McNeal said. "This is a really exciting time for me to be part of creating a working group of faculty that have groups like myself within a disciplinary home department such as chemistry, biology, physics and geosciences."

She said the work she does now is researching how people think, learn and understand the earth as a system and the various phenomena such as global climate change and other environmental impacts.

"My research includes how to best communicate the science and teach effectively in the undergraduate classroom as well as outside the classroom," McNeal said.

She currently teaches a climate change and society course and climate literacy communications course at Auburn.



Richard Hoffpauir: Water Resources Engineer

Dr. Richard Hoffpauir received both the USGS grant and the Mills scholarship in 2001-2002 while pursuing his doctorate in water resources engineering in the Zachry Department of Civil Engineering at Texas A&M.

His dissertation focused on development of new features of the Water Rights Analysis Package or WRAP. Hoffpauir said while completing his degree, he started to pick up consulting work to do water rights modeling around the state.

"From there I slowly built up a consulting business, and now I am a full-time consultant," Hoffpauir said, who still uses the WRAP model at his business, Hoffpauir Consulting, PLLC.

He said his primary and longest client is the city of Austin.

"I do work directly for the city's water utility and legal departments. I help them with their existing water rights permits, permit amendments and water planning," Hoffpauir said.

He said he also provides analyses and decision-making support based on the results obtained from the water modeling system.

Hoffpauir said it is nice that the research he was able to complete with help from the scholarships turned into a career and the foundation of his business.

Andrew Karvonen: International Professor

Dr. Andrew Karvonen received his doctorate in community and regional planning from the University of Texas at Austin (UT). He received the USGS grant in 2006-2007 while completing his doctorate.

Karvonen said his interest while at UT was focused on stormwater management, specifically in urban areas. Building upon this topic, he conducted a comparative study of Seattle and Austin and the politics of urban runoff.

After completing his doctorate, Karvonen moved to the United Kingdom in 2009 and started a post-doctorate in architecture at the University of Manchester.

"I was still working on water issues but also did work on energy issues and housing," Karvonen said. "I continue to have an interest in natural resources in cities and how nature, technology and society interact in cities." ⇨

After working at the University of Manchester for seven and a half years, he moved to Stockholm, Sweden where he is now an assistant professor at the KTH Royal Institute of Technology.

Karvonen said his work focuses on sustainable urban development and smart cities. He said smart cities explore the idea that information and communication technologies are applied to urban infrastructure networks to make a city function more efficiently and effectively. Similar to the technologies on smart phones, they are applied on a much wider scale to optimize urban systems.

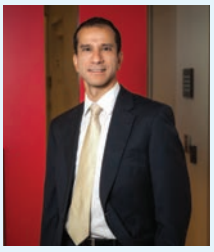
"We have Facebook on our phones and all kinds of speakers and crazy things in our houses that control our lights and even tea kettles," Karvonen said. "Now there is a push to do the same thing for cities."

He said one of the most interesting things about his work as a professor is that universities are being challenged to explain how teaching and research benefit society.

"There is an idea that we need to demonstrate that university research is worthwhile, and I have made specific efforts to engage with nonacademic partners in both teaching and research," Karvonen said.

He said having these research projects for his students outside the classroom encourages engagement and makes the research more real.

Karvonen said he appreciates the scholarship he received from TWRI because it helped him complete his doctorate degree and set him on a rewarding academic career trajectory. The same idea that the USGS grant increases engagement from all aspects of government and public sectors can be seen in the research Karvonen is doing today.



Andres Salazar: Director of Water Resources

After moving from his home in Colombia, Dr. Andres Salazar came to Texas A&M to pursue his doctorate in civil engineering with an interest in water resources.

Salazar was a USGS grant recipient in 2001-2002, and he said the funding could not have been more helpful to him.

"Coming from another country with limited resources, you need help to get to the finish line," Salazar said. "Without the funding and support, I would not have been able to complete my studies."

He said the funds he received from the grant helped him decide on the topic of his dissertation and provided the financial support to continue his education in water resources.

His dissertation was on water and reservoir management focusing on drought conditions. With the experience he gained through his doctorate, he started doing consulting work for a water supply and planning firm.

In 2007, he had the opportunity to be an adjunct professor at the University of Texas at Arlington (UTA). Salazar taught at the undergraduate and graduate level in water resources engineering.

He said that because of his experience working in the industry and as a consultant, he had insight into teaching how the courses applied to real-life examples.

Even though he was only able to teach at UTA for two years, Salazar said he enjoyed the experience.

"It was a very fulfilling opportunity to get to teach; I like teaching younger professionals in my field," he said.

Salazar started working at Walter P Moore, an engineering company in Houston, Texas, in 2009. His work focuses on hydrology and hydrology studies for essential flood rates and flood risk management, which, being in the Houston area, is very important, he said.

In his position as the managing director for water resources, he provides guidance on sustainability for site development, hydrology studies and water supply studies.

Audra Morse: Engineer and Dedicated Professor

Dr. Audra Morse received a USGS grant in 2002-2003 while pursuing her doctorate in civil engineering at Texas Tech University.

Morse said the grant funded a project connected to water recycling in space. Her research interests have stayed the same since the project and include water treatment, wastewater treatment and wastewater reuse.

After graduating from Texas Tech, Morse remained there and moved through the ranks from assistant professor to associate to full for the Department of Civil and Environmental Engineering.

She also spent four years as associate dean for undergraduate studies for the Whitacre College of Engineering, where she was responsible for anything related to undergraduate students and programs.

She said she spent part of her time exploring ways to recruit students into engineering programs and specifically focused on underrepresented minority students.

"I worked to create programs and activities that would help underrepresented students succeed but also approached it from an outreach perspective," Morse said. "How do we get them interested and help them think that engineering may be an interesting place for them?"

She is currently a professor and department chair for the Department of Civil and Environmental Engineering at Michigan Technological University.

Morse said her job is partly to manage the department and to look at where the department is going. She has been examining opportunities to grow the department's graduate programs and increase the Michigan Tech reach.

"We at Michigan Tech need to think about our influence and who we reach out to and recruit here," Morse said.

While her research lab has not started up yet, she said she looks forward to working with other researchers at Michigan Tech and researching membrane filtration and the fate of microplastics.

Vivekanand Honnungar: Engineering Consultant in Water Sector

Dr. Vivekanand Honnungar completed his undergraduate studies in environmental engineering at the University of Mysore in India, and his integrated master's and doctorate in environmental engineering from Texas A&M University-Kingsville (TAMUK).

While pursuing his doctorate, Honnungar received a 2004-2005 USGS grant.

"For someone like me, who was in the beginning of his Ph.D. program, winning the TWRI grant added a good amount of confidence," Honnungar said.

He said the grant also gave him the opportunity to learn how to manage a research grant and multiple projects, while being a student.

Honnungar said his time at TAMUK exposed him to many different areas of water research. His doctoral research involved assessing groundwater vulnerability for 18 counties in South Texas.

After completing his doctorate, Honnungar stayed at TAMUK for one year, continuing to work on research projects ranging from groundwater modeling to agricultural runoff studies and assisting graduate students with their theses.

Honnungar moved back to India after completing his post-doctorate research. He said he has been fortunate enough to work on diverse projects in the field of water since then, such as climate change impacts on the availability of water in river basins, hydrological modeling of river basins and climate change impacts on sanitation and hygiene.

He is currently an engineering consultant in the water sector at CH2M HILL, a global engineering company, working to find solutions for urban water issues.

"All these years, I was very fortunate to collaborate with researchers from various institutes from different countries such as Norway, Australia, United States and India," Honnungar said. "My training at TAMUK has helped me to work on diverse water issues ranging from rural and urban drinking water to hydrological modeling to climate change. It's been a pleasant journey in water, so far!"

Prior to 2001, TWRI awarded the Mills and USGS funds to professors who then dispersed the money to students studying water research under them.

Dr. Marsh Lavenue, president and CEO of INTERA, a geosciences and engineering consulting firm located in Austin, Texas, received funding through the Mills program in 1984. Lavenue has been with INTERA since 1985 and has been president and CEO since 2008.

"Getting the TWRI Mills scholarship was absolutely fantastic and gave me the extra help needed to finish the semester," Lavenue said.

Dr. James Dobrowolski, national program leader for U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA), received funding through the Mills program while studying for his doctorate at Texas A&M.

Dobrowolski said he started at Texas A&M with plans to pursue a doctorate degree in ecophysiology, but plans changed after meeting the watershed professor, Dr. Wil Blackburn.

"He grabbed me and told me he had just the project for me," Dobrowolski said. "I ended up completing my degree under his tutelage and it changed my life."

After completing his doctorate in watershed science and management, Dobrowolski taught at Utah State University and Washington State University, teaching courses on hydrology, watershed management, rangeland management and much more.

His current position as national program leader for USDA-NIFA involves distributing funds through competitive and noncompetitive proposal review processes and managing a portfolio of research, education and outreach that exceeds $60 million dollars.

The area around Texas A&M's Soltis Center for Research and Education in Costa Rica averages about 165 inches a year, making it an ideal place to study tropical forest evapotranspiration. Photo courtesy of Dr. Georgianne Moore.

Story by Kathy Wythe

Compiling a Puzzle

Researchers study water cycle in the tropics to help refine climate model

Global climate models could be compared to giant jigsaw puzzles. It takes hundreds of pieces — or components — to make up the whole puzzle or global model.

A group of Texas A&M University scientists has just completed refining one small piece of the puzzle for a particular model, the Community Land Model (CLM), which feeds into a model of the global climate, the Community Earth System Model (CESM).

Through three years of research funded by the U.S. Department of Energy, Drs. Gretchen Miller and Tony Cahill, associate professors in Texas A&M's Zachry Department of Civil Engineering, and Dr. Georgianne Moore, associate professor in Texas A&M's Department of Ecosystem Science and Management, and their graduate students studied evapotranspiration processes in the tropical forests near Texas A&M's Soltis Center for Research and Education in Costa Rica.

Particularly, Moore said, they wanted to improve the modeling of fluxes or flow of water vapor and carbon dioxide to and from tropical forests with a particular focus on transitions between wet and dry canopy conditions.

Having a better understanding of the climate processes in the tropics is important, Miller said, because weather and other large-scale global processes in the models are heavily influenced by what goes on in the tropics.

"The Department of Energy knew there was a disconnect in the models in what was happening on the land in the tropics and what was happening in the atmosphere," Miller said. "For our project, we were looking at one of the disconnects: evapotranspiration."

Understanding the disconnect

Moore said the inadequate representation of evapotranspiration may partly explain why global climate models do not match observed precipitation patterns.

"The questions we had centered on how we could better inform the processes within these models," Miller said. "For example, rainfall patterns in the tropics can really influence how wet the forest stays."

The area around the Soltis Center receives a lot of rain, averaging 4,200 millimeters, or 165 inches, a year, about four times more than College Station averages.

"We wanted to know how the water cycle changed because of all that rain," Miller said, specifically how much water was flowing to the atmosphere through plant transpiration versus falling to the ground and then evaporating into the atmosphere.

Miller said one of the reasons they were interested in evapotranspiration is to better understand carbon uptake within the tropics.

"We think of these tropical forests as huge stores of carbon," she said. "But we weren't sure what trees were doing when they had all this water on their leaves," she said, whether the leaves were able to take up the carbon at normal rates or if they were suppressed when wet.

(Bottom left) Dr. Georgianne Moore and Gavin Miller, a former graduate student, examine leaves on one of numerous plants in the tropical forest near Texas A&M's Soltis Center for Research and Education in Costa Rica. Photo courtesy of the Texas A&M Costa Rica REU program.

(Top right) A group of Texas A&M University scientists and their graduate students studied evapotranspiration in the tropical forest of Costa Rica. Photo courtesy of Texas A&M Costa Rica REU program.

"We looked more closely at these processes inside the forest so we can better resolve them to feed into the bigger picture."

Measuring water, carbon and more

Over the course of the project, the researchers collected a whole suite of measurements to determine the different ways water moved throughout the canopy.

For example, Moore and her graduate students monitored how fast water was moving through the trees using sap flow sensors, made from scratch in Moore's laboratory. She said the sensors were inserted into the xylem of the tree trunks where water flows from the roots to the canopy.

"The sensors can detect changes in the velocity of water inside the trees, which is then used to calculate transpiration for individual trees based on the cross-section of wood that carries water," Moore said. "We have a total of 64 sensors running in trees of all sizes throughout the forest, which allows us to estimate the total amount of transpiration every 30 minutes of every day for the entire forest stand."

Another experiment looked at the fluxes of carbon and water vapor into and out of the forest. Using a technique called eddy covariance, researchers can measure how much carbon enters the forest from the atmosphere and, conversely, how much water is released to the atmosphere from the forest.

"Some researchers refer to this as the 'breathing' of the biosphere," Miller said, "and tracking these fluxes is important for understanding both forest health and changes in the forest over time."

One of Moore's doctorate students looked at different leaves in the tropical forest to determine how quickly they were moving water off their surfaces and how this affected carbon uptake. Moore said water droplets on the leaf surface block the uptake of carbon dioxide for photosynthesis, and in the tropics, leaves in some parts of the canopy remain wet more than 50 percent of the time.

"Not only did we want to try to document a decline in photosynthesis in wet leaves, which is really difficult to measure with the instruments currently available, but we also wanted to learn about how some species are better adapted to shed water than others," she said.

They found that some leaves had particular adaptations to channel water quickly off their surfaces while others would hold water longer on their surfaces.

"It turns out that there is an amazing amount of diversity in leaf adaptations, from a shaggy carpet of trichomes that soak up water like a sponge, to thick plastic-like waxy layers with channels that divert away water immediately," Moore said.

To understand variations throughout the canopy, the researchers established a profile system that measured humidity, carbon concentration, temperature, light and leaf wetness up and down the height of the canopy to show how those components changed over time and how the different environments within the canopy affected the plants' behavior.

For instance, Miller said, in the lower canopy the combination of the low light, wetness of the leaves and the humidity alters how the smaller trees behave and how long it takes those trees to dry out after rain versus the larger, taller trees higher in the canopy with more sunlight.

The researchers found that the wet and dry processes are actually occurring faster than the Earth system models are currently running.

The timing of the rainfall, or when the leaves are wet, is extremely important for distinguishing between transpiration and evaporation processes, Miller said, because the movement of water was suppressed when the trees had wet leaves. However, the lower portion of the canopy could be very wet while the upper portions had dried, making for large contrasts in their behavior.

Compiling the pieces

Miller said they are now working on putting some of the concepts they developed into the CLM, the land surface model. One of Miller's graduate students is currently developing equations to better reflect the timings of precipitation and how the model partitions what is wet and what is dry.

She said the CLM, which shows what the plants are doing, and the community atmosphere model or CAM "talk" to each other.

"If the atmosphere model is saying that it is raining at some low rate all the time in the forests — which is not true — then that is going to be giving incorrect information to the land model," she said. "But if we have not been getting the wetness right, not getting when it rains, then that essentially means we get lots of other things wrong. We get temperature of the trees in the canopy wrong, then we get their carbon uptake and water use wrong. There is a whole cascade of things if we don't get the precipitation right in the model."

Miller said the Department of Energy is developing a new iteration of the Earth system model, and the Texas A&M group is hoping to contribute its findings to improve estimates of evapotranspiration and rainfall in the tropics.

"We have one small part in helping to get these overall models right," Miller said. "Our project might just be one small part, but the small parts add up."

Story by Kathy Wythe

Water Scientist by Profession, **Humorist** by Choice

Robert Mace combines knowledge with humor to engage audiences

To hear Dr. Robert Mace speak at a water conference is to hear a very knowledgeable water expert mixing in a little humor on the side.

Determined to retain the interest of the audience, many times Mace titles his presentations with humorous names, such as "Gone With the Wind: The History of Pumping Water With Windmills" and "Mace's Believe It or Not: Bizarre Texas Groundwater facts!" and inserts humorous quips in the talks.

Even though the new chief water policy officer and associate director for the Meadows Center for Water and the Environment calls himself an "available goofball," he is an accomplished and respected water scientist serious about the future of Texas water.

A new venture

Joining the Meadows Center in December 2017 after an 18-year career with the Texas Water Development Board (TWDB), Mace is responsible for integrating science into the development and assessment of policy.

The Meadows Center, part of Texas State University, focuses on developing and promoting programs and techniques dedicated to ensuring sustainable water resources for human needs, ecosystem health and economic development, according to its website.

"This position seemed rather perfect for me because I had worked at a state agency with a lot of interaction with the Texas Legislature, which gave me a front-row seat on seeing how to effectively employ science in the policy world," he said.

Dr. Robert Mace became chief water policy officer and associate director for the Meadows Center for Water and the Environment in December 2017. Photo by Claudia Campos, Meadows Center for Water and the Environment.

Dr. Robert Mace tweets about Texas water issues and blogs about artesian wells, groundwater and architecture. Photo by David Migues, freelance photographer.

His background at the board also gave him experience in a wide range of water issues.

"In my career at the board, I touched on nearly everything related to water — water conservation, groundwater modeling, groundwater management issues, environmental flows, desalination, floods, what causes drought — all those things are intertwined when you talk about water in the policy world," he said.

At the Meadows Center, Mace said his goal is to use his experience to help other scientists be more effective in getting their science heard by policymakers and by the public.

"Often scientists have their hearts in the right place to bring science to the real world and to the policymakers and decision-makers," he said, "but they are talking way over the heads of the people they are trying to communicate to, which means they are not communicating."

He said although he will not be writing or advocating water policy, he hopes to provide analysis of policies and how they intersect with science.

For example, depending on how a certain policy is put in place, Mace said it could have unintended consequences that policymakers might not be aware of.

"Policymakers need to know the potential impacts of these decisions," he said.

With a joint appointment as a professor of practice in Texas State's Department of Geography, Mace said he hopes to extend this understanding of the interconnection of science and policy to students.

"I want to be able to help prepare students for working as scientists not only in the working world but also in the policy world, by giving them a practical understanding of how the policy world works," he said.

Rocks + math = water

Growing up in rural northwestern Illinois near the Mississippi River, Mace had many, varied interests, especially in rocks. This interest, combined with his innate ability in mathematics, led him to New Mexico Institute of Mining and Technology where he received a bachelor's degree in geophysics, a "good fusion of mathematics and rocks."

He stayed at New Mexico Tech to earn a master's degree in hydrology. From there, he came to Texas and worked nine years at the University of Texas' Bureau of Economic Geology, earning his doctorate in hydrogeology from the University of Texas during this time.

While working at the bureau, Mace led a project studying the natural attenuation of spills from gasoline stations.

"People started noticing that contaminant plumes would decrease in size with no human interaction," Mace said. "Naturally occurring bacteria were cleaning up the sites.

"Working on that project was satisfying and a lot of fun. I was bit by the bug," he said, referring to a project that had policy implications.

Working at the state's water agency

Throughout his 18 years at TWDB, Mace held several positions, starting out as unit leader for the groundwater availability modeling unit and ending as deputy executive administrator.

As deputy executive administrator, he led the board's water science and conservation programs, including municipal and agricultural water conservation, environmental flows and groundwater programs. He also oversaw the innovative water technologies program, which included activities related to desalination, aquifer storage and recovery, rainwater harvesting and water use, and flood mitigation planning. He testified frequently at Texas Legislative hearings and spoke to reporters about agency programs.

Mace considers his biggest accomplishment while at TWDB was the task that he joined the water agency to work on: the groundwater availability modeling program.

Inspired by stakeholder involvement in the regional water planning process, the board wanted to have stakeholder input in the development of the state's first groundwater availability model, a model of the Trinity Aquifer in the Hill Country. Mace directed the team that developed the groundwater model and became the main communicator of the project's science.

From there, he went on to lead the statewide program for developing groundwater availability models for major aquifers in the state.

Mace said developing the models was important in the groundwater management process for the state, describing the models as "aquifers in a computer."

With the models, planners can establish desired future conditions by simulating how the aquifer responds to pumping and changes in recharge, and access how much groundwater is available for use.

"We wouldn't have desired future conditions if we didn't have those models," he said.

While his first task at the agency was his biggest accomplishment, his last one presented his biggest challenge. Mace said after the 2015 Wimberley floods and Halloween floods in Austin and elsewhere in the state, the Governor's office gave the water agency about $6.8 million to advance early warning detection systems to arm Texans with the ability to make informed decisions during floods. The board also moved the state coordinator's office for the National Flood Insurance Program under Mace.

"So the challenge was suddenly getting this new program, this new issue, with a great deal of attention by the Governor's Office and legislative leadership of the Texas Capitol as well as a lot of attention by the press," he said. "We had very ambitious deadlines with a lot of moving parts and lots of things to learn. That was a big challenge but very rewarding because the agency's staff rose to the occasion, met expectations and made the state safer."

Entire new programs, such as the TexMesonet, a statewide network of weather stations to support flood monitoring and flood forecasting efforts, were developed, and new streamflow gages were installed.

Mace and his team also began working on the first state flood plan, although it is still in development.

Communicating science and policy

It's from his early work at the bureau and then at TWDB on the groundwater availability modeling program that his understanding of the power of communications and working with stakeholders began and was carried through his various positions at TWDB and is now an integral part of his Meadows Center position.

From his initial TWDB job, Mace said he learned to work well with stakeholders and to communicate science to nonscientists so that they not only understood the science but also became advocates of the science and the tools that science produces.

"Scientists can feel like they have all the answers and know exactly what needs to be done," he said. "When working with stakeholders, you learn that maybe you don't have all the answers or maybe you are focusing on the wrong problem."

Recognized as an excellent communicator, Mace travels throughout the state and the United States, presenting on topics ranging from groundwater management to drought to the history of windmills. He has authored or coauthored more than 200 reports, papers and abstracts, and given more than 200 speeches on water.

He has received numerous awards, including being inducted into the Texas Water Innovation Hall of Fame by AccelerateH2O in Austin. He is a founding member of the *Texas Water Journal*, an online, peer-reviewed journal about water in Texas. Recently, Mace was instrumental in launching a new newsletter, *Texas+Water*, published jointly by the *Texas Water Journal*, The Meadows Center for Water and the Environment and the Texas Water Resources Institute. ⇨

"*The Texas Water Journal* has been great in providing a peer-reviewed outlet for policy and science papers specific to Texas," Mace said, "And *Texas+Water* is going to help us to communicate science and policy to the public. The Texas Water Resources Institute has been a critical partner in both of those efforts."

Texas at the forefront of water research

In his long career in Texas water, Mace has observed not only some overwhelming challenges to meeting Texas' future water needs, but he also has seen how the state has met some of the challenges with groundbreaking innovations.

The chief challenge for Texas water, Mace said, is implementing the state water plan, a plan that is developed every five years, based on 16 regional water plans, and addresses the needs of all water user groups in the state during a repeat of the drought of record that the state suffered in the 1950s.

"With every plan that comes out, we are falling further behind in being able to meet those needs during a repeat of the drought of record," he said. "And the state water plan doesn't solve all the problems because we could have worse droughts than the drought of record. But if communities plan for drought, we are sitting in better place than if we don't have those plans."

Mace said the communities that struggle the most with developing drought plans are the rural communities. Rural Texas needs financial help in the form of grants so they can do what they need to do to get ready for these droughts of record.

To help urban communities, Mace suggested that tools need to be developed to help local policymakers better communicate the value of being ready for these droughts.

But, it is also because of these issues Texas has faced that the state has led the world in solutions, Mace said.

For example, he said, the engineered wetlands around Dallas, such as the North Texas Municipal Water District's East Fork Wetland Project, are the first of their kind in the United States, and Texas has the second and third direct potable reuse water treatment plants — Colorado River Municipal Water District's Big Spring plant and the city of Wichita Falls temporary plant — in the world.

El Paso Water Utility is collaborating with a private company, Enviro Water Minerals, to harvest minerals out of desalination brine, which, Mace said, puts more freshwater into El Paso's water distribution system and decreases — if not eliminates — the amount of water the utility has to inject into its disposal wells.

"Texas has gotten a lot of worldwide attention because of those efforts," Mace said.

Mixing things up

As he did growing up, Mace still has many interests, ranging from collecting artesian wells postcards to researching the history of windmills and the history of modern architecture. He is particularly interested in R. M. Schindler, an Austrian-American architect who sparked Modernism in the United States, according to Mace.

He has combined his ability to communicate and his wide-ranging interests to develop blogs about Schindler (thermschindlerlist.blogspot.com), Austin architecture (austincubed.blogspot.com) and artesian wells (youhavewatermail.blogspot.com). Since leaving the board, he's also started a blog on Texas groundwater (sosecretoccultandconcealed.com).

If he hadn't become a hydrologist, Mace said he probably would have been an architect because he loves to build things and has what he calls "a deep love of architecture."

"At one point in high school, I was going to be a design engineer because I loved to draw," he said. "I liked to draw schematics. I liked science fiction, and I would design my own spaceships on paper and have cross sections.

"I'd like to think I would be a green architect, worried about water conservation and energy conservation," he added.

When asked why he decided to leave TWDB, Mace answers with his characteristic humor.

"Three things happened early last year. One, I turned 50; two, I became eligible to retire from the state; and three, David Bowie died.

"I asked myself 'what do I want to do with the rest of my working career,'" he said. "I loved the people I worked with, loved the mission, loved the board members, but I decided I wanted to mix things up a bit."

In his position at the Meadows Center, Mace will draw on his experience, knowledge and even his witty personality to continue to make an impact on Texas water.

"I'm an occasional DJ with varied music interests, so I like to fuse different genres, something the kids call 'mash-ups,'" Mace said, who, as DJ Spaghetti, performed at a SXSW showcase back in the 1990s and wrote a dance-floor track titled "GIS is More Fun Than Beer."

"The water world is no different in that it's multidisciplinary. We need to mash-up the disciplines to create science and policy relevant to today's world. I want to be at the decks and help with the mixing."

Story by Sarah Richardson

TO INFINITY AND BEYOND

Texas Tech researchers develop wastewater treatment system for space missions

(Top) Dr. Andrew Jackson works in the space habitation wastewater recycling lab next to his microgravity compatible bioreactor (CoMANDR). Photo courtesy of Dr. Andrew Jackson.

(Bottom) Dr. Andrew Jackson (left) and his research group around a prototype microgravity compatible bioreactor (CoMANDR). Photo courtesy of Dr. Andrew Jackson.

What if you had to bring all of the water you needed with you everywhere you went? That could get expensive, not to mention inconvenient and cumbersome.

That is exactly what astronauts have to do.

Astronauts living on the International Space Station get their water from U.S. and Russian cargo ships when supplies are replenished as well as from recycled wastewater and humidity condensate. They are limited to using less than a gallon a day while the average American uses 35 gallons per day, according to NASA.

But even using less than a gallon a day would quickly diminish the water supply — if not for recycling.

For long distance travel from Earth to be possible, NASA requires a water recycling process that recovers 99 percent of the wastewater. Currently at the International Space Station, wastewater is recycled at a rate of roughly 90 percent. After repeated recycling, less and less water would remain, at which point new water would need to be delivered.

A group of Texas Tech University scientists is researching how to make the most of every drop of water during space missions using close-looped recycling to efficiently turn wastewater into drinking water.

"It becomes impractical to export water to another planet; you've got to reuse it over and over," said Dr. Andrew Jackson, professor in Texas Tech's Department of Civil, Environmental and Construction Engineering. "It gets really expensive to send mass into space."

Jackson and his team, which includes former Texas Tech faculty member Dr. Audra Morse, currently professor and chair in the Department of Civil and Environmental Engineering at Michigan Technological University, have been researching the incorporation of biological wastewater treatment into space habitation water recycling systems since 2003.

Sustaining space travel through biological water treatment

Biological water treatment, or the use of microorganisms such as bacteria to break down contaminants, is a frequently used step in municipal wastewater treatment.

"On Earth, biological treatment has been used as the foundation to treat our waste before it is returned to the environment and reused, since it is low cost, sustainable and self-regenerating," Jackson said.

The self-regenerative component is the microorganisms, which reproduce, preventing the need to supply, store or replace parts in the biological wastewater treatment process.

Jackson and his group developed CoMANDR, a bioreactor used in space that could replace the current pretreatment process, which uses more consumables and requires hazardous chemicals.

Jackson said once water is pretreated, most of the problematic substances are removed or reduced, but the water must then go through the desalination process, which removes salts and other remaining contaminants, creating potable water.

Partnering with Paragon

In a Small Business Technology Transfer grant awarded by NASA, Jackson's team partnered with Paragon Space Development Company to create the Integrated Water Recovery Assembly (IRA). The IRA will combine the bioreactor developed at Texas Tech with Paragon's water filtration technology, resulting in an integrated biological wastewater treatment system designed for space missions.

"Our system recovers nearly 100 percent of the water," Jackson said.

Since water used daily could be recycled at this rate, the amount of water needed on a mission would be significantly less no matter what the length of the trip is, allowing more room for other equipment to be stored.

Jackson said the success of this research could lead to the IRA being installed in the International Space Station or more likely on Mars or at lunar bases for long-term missions, resulting in a more sustainable human presence in space.

Recycling water in a microgravity environment

Another factor the researchers had to consider when recycling wastewater in space is microgravity, or very weak gravity in which people and objects appear weightless. Most water treatment and filtration systems on Earth rely on gravity to help move water through the treatment process and separate solids and gases from liquids.

"The ability to have a bioreactor operate in space increases the possibility for having a permanent footprint outside the Earth, and it was made possible because of the microgravity issue that was resolved," Jackson said.

Inside the CoMANDR, waste-eating bacteria grow on hollow tubes from which oxygen is supplied.

"On Earth we commonly bubble air through water to provide oxygen but in space this cannot be done as the bubbles will not separate from the water," Jackson said.

The membranes inside CoMANDR allow oxygen to cross to the bacteria without forming bubbles, resulting in bubble-free aeration, lower aeration costs and control of off-gases and odors.

"As far as I'm aware, we're the only group working on bioreactors for space, at least in the United States," Jackson said. "There are groups in Europe and China, but we may be the only group currently working on microgravity-compatible bioreactors."

He said they are providing the groundwork to prove a bioreactor can and will work by demonstrating that it is functional and sustainable in space habitation systems.

"The outcome involves a flight experiment because no one has ever flown with a bioreactor for wastewater treatment before," Jackson said.

More and more benefits

Not only is the CoMANDR a sustainable portion of a life support system, Jackson said it can also facilitate other processes such as plant growth for food or oxygen generation by providing needed nutrients.

According to Jackson, the ability to operate bioreactors in microgravity will enable astronauts to grow their own food in space, and in the future could help to allow bioreactors that have the means to create plastics, fuel and pharmaceuticals.

"We can't afford to continually ship mass off Earth to resupply space habitats; they have to be somewhat self-sufficient, and I believe that bioreactors can play a critical role in an overall sustainable life support system," he said.

Possible uses on Earth

Here on Earth, the CoMANDR could benefit communities with poor water quality or serve to replace outdated wastewater treatment technology. Jackson said it could be used during disaster relief to protect surface water, flying reactors in and using them for treatment in camps or temporary housing, and at military bases in remote areas where water cannot be delivered because of security risks.

Based on the promising results to date, Jackson earned a three-year, incremental grant worth $500,000 from the NASA Shared Services Center in February 2018. This allows him to continue his research at Texas Tech on close-looped recycling.

"Water is the biggest mass consumable for life support; our work focuses on making that process more sustainable," Jackson said. "Our research is important because we have the potential to impact future missions at NASA, making long-term habitation in space possible and giving humans a sustainable presence extraterrestrially. Certainly we hope it will be chosen by NASA for missions to space."

Story by Claire Corley

Boundless Opportunities

Students travel abroad to pursue water resources studies

The Delta Works in the Netherlands are a series of sea gates to prevent flooding when the North Sea rises. Photo by Dr. Clyde Munster.

Texas A&M University has more than 1,000 varied opportunities for undergraduate and graduate students to conduct research or study internationally. Among the vast opportunities are programs that focus specifically on water resources.

These programs not only give Texas A&M students the chance to travel internationally, but some programs invite students from other universities to apply.

The Biological and Agricultural Engineering study abroad in Belgium and a Costa Rica Research Experience for Undergraduates (REU) at the Texas A&M Soltis Center in Costa Rica are two specific programs focused on water-related studies.

Biological and Agricultural Engineering Belgium Study Abroad

Led by Dr. Clyde Munster, senior professor in Texas A&M's Department of Biological and Agricultural Engineering, the A&M Belgium Environmental Science and Engineering program is a five-week program during the second summer session that focuses specifically on hydrology and wastewater treatment.

Munster said 2018 will be the 14th summer the department has taken undergraduate students to Belgium for this program. On average, 20 students go on the trip, but this year 30 have signed up, making it the largest group to date.

Based in Leuven, Belgium, the students take two classes, one in hydrology and one in wastewater treatment, and receive six hours of credit.

Munster said the program also has four days devoted to field trips. The field trips typically consist of a morning stop and an afternoon stop to see environmental projects related to the courses.

Students are able to see many different water-related facilities, such as a wastewater treatment plant, a drinking water production plant, a water plant that collects groundwater and a pig farm where a constructed wetland is used in the manure treatment process.

Students also have a chance to see the unique Delta Works used for coastal protection in the Netherlands. ⇨

(Left) Students from the Belgium Environmental Science and Engineering program tour the Delta Works in the Netherlands. Photo by Dr. Clyde Munster.

(Right) A former graduate student tests for temperature and conductivity as part of his summer research in Costa Rica. Photo courtesy of Texas A&M University Costa Rica REU program.

Munster said the Netherlands built a series of sea gates called the Delta Works to prevent flooding when the North Sea rises 3 meters (9 feet 10 inches) above normal. This flood defense system is made up of 13 sections with about 60 gates total that are open 99 percent of the time but can be closed to protect southwest Netherlands from flooding.

"The Dutch are very innovative because they are so vulnerable to sea storms and sea level rise that they are leaders in the technology for coastal protection, and it is great that the students get to see that," Munster said.

He said students, especially those from Texas, enjoy this field trip because there are similarities with what can be done to protect people and industries along the Texas coast.

The Belgium program is open to engineering and nonengineering students interested in water and the environment. In addition, Munster said this study abroad program is not limited to students at Texas A&M. Students from other universities from across the United States have participated in the program.

"It really enriches the program to have students from different universities coming together in Belgium," Munster said. "They get to live together, go to class together and even travel together."

Munster said he enjoys seeing the students grow throughout their experience abroad and how they enjoy living and traveling in Europe. The program gives students four-day weekends that allow them to travel to other countries and experience different cultures.

"This is where they get their true international experience. I see them become confident international travelers on these four-day weekends and their lives are changed forever right in front of my eyes," he said. "That is really what motivates me to keep doing this year after year."

When the students return from Belgium, many are interested in careers in water resources or wastewater treatment.

Research Experience for Undergraduates in Costa Rica

Another opportunity for students to study water research is the Ecohydrology of Tropical Montane Forests – Diversity in Science, Interdisciplinary Breadth and Global Awareness REU, funded by the National Science Foundation.

The program takes place at the Texas A&M Soltis Center for Research and Education in Costa Rica that was established in January 2009 with the purpose of supporting Texas A&M's research, education and outreach initiatives in Costa Rica and throughout the Central American region. The center had another REU program from 2011 through 2013 that took 30 students to the Soltis Center to conduct research alongside a faculty member.

For the 2018 program, more than 100 students from all across the United States applied for only eight available spots.

Dr. Gretchen Miller and a former graduate student work in the tropical forests around Texas A&M's Soltis Center for Research and Education in Costa Rica. Photo courtesy of Texas A&M University Costa Rica REU program.

Dr. Georgianne Moore, associate professor in Texas A&M's Department of Ecosystem Science and Management (ESSM), and Dr. Kelly Brumbelow, associate professor in Texas A&M's Zachry Department of Civil Engineering, are the program leader and co-leader for the current REU.

Moore said what makes this program unique is that the target was a group of students who would otherwise not have a chance to do research, such as students attending community colleges.

"They tend to not be as good at imagining themselves doing research for the summer, so we have to really get the students to understand it enough to make them want to apply," Moore said.

The 10-week long research experience gives students hands-on experience with every step involved in the research process. She said the students are on the College Station campus for the first two weeks, for orientation, getting the gear ready and preparing to leave for Costa Rica.

Students then spend five weeks at the Soltis Center before returning to Texas A&M to wrap up and present their research.

Moore said the five weeks in Costa Rica are where the students have the opportunity to conduct research alongside each faculty member.

"We are going to have the students work on as many projects with as many faculty as possible and work in teams for the majority of the time," she said.

Faculty mentor, Dr. Gretchen Miller, associate professor in Texas A&M's Zachry Department of Civil Engineering, said the faculty mentors are from all across campus in geography, engineering, ESSM and geology.

Miller said having the students work in teams with a faculty member produces more meaningful data than if the students were working individually.

Moore said the research this year will be on the hydrology of the Peñas Blancas watershed. The watershed extends to the Monteverde in the high mountain cloud forest, so students will be studying to understand how runoff processes are generated and how the water in the mountains and forested areas can impact agriculture downstream.

She said students will be investigating questions tied to the climate of the watershed, land use, how water moves through the soil and what kind of flow dynamics are in the streams.

"Students will be learning a lot about how the forest and streams respond when you get 5 meters (16 feet and 4.85 inches) of rain a year," Moore said.

After returning to Texas A&M, students will spend the remaining three weeks in College Station analyzing data and preparing to present their results. Moore said at the end, students present the work at the Undergraduate Research Symposium on campus and submit an abstract to the American Geophysical Union.

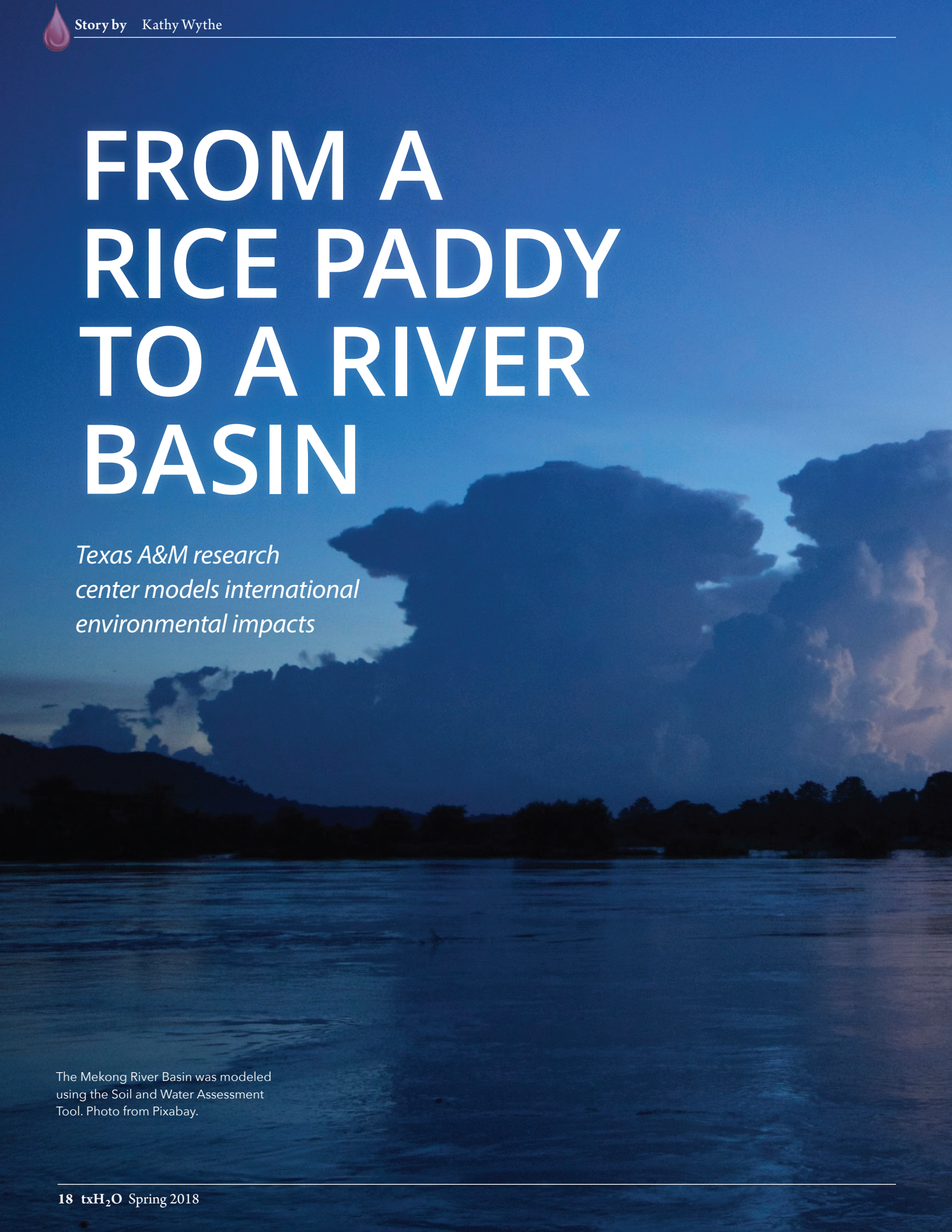
Miller said the program's overall goal is education and to expose these underrepresented community college students to the research process while capturing the creativity and excitement of being out in the forest.

"The whole idea of the REU in general is to get undergraduate students excited about research and pull them into graduate school, research community and have them play an active role," Miller said.

Story by Kathy Wythe

FROM A RICE PADDY TO A RIVER BASIN

Texas A&M research center models international environmental impacts



The Mekong River Basin was modeled using the Soil and Water Assessment Tool. Photo from Pixabay.

If the 2018 Olympic athletes had time to step away from their competitions in February to visit the South Korean countryside, they would have spotted acres of rice paddies covering more than half of the cultivated lands in the small Southeast Asian country. Rice has been South Korea's predominant crop for hundreds, if not thousands, of years.

Because rice takes so much water to grow, most of the rice paddies in this small country of 24 million acres are near streams or rivers. The farmers use this surface water to irrigate and flood the rice paddies.

What the Olympians wouldn't see is how a computer simulation model developed in Temple, Texas, is helping South Korean scientists evaluate the water quality of these paddies and the streams and rivers.

Developing a crop-specific model

As with U.S. farmers, South Korean rice farmers use fertilizers and pesticides to manage their rice fields. Once the paddies overflow, water runs back into the nearby water bodies, potentially polluting the water. With the country's five major rivers showing recent signs of pollution, the Korean government knew it needed to monitor and measure the possibility that rice paddies were part of the problem.

Scientists from the Republic of Korea's National Institute of Agricultural Sciences approached Dr. Jaehak Jeong, research scientist with the Texas A&M AgriLife Research and Extension Center in Temple, several years ago to help with determining the amount of nonpoint source pollution from the rice paddies for the entire country.

"The South Korean scientists had been conducting a lot of field-scale research, monitoring rice paddy fields and measuring contaminant concentrations," Jeong said. "But at the country-scale they didn't have the numbers to quantify rice paddy pollution." ⇨

Results from modeling done by the Soil and Water Assessment Tool has helped decision-makers in five countries in the Mekong River Basin make decisions and negotiations about water management. Photo from Pixabay.

The scientists travelled to Temple to learn the computer model APEX, or Agricultural Policy Environmental Extender.

APEX is a computer simulation model that can be used to evaluate crop and land management technologies and decisions that can affect agricultural production and environmental sustainability for individual fields, whole farms or small watersheds. APEX has components for routing water, sediment, nutrients and pesticides across complex landscapes and channel systems to the watershed outlet. It also contains groundwater and reservoir components.

Jeong said the South Korean scientists wanted to learn how to possibly use APEX and modify it to estimate loads of nutrients from rice paddies. "We discussed how to optimize the model for Korean use, what to improve to have the model better simulate rice paddy processes."

Jeong and others at the center worked with the Korean scientists on developing a module within APEX to make those modifications, using the Korean scientists' field research to test and calibrate the new model. The result is a rice paddy-specific model: APEX-Paddy.

The Korean government is now collecting and organizing data to expand the APEX-Paddy model to the entire country.

"They will be running the model and evaluating best management practices to reduce nutrient and sediment loads," Jeong said.

Multitude of models

APEX is just one of the major agricultural and environmental computer simulation models developed primarily at the Temple center in collaboration with the U.S. Department of Agriculture (USDA)'s Agricultural Research Service (ARS) and Natural Resources Conservation Service. These research groups have collaborated for more than 40 years, developing and perfecting models that are now used worldwide.

"We have had a long relationship of working very collaboratively together especially with development of these models," said Dr. Tom Gerik, the center's director.

Computer simulation models, such as APEX, can help researchers solve complex environmental problems. Large amounts of information, including weather and soils information, geospatial information and crop management practices, as well as equations, or algorithms that describe biophysical processes, such as transpiration and groundwater infiltration, are fed into the models.

Jeong said the models "recreate the earth systems" to help answer how human activities on the land influence the environment.

"As humans, we can come up with the creativity, but the models can help us answer complicated questions," he said. "We can't calculate all the processes at a point level of a watershed; there are hundreds of thousands of points to consider."

The models, including APEX and EPIC, or Environmental Policy Integrated Climate, a crop and soil productivity model, can then evaluate the effects of technology, management or climate change impacts on the productivity and sustainability of agriculture and natural resources, such as soil and water.

Although there are many crop models in existence, Gerik said the ones developed at the Temple center are unique.

"What sets our models apart from other crop models out there is our models consider the management and the tools used to grow the crops.

"When we simulate the crop production system or crop, we can simulate the biophysical attributes that go along with the piece of equipment being used, whether it's irrigation equipment or a fertilizer applicator, and show how that equipment is affecting the crop and soil properties," Gerik said.

While other crop models are focused on plant development and yield production, Gerik said APEX and EPIC are "focused more on how agriculture is using natural resources, and the two main natural resources are the soils and water."

SWAT, or Soil and Water Assessment Tool, is another model jointly developed with ARS primarily at the center. This model is a river basin-scale computer model developed to quantify land management practices in large, complex watersheds. The public domain model is widely used to simulate the quality and quantity of surface water and groundwater and predict the environmental impact of different land management practices.

International impact

The models initially developed at the Temple center have been used all over the world to simulate, estimate and solve environmental issues.

Gerik said the models are all open source, and other scientists have taken these fundamental models and developed them further for specific applications.

"We rely on other people to share their knowledge and information and capabilities with us," he said. "Thousands and thousands of other modelers around the world are using the models in ways we don't even know they are being used."

Jeong said other modelers might build a specific interface program that answers a question that applies to their research of interest. "Oftentimes our models serve as scientific background to answer those questions," he said. ⇨

(Top left) Dr. Raghavan Srinivasan has been instrumental in organizing international SWAT conferences. Photo courtesy of SWAT.

(Bottom left) Dr. Jaehak Jeong has trained South Korean scientists in using APEX-Paddy in Korea for each of the last three years with another training this year. Photo courtesy of Korea's Rural Development Administration National Institute of Agricultural Sciences.

(Top right) A key component of APEX application in Korea is simulating the water quality impacts of rice paddies because rice claims the largest cropland area in the country. Photo courtesy of Korea's Rural Development Administration National Institute of Agricultural Sciences.

In addition to working with Korean scientists on the APEX-Paddy, Jeong is part of an international working group for rice paddy modeling.

The group is interested in better simulating rice paddy processes in Japan, Vietnam, India, China and United States.

By far the most widely used model developed at the Temple center is SWAT. An entire research community exists around SWAT; the river-system model has been used in more than 120 countries to address environmental and water management issues.

Dr. Raghavan Srinivasan, professor in Texas A&M's Department of Ecosystem Science and Management and director of the Spatial Sciences Laboratory, has championed the use of SWAT internationally.

"The fastest growth of the application of the SWAT model is in Africa and Asia," Srinivasan said. "And most of its application in next five to 10 years will come from Asia and Africa."

In one of its most comprehensive uses, SWAT has been adopted as a model by five countries in Southeast Asia to help these countries collectively negotiate water rights and manage water resources in the Mekong River Basin. The 675,000-square-kilometer Mekong Basin cuts through Thailand, Vietnam, Cambodia, Laos and Myanmar.

Srinivasan said in other multiple-country river basins, the countries don't have a common platform — the same model and same assumptions — to make decisions.

"When water planning has to be done, these five countries use the same model and the same tools to make the decisions," Srinivasan said. "This platform has really made the negotiation easy because everyone has the same information."

The U.S. Agency for International Development funded a research project for the Kenyan government in which researchers applied the SWAT model to a portion of the Tana River below Mt. Kenya to determine the effects of reforestation policies on a reservoir.

Also in Africa, SWAT and APEX are being used in the Innovation Lab for Small-Scale Irrigation project, part of Feed the Future, the U.S. Government's Global Hunger and Food Security initiative. The project works in Ghana, Ethiopia and Tanzania to provide improved efficient methods of supplying water to small farms. (See "Feeding the Future" on page 24.)

"The project partners used APEX at the field level to look at small-scale irrigation in terms of how the farmers can grow crops and determine if they have enough water within those small areas to be able to

South Korean farmers flood their rice paddies, transporting water from nearby streams or rivers. Photo courtesy of Korea's Rural Development Administration National Institute of Agricultural Sciences.

grow crops," Gerik said. "We can simulate crop water use and the depletion of the aquifer and well around it to see if they have enough water to fully grow the crop and what the yield potential would be if water starts to run out."

Srinivasan said SWAT and APEX were also used to identify potential regions in the countries to expand the use of specific irrigation technologies that were adapted for use on the small farms.

Expanding through training

Training workshops have been a fundamental pathway for expanding the use of these models internationally and opening up possibilities for collaborations.

"Once we do training, we become engaged with a few of the students, and they begin to use the models and become pretty avid model users," Gerik said. "We develop ties and linkages with those people. Sometimes we develop a collaborative working relationship with them to develop a new feature or new capability that gets added to the models."

Jeong initially trained the Korean scientists in using APEX in Temple and has since conducted trainings in Korea for each of the last three years with another training this year. In addition to his workshops in South Korea, Jeong is visiting a Chinese university this year to teach researchers about using APEX-Paddy in China and will be a visiting scholar for a month at a Japanese university next fall.

Srinivasan, particularly, has worked to organize SWAT trainings and conferences all over the world.

Srinivasan said the Temple team is conducting eight to 10 workshops a year worldwide while other researchers are conducting about 50-60 workshops a year. The Temple group organizes two to three international and regional conferences a year, each averaging 150 participants from 30-40 countries.

The increase in SWAT being used worldwide by so many scientists has brought along an increase in the number of peer-reviewed publications. Srinivasan said 3,100 peer-reviewed publications about SWAT have been published, 600 in 2017.

Not only do the modelers travel internationally teaching and conducting research using these models, scientists from all over the world come to Temple to learn and work with the Temple group.

Gerik said the center itself has 40-50 scientists on staff from other countries, including Zimbabwe, China, Argentina, India, South Korea, Italy, Bolivia, Germany, Taiwan and Ethiopia. Other scientists come to Temple for extended visits to work on adding new features to the models.

Gerik said these scientists are experts in particular areas of science who contribute their knowledge on biophysical processes to the model.

"In many cases, they are the people who help refine the models because they look at the simulation methodology and outcomes differently than we do," he said.

Dr. Ann Van Griensven, associate professor of hydrology and water quality at the IHE Delft Institute of Water Education in the Netherlands, recently was in Temple working closely with Dr. Jeff Arnold of ARS and the SWAT team of developers. She has worked with SWAT for 20 years, including model developments and auto-calibration tools.

"At this moment, I am working on the new SWAT+ version, which is under development," Van Griensven said. "I am working on improving the representation of riparian wetland processes in SWAT model applications."

She said wetland processes have a large impact on water quality and quantity but are poorly represented in catchment models.

"The new SWAT+ version better represents interactions between rivers and landscape units, which is important for the simulation of riparian wetlands, which interface between the river and the landscape."

Continuing model collaboration

Gerik said the Temple group will continue to collaborate with scientists around the world to refine and develop the models for new applications.

The team is currently developing a global platform for the SWAT model with cloud-based worldwide basic data.

Srinivasan said scientists now using SWAT download the model, collect and input the needed data into the SWAT model and then develop their own project.

"This new platform will make it easier for anyone in the world to use the SWAT model without worrying about how to get data," Srinivasan said. "With the global platform, we are developing the model for the whole world and others can just do the application."

"Because we have such a long history here and because of the models' wide application and because people are interested in improving water use and finding ways to reduce the impact of agriculture on the environment and to more efficiently use all of our natural resources, there is lot of demand to use models," Gerik said.

Story by Sarah Richardson

Feeding the Future

Texas researchers work to improve small-scale irrigation for African farmers

Female farmers in Ghana benefit from the Innovation Laboratory for Small-Scale Irrigation project, which researches the link between irrigation, gender and household nutrition. Photo courtesy of Timothy Adei/Team 1000 Words.

One person in every four in sub-Saharan Africa lacks adequate food for a healthy and active life, according to the United Nations' Food and Agriculture Organization (FAO). Many times water is the constraining factor.

The Norman Borlaug Institute for International Agriculture within the Texas A&M University System leads a project that is helping farmers acquire and use water more efficiently for irrigation to produce more food in Ethiopia, Ghana and Tanzania.

The project — Innovation Laboratory for Small-Scale Irrigation (ILSSI) — is one of 24 innovation labs within Feed the Future, the U.S. government's global hunger and food security initiative, led by the U.S. Agency for International Development (USAID).

The Borlaug Institute is partnering with four organizations — the International Water Management Institute (IWMI), International Livestock Research Institute, International Food Policy Research Institute and North Carolina A&T State University (N.C. A&T) — in this five-year project. Dr. Neville Clarke, special assistant to the vice chancellor of Texas A&M AgriLife Research, is director of ILSSI.

Together, the partners of ILSSI are working to help farmers by improving the use of scarce water supplies through innovations in small-scale irrigation. The innovation lab is creating research-based evidence that will contribute to increased food production, improved nutrition, accelerated economic development and environmental protection.

The need for irrigation

Many parts of sub-Saharan Africa only experience two seasons — rainy and dry seasons. When farmers are in a dry season, scarce water supplies can lead to less food and inadequate nutrition for families.

Of the many irrigation technologies Innovation Laboratory for Small-Scale Irrigation is researching, solar power pumping has been shown to have great potential at the farm level. Photo courtesy of the International Water Management Institute.

Using small-scale irrigation increases food production in the dry season and improves livelihoods, but currently only 7 percent of crops in Africa are irrigated, according to the FAO.

"Farmers grow and store grain in the wet season, and in the dry season all they eat is grain," Clarke said. "Irrigation has the obvious advantage of fresh food all year long."

Efficient water innovations

Field studies at the farm and watershed level evaluate small-scale irrigation interventions to improve the lifting, transporting and distribution of water to the farmers' fields. Extraction tools include well-water pail-lifters, mechanical pumps and solar pumps, all of which provide multiple benefits for irrigation, livestock and household purposes. With funding from the project, a team of engineers designed a simple, mechanized pail-lifter that lifts water from a well and then stores it in a tank. From the tank, water is distributed to the field using a drip irrigation system.

Matt Stellbauer, senior project manager for ILSSI at the Borlaug Institute, said this easier access to water addresses many problems. "When farmers no longer have to hand lift water from the well, they save on labor costs and time and increase productivity," he said.

Farmers also receive training to use irrigation scheduling tools that will further conserve water and labor.

Dr. Nicole Lefore, project leader for IWMI, said irrigation scheduling technologies range from mechanical, low-cost tools to higher-tech cameras and sensors that link to the internet, automatically uploading the soil moisture and crop water requirement data.

Stellbauer said farmers previously used flood irrigation, a less efficient method of irrigation that decreases soil quality and does not always allow the farmer to maximize the crop water potential.

Innovations such as wetting front detectors prevent farmers from overwatering, saving time and water while growing just as much crops as compared to conventional farming methods.

"A wetting front detector is a valuable irrigation scheduling tool that senses moisture in the soil and indicates when to increase water consumption to be most effective," Stellbauer said.

He said trials of irrigation scheduling tools suggest that using the wetting front detector can increase on-field water use by 30 percent at critical growth stages and reduce water use when it is not needed. "This can double crop yields, resulting in more yield for water used while also reducing labor for farmers," he said. ⇨

Farmers in Ethiopia install a wetting front detector, an innovation that allows farmers to better measure their soil moisture. Photo courtesy of Innovation Laboratory for Small-Scale Irrigation.

Water conservation in farming

Field studies also compare the results of conventional farming methods to conservation agriculture. Conservation agriculture practices include applying mulch and using drip irrigation.

Dr. Manoj Jha, an associate professor at N.C. A&T, said multiple benefits were observed from the vegetable garden field experiments that used conservation agriculture practices in terms of improving the livelihood of smallholder farmers.

"Producing vegetables under conservation agriculture and drip irrigation were found to increase yield and water productivity, improve soil quality and save labor when compared to conventional farming practices," he said. "In addition to having significant increase of vegetable yield, a substantial amount of water savings were observed. This helped the farmers in the region to produce twice in the dry season alone.

"Conservation agriculture is considered as a strategic approach to improve food security and minimize children's death and stunting caused by malnutrition, which is a serious problem in the region," Jha said.

Texas A&M modeling technology proves irrigation success

Along with the field studies and irrigation innovations, researchers use an integrated modeling system developed and used at Texas A&M. The Integrated Decision Support System (IDSS) is a suite of models — APEX (Agricultural Policy Environmental eXtender), SWAT (Soil and Water Assessment Tool) and a farm income simulator, FARMSIM — used to estimate overall effects of small-scale irrigation at the national level. This provides methods for planning and evaluating new initiatives for water use.

The IDSS estimates the best combination of water, fertilizer and management practices as well as assesses the consequences of small-scale irrigation and these innovations on production, environmental and economic outcomes.

"The modeling can show the best places to irrigate, impact of irrigation on economics, and what technologies are going to work best in those areas, for which countries," Stellbauer said.

"We can take tools from Ethiopia for instance, and take it to Uganda and model the results of irrigation for other countries," Clarke said.

Irrigation impacts

Project members conducted household surveys, interviewing families to understand the impact small-scale irrigation has on improved diet, income, hygiene and issues related to gender.

"A large percentage of farmers in Africa are women because of labor migration of the men to the cities for income and women are left to do the farming," Clarke said. "Women are limited in their ability to use irrigation because of limited access to irrigation, education and borrowing money."

ILSSI is researching this knowledge gap to identify the technological, economic and cultural factors limiting women's ability to irrigate. Researchers have found that gender-based differences in preferences, responsibilities and access to resources need to be considered, and a one-size-fits-all approach to irrigation is insufficient to achieve national gender equality, food security and climate resilience goals.

Clark said surveys of participating farm families are showing that income from crop sales is not only providing for more food and a diversified diet but the increased income is being used to improve quality of life, including education and medical care for children. ⇨

(Left) Ethiopian farmers use a solar-powered pump at the farm level. Photo courtesy of the International Water Management Institute.

(Right) A field researcher in Ethiopia demonstrates the use and impact of a wetting front detector. Photo courtesy of Innovation Laboratory for Small-Scale Irrigation.

Sustainable results

Capacity development, or transferring the knowledge and training to local and national stakeholders, is essential for the long-term impact of the ILSSI project.

"ILSSI targets capacity development interventions at multiple levels, including farmers — women, men, youth — local artisans, extension and subject matter specialists, as well as researchers, scientists, national planners and decision-makers," Stellbauer said.

Lefore said the project connects with national universities to provide training to local extension and farmers. "Many extension agents in Africa have had no training on irrigated production, so the project works directly with local extension," she said.

During the five-year project, 700 students have been trained in modeling techniques. Short-term training was provided for 465 farmers, government staff, civilians and others that focused on increasing small-scale irrigation and the use of the technologies, tools and practices.

Although in its fifth and final year of funding, ILSSI is currently being considered for an additional five years of funding to continue irrigation training and research.

Capacity development also ensures the knowledge is successfully transferred to farmers and will last generations after the project is complete. "Each season I visit the farms, and I see changes on farmers' fields," Lefore said. "In some cases, the area under irrigation has expanded 10 times the original piloting plots as farmers gain confidence in the benefits of irrigated vegetables and fodder."

The project's success has brought people from neighboring villages who took the initiative to ask the project farmers about their experiences and learn about irrigated production.

"The quality of the diet and amount of food available has substantially increased because of the research we're doing, so that's a good thing," Clarke said.

Children in Ethiopia use a treadle pump, one of the many small-scale irrigation technologies that the Innovation Laboratory for Small-Scale Irrigation project is researching. Photo courtesy of Innovation Laboratory for Small-Scale Irrigation.

Story by Kathy Wythe

Bringing Together Key Players

Photo from Pixabay

AgriLife Research tackles water scarcity to ensure food security as part of international task force

The Texas Water Resources Institute (TWRI) represents Texas A&M AgriLife Research on an international task force that is tackling the challenge of better using water in agriculture to ensure food security.

The Global Framework on Water Scarcity in Agriculture, or WASAG, is a global task force and part of the United Nations Food and Agriculture Organization's initiative, Coping with Water Scarcity in Agriculture.

WASAG is designed to bring together key players across the globe and across various sectors to support the development and deployment of policies, strategies, programs and field capacity for the adaptation of agriculture to water scarcity, according to its website.

"The task force's purpose is not so much to do a specific action," said TWRI Director Dr. John C. Tracy, AgriLife Research's representative on the task force, "but to coordinate the activities so the countries around the globe can understand what they may be able to do in the short-term and long-term if they are facing a water scarce situation to make sure the impacts to agricultural production are minimized."

WASAG currently has 50 partners from research institutions, think tank organizations, global partnerships, the United Nations and international agencies. The first partner meeting took place in April 2017 in Rome to discuss the structure and mechanisms of cooperation.

Tracy said about 100 people representing governments and nongovernment organizations attended this first meeting. TWRI, the Robert B. Daugherty Water for Food Global Institute at the University of Nebraska and World Food Centre at the University of California, Davis were the three academic institutions represented. Arizona State University's School for the Future of Innovation in Society is also a partner in the task force.

Tracy expects the task force to examine both short-term water scarcity, such as droughts, and long-term water scarcity, such as groundwater depletion, and put forth possible recommendations for addressing these situations, perhaps in a document or in presentations.

"Texas deals with both of those so we have a lot to contribute to the discussion internationally as to what needs to happen and what needs to change to be able to address those situations," he said.

Particularly in addressing long-term groundwater depletion effects on agriculture, Texas universities involved in Ogallala Aquifer research projects are on the front lines with advances in not just irrigation efficiency but in evapotranspiration scheduling tools and understanding the economics of using these tools, Tracy said.

"Few places around the world are using those kinds of tools, but there is a tremendous potential in educating the rest of the world on using those tools," he said.

The Rome Statement on Water Scarcity, a joint statement issued after the Rome 2017 meeting, highlights the importance of the agricultural sectors in coping with water scarcity for food security and climate change adaptation and mitigation.

For more information on the task force and its documents, visit http://www.fao.org/land-water/overview/WASAG.

Story by Kathy Wythe

TWRI IN 2017

Helping Texans make every drop count since 1952

The Texas Water Resources Institute (TWRI) has helped study Texas' water issues through research, education and outreach for 65 years. Each year TWRI assembles its accomplishments and metrics to reflect the impact the institute and its collaborators and stakeholders have on making every drop count.

TWRI collaborates with all Texas A&M University System units engaged in water resources research and outreach, maintaining strong collaborations with the College of Engineering, the Water Management and Hydrological Science Program in the College of Geosciences, and the Institute for Science, Technology and Public Policy in the Bush School of Government and Public Service.

Restoring & protecting

As a leader in restoring watersheds, TWRI engages local stakeholders to improve water quality in Texas watersheds through watershed-based plan development and implementation assistance. In 2017 much of this work focused on the Matagorda Bay watershed along the Texas Gulf Coast. This 3,619-square-mile watershed supports a diverse and rich ecosystem that sustains a robust commercial fishery, abundant wildlife and more than 300 species of birds.

TWRI's water team worked with more than 250 local stakeholders and eight state or regional agencies in the Tres Palacios, Lavaca and Carancahua Bay watersheds, all of which had portions designated by the state as impaired because of elevated levels of bacteria.

The Tres Palacios Watershed Protection Plan (WPP) and the Lavaca River WPP were approved by the state, and the Tres Palacios WPP was approved by the U.S. Environmental Protection Agency.

Sustaining & enhancing

TWRI began working with the U.S. Geological Survey Water Science Centers in Arizona, New Mexico and Texas, Arizona Water Resources Research Center and New Mexico Water Resources Research Institute in 2017 on the Transboundary Aquifer Assessment Program.

TWRI's scientists assessed hydrogeological transboundary linkages of aquifers and developed the first geological correlation of hydrogeological units between Texas and Mexico as well as a classification of aquifer potential. They began updating the numerical model of the Hueco Bolson Aquifer and integrated the first conceptual model of the Allende-Piedras Negras Transboundary Aquifer. The scientists also developed a ranking system to prioritize aquifers based on their level of "transboundariness," an approach that prioritizes transboundary aquifers using socio-economic and political criteria.

Engaging & educating

The Texas Well Owner Network (TWON), a joint Texas A&M AgriLife Research and Texas A&M AgriLife Extension Service program between TWRI and the Departments of Soil and Crop Sciences and Biological and Agricultural Engineering, educates landowners about private well water testing, protection and management.

Photo by Ed Rhodes, Texas Water Resources Institute.

TWON held 12 Well Informed screenings analyzing 670 samples and nine Well Educated trainings with 651 participants. TWON won the prestigious 2018 Texas Environmental Excellence Award in the education category.

The new Urban Riparian and Stream Restoration Program, in collaboration with AgriLife Research in Dallas, is bringing awareness, education and the value of riparian and stream restoration to urban areas around Texas with 15 workshops for professionals planned over three years.

Expanding our impact

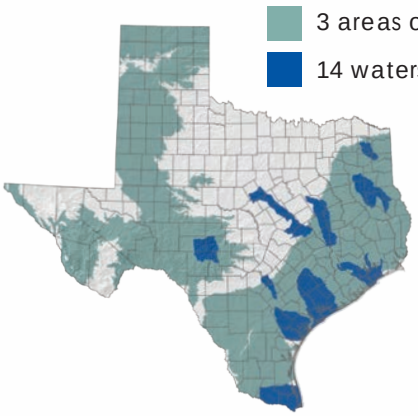
TWRI also expanded its impact by working with a new partner and leading a four-year grant to address water challenges in the Rio Grande Basin during 2017.

In collaboration with Oklahoma State University and Kansas State University, TWRI partnered with the U.S. Department of Agriculture (USDA)'s Southern Plains Climate Hub to host the Resilient Southern Plains Agriculture and Forestry in a Varying and Changing Climate conference in El Reno Oklahoma, at Redlands Community College. This 1.5-day conference, led by Dr. Ron Lacewell, Texas A&M Department of Agricultural Economics professor and assistant vice chancellor for federal relations, brought together 68 researchers, extension professionals and stakeholders from the Southern Plains region of Kansas, Oklahoma and Texas. Regional research and extension priorities were identified and a 10-year strategic roadmap developed for ensuring resilient agricultural and forestry systems in the face of varying and changing climatic patterns.

Through the Diversifying the Water Portfolio for Agriculture in the Rio Grande Basin project, TWRI is working with almost two dozen faculty, research scientists, extension specialists and graduate students at Texas A&M AgriLife Research and Extension Centers, departments in the College of Agriculture and Life Sciences, and the New Mexico Water Resources Research Institute at New Mexico State University. The project team is investigating alternative water sources, new crops, management practices and improved water conservation to sustain agriculture in the basin. The project is funded by a USDA National Institute of Food and Agriculture Water for Agriculture Challenge Area grant.

To download TWRI's annual report, visit twri.tamu.edu/about/.

IMPACTS & ENGAGEMENTS



$5,583,103
in external grants

69% increase in external grants for CY 2017

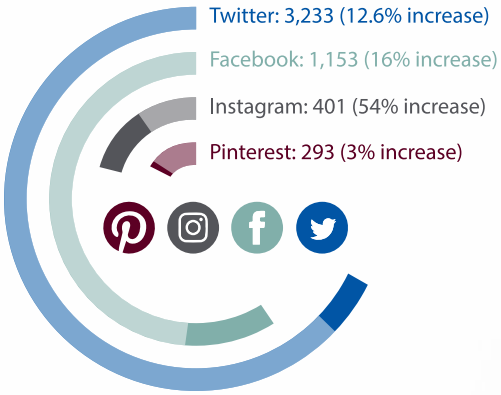
Project collaborations

20 internal TAMU System

38 external collaborators

58 total collaborators on 62 projects

Social media followers



5,080 total followers (14% increase)

59 news releases

100 media mentions

144 presentations to

5,602 people in attendance

21 students supported

3,712 Facebook users engaged

88,663 Facebook users reached

35 publications

3,466 *txH$_2$O* magazine subscribers

5,211 newsletters subscribers

Texas A&M has large presence at World Water Congress

Texas A&M University made a big impact at the five-day International Water Resources Association's (IWRA) XVI World Water Congress held last year in Cancun, Mexico.

Of the more than 1,100 participants representing 65 countries attending the Congress, more than 40 were from Texas A&M, many of whom presented papers.

The World Water Congress draws water professionals from all disciplines — science and engineering, economics and policy, governance and law — as well as stakeholders and government officials from around the world to discuss and respond to global water management, security and accessibility issues.

Texas A&M School of Law Professor Gabriel Eckstein served as chair of the International Scientific Committee and as a member of the International Steering Committee for the Congress. Texas A&M participants included faculty and students from its School of Law, Water Management and Hydrological Science Program (WMHS), Bush School of Government and Public Policy, Texas Water Resources Institute (TWRI), and Departments of Biological and Agriculture Engineering (BAEN), Soil and Crop Sciences (SCSC), Ecosystem Science and Management (ESSM), and Recreation, Park and Tourism Sciences (RPTS).

"There are not many universities in the United States, let alone globally, that have the extent and the breadth and the depth of experts and professionals working on various aspects of water as Texas A&M has," Eckstein said. "Texas A&M has never been involved in an IWRA Congress at this level. I'm sure it was the biggest delegation at the Congress."

The Congress' theme of "bridging science and policy" highlighted the need to strengthen the linkages between scientific knowledge and decision-making at the policy and political levels.

IWRA organizes the triennial event, and the 2017 Congress was jointly organized by Mexico's National Water Commission and National Association of Water and Sanitation Utilities.

Dr. Rabi Mohtar, Texas A&M Engineering Experiment Station endowed professor in BAEN, served as the organizer and moderator of the high-level panel: The Water-Energy-Food Nexus. He also served as a speaker on the high-level panel: Integrated Water Resources Management.

Dr. Mary Hilderbrand, a Bush School senior lecturer; Dr. Ronald Kaiser, RPTS professor; Dr. John Tracy, TWRI director; and Dr. Rosario Sanchez, TWRI senior research scientist, each chaired a regular session at the Congress.

Sanchez presented on transboundary aquifers in an all-day special session on transboundary waters in North America. Dr. Lucas Gregory, TWRI senior research scientist, discussed water quality standards across hydrological extremes, and Amy Uyen Truong, TWRI extension assistant, presented on urban water conservation and drought management using integrative irrigation techniques.

Other Texas A&M faculty who presented papers included Eckstein; Kaiser; Dr. Rudolph Rosen, director of the Institute for Water Resources Science and Technology at Texas A&M-San Antonio; Dr. Zhuping Sheng, professor in BAEN and resident director at the Texas A&M AgriLife Research and Extension Center in El Paso; Dr. Kevin Wagner, former TWRI deputy director; and Dr. Diane Boellstorff, SCSC associate professor.

Students presenting included Lindsey Aldaco-Manner and Laura Rodriguez Lozada, WMHS graduate students; Man Yang and Sydney Weland,

More than 40 participants at the XVI World Water Conference were from Texas A&M University. Photo courtesy of Gabriel Eckstein.

former WMHS graduate students; Lindsay Sansom, doctorate student in ESSM; Brett Miller, School of Law graduate; Jessica Foster, School of Law graduate and former law research associate; and Bassel Daher, BAEN graduate student.

Sessions covered a diverse set of topics such as integrated water resources management, sustainable development goals, water security, and water policy and governance, among many other topics.

The Congress developed the Cancun Declaration. Linked to a United Nations initiative known as the 2030 Agenda for Sustainable Development, the Cancun Declaration is a four-point call to action outlining how Sustainable Development Goal 6 of the agenda, which calls for the "availability and sustainable management of water and sanitation for all," can be attained.

This story used information from Texas A&M School of Law news stories.

Comprehensive report outlines governance, management of Texas-Mexico transboundary aquifers

A new report published by the Texas A&M University School of Law's Program in Natural Resources Systems outlines the multiple groundwater governance frameworks that cover the transboundary aquifers along the Texas-Mexico border.

"Survey of legal mechanisms relating to groundwater along the Texas-Mexico border," authored by Jessica Foster, a recent graduate of the School of Law, examines, catalogs and compares the various approaches that communities along the Texas–Mexico frontier take toward managing and allocating groundwater resources. It also presents a comprehensive survey of the existing rules, regulations, practices and guidelines that users and institutions on both sides employ to govern groundwater usage within their various jurisdictions.

The School of Law, Texas A&M Bush School of Government and Public Service's Institute for Science, Technology and Public Policy and Texas Water Resources Institute, who are collaborating on an interdisciplinary transboundary aquifer project, sponsored the report.

Law professor Gabriel Eckstein said the report is a critical step in understanding the existing management structures for the shared groundwater resources in the border region as well as considering how to improve those mechanisms to ensure that the resource continues to be available in the future.

"While some of the information in the report was rather difficult to obtain, which makes it an excellent source of information, the real value of the report is its comprehensiveness," Eckstein said. "It identifies every governance and management mechanism and institution on both sides of the frontier that pertains to groundwater resources and identifies how they all work, and often do not work, together."

Dr. Rosario Sanchez, TWRI senior research scientist, agreed on the importance of the report.

"This is the first report of its kind about the border region," Sanchez said. "There is no other additional resource that compiles all this information together. It is really a very important resource for groundwater policy development in the region."

Sanchez said TWRI provided feedback on the policy/legal/institutional data from Mexico, contact information from experts on the Mexico side to assure robustness on the analysis and unedited GIS data adapted for this research.

Eckstein said the past work that the three sponsoring entities have done in research, locating and characterizing the various aquifers that lie on the Texas-Mexico border served as a critical foundation underpinning this report.

He said the report's goal is to lay a foundation for additional research and possible coordination across the border to improve knowledge and information about groundwater on the Texas-Mexico border and to ensure that these critical resources are governed and managed in a manner that ensures their availability into the future.

Texas A&M AgriLife Extension Service

Texas Water Resources Institute
make every drop count

2118 TAMU
College Station, TX 77843-2260

Change Service Requested

NON PROFIT ORG.
U.S. Postage
PAID
Bryan, TX
Permit No. 83

Let's get social!

facebook.com/txwri

twitter.com/txwri

instagram.com/txwri

pinterest.com/txwri

For additional information and resources for each story, visit

twri.tamu.edu/txH2O