tx H2O

A Publication of the Texas Water Resources Institute

Summer 2015

ADVANCING CONSERVATION

Inside: Technologies, partnerships and leaders help conserve Texas' natural resources

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

Most of Texas has received significant rainfall this spring with some areas experiencing severe flooding. With these rains, lake levels have finally improved throughout much of state. Between the end of February and end of May, Texas' lakes gained around 13.5 million acre feet. That's enough water to supply all the municipalities in the state with water for more than two and a half years. Although this is a much welcomed respite from the recent years of drought we've experienced, let's not lose focus of the continued need for planning, conservation and work to ensure adequate water for Texas' growing population. Let's not become apathetic, as commonly occurs in the "hydro-illogical cycle."

We have a great opportunity with these rains to get ahead of the curve and avoid reverting to the situation we've been in the last few years. In this issue, we will be looking at some innovative work on improving urban water conservation by providing homeowners and municipalities new tools for monitoring and managing water usage. We will also explore several important natural resources nexuses — the water-energy-food nexus, water-wildlife nexus, water-soil nexus, and water quality-supply nexus. As we move forward and strive for sustainability, it is important to understand the interconnectivity of all our natural resources.

And, we're not 100 percent out of the drought. Central Texas and the northern panhandle remain abnormally dry or in moderate drought. Further, roughly 20 percent of our lakes remain less than half full. Let's keep our focus on ensuring adequate water supplies for the future and continue to make every drop count.

Kevin Wagner, PhD
Associate 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
Leslie Lee
Texas Water Resources Institute

Graduate Student Writer
Sara Carney
Texas Water Resources Institute

On the cover:

Landscape irrigation is one of the ways Texans can conserve water. Photo by Danielle Kalisek, TWRI.

For more information and to subscribe to *txH_2O*, 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 10, number 1, Summer 2015

Advanced Metering Infrastructure systems can help utilities and consumers save water. Photo by iStock.

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 e-mail newsletter, visit twri.tamu.edu.*

Story by Danielle Kalisek

Advancing conservation

Homeowners and utilities can conserve water using new technologies

Technological advancements are helping homeowners and utilities use water more efficiently, and new consumer information is helping utilities better understand and target consumers' needs and attitudes.

From cities' conservation plans, rebates and education programs to accessible near-real-time water-use information and online irrigation tools, there's something out there for anyone interested in home or landscape water conservation.

Identifying the conservation knowledge gap

A 2008 survey of 419 Texans conducted by the Texas A&M AgriLife Extension Service, Water Issues in Texas: A Survey of Public Perceptions and Attitudes about Water, showed only about half thought water quantity was a problem in their area.

"To me that was a jaw-dropper, because with our population growing leaps and bounds, even during those years when there is plenty of water, we need to be careful with the water we have, how we use it and the decisions we make about it," said Dr. Diane Boellstorff, AgriLife Extension water resource specialist and co-author of the survey results.

A group of AgriLife Extension specialists at Texas A&M University conducted an updated version of this survey in 2014 to see how Texans' perceptions had changed, if at all. Preliminary results suggest the percentage of Texans replying that water quantity was an issue in their area increased from 47 percent in 2008 to 61 percent in 2014. Similarly, the percentage of Texans believing their area would suffer from prolonged drought also increased from about 52 percent to 69 percent in 2014.

"Most of Texas, particularly in 2011, experienced exceptional or extreme drought, and I think people are much more aware of how bad it can get," Boellstorff said. "We had communities that were genuinely concerned they might not have water, so I think that's the most significant result that might pop out as we continue analyzing results."

Cities bring conservation programs to homes

In Arlington and Round Rock, as in most cities, residential customers are the majority of water users with most water use occurring on landscapes in the summer and indoors in the winter. As population growth looms, cities are preparing for the future by implementing water conservation programs to help their customers conserve and extend the life of existing supplies.

Round Rock's service area population is around 140,000 people and is expected to grow to about 300,000 by 2050.

Photo by iStock.

"We've expanded our water system a little bit and expect to have the same amount of water we have currently to meet our full, built-out population of 300,000," said Jessica Woods, Round Rock's water conservation coordinator. "We need to get people used to using less water now, so when the population grows, it's not going to be as big of a stress to have enough water for everybody."

Likewise, with a service population of nearly 370,000 people, Arlington Water Utilities is striving to meet the Texas Water Development Board's Water Conservation Implementation Task Force recommendations of reducing annual water use by 1 percent of total gallons per capita per day with an ultimate goal of reaching an average of 140 gallons per capita per day, said Arlington Water Utilities' Conservation Program Coordinator Dustan Compton.

"We have an obligation to the state of Texas, our water provider — Tarrant Regional Water District — and our own customers to ensure we have a sufficient supply of water for the future," Compton said.

Cities strive to meet their water conservation plan goals using different methods, depending on the city's size, customer base and how effective such methods have proven to be in the past.

Compton said Arlington has been operating a relatively aggressive conservation program for residential water conservation since 2006, starting with daytime watering restrictions year-round — no outdoor irrigation from 10 a.m. to 6 p.m. Since hiring a full-time water conservation coordinator in 2008, the city has implemented many more programs, such as educational classes on improving landscapes, installing rain barrels and fixing irrigation systems. It also offers a toilet distribution program; a shower head exchange where people bring in old shower heads and receive new 2 gallon per minute high-efficiency shower heads; and rebate programs for landscape and irrigation improvements.

Compton said Arlington has started a new program as well that gives homeowners incentives to convert to drip irrigation or efficient sprinklers and even convert irrigated areas to nonirrigated areas.

In contrast, Round Rock has only had a water conservation program for six years, and it finds that a combination of a few rebates and education works best with its customers, Woods said.

"Because of the projected population growth and people using too much water, the city decided to be more effective with water conservation and start educating our customers," she said.

In addition to producing traditional educational water bill stuffers, Woods maintains a water blog, Facebook page and the city's water conservation Web page. The city offers rebate programs for efficient appliances, toilets, irrigation systems, rainwater collection and lawn aeration, and it provides free irrigation system evaluations.

Both cities have had positive feedback, participation and continued interest from customers. Round Rock has even seen its gallons per capita per day decrease almost every year, Woods said.

Regional near-real-time water-use programs

People have varying attitudes and behaviors about water use and conservation. However, advances in water metering measurement by utilities have helped homeowners see their water use nearly in real time. Experts hope that having access to this information will help homeowners see where they use the most water and change their behaviors to reduce excess water use.

Dr. Kelly Brumbelow, associate professor of water resources engineering in Texas A&M's Zachry Department of Civil Engineering, along with Dr. Allen Berthold, research scientist at the Texas Water Resources Institute, are working on one such program. They are collecting advanced metering infrastructure (AMI) data from utilities and translating that information into online graphs and tables that are easy for enrolled homeowners to use to see their hourly water use.

"We're attempting to provide more real-time data to homeowners and see if them accessing this data encourages any water-use reductions," Berthold said. "The gist of this project is to see if we can identify new methods for encouraging water conservation with some of these emerging technologies."

Made possible by a joint Texas A&M AgriLife Research, AgriLife Extension and Texas A&M Engineering Experiment Station Water Seed Grant, Brumbelow and Berthold began this project in partnership with Arlington in March 2014.

Brumbelow said in addition to Arlington, the project will work with more cities to provide AMI data to enrolled homeowners. "Right now it's a subscription portal where residents sign up to get their individual data at no cost to them. We can get them information on what exactly is the time pattern when they're using water, and what's the cost per day and hour of that water use."

The website provides customers various levels of detail, showing a monthly overview by billing cycle with links to then see daily and hourly water usage graphs during that period.

With this data, experts can point out peak water-use times and if there is something seemingly out of place. For example, if they see someone is using a lot of water during the middle of the night, that might be indicative of a leak, Brumbelow said.

"We're trying to get good tools together for the utility side, so the customers can see their data but the utility can see reports on everybody's data and understand where they need to be focusing their conservation efforts," he said.

Berthold said this project compliments utilities' existing water conservation programs and is one more tool for reducing residential water use.

Brewster McCracken, president and CEO of Pecan Street Inc., a nonprofit research and development organization headquartered at The University of Texas at Austin (UT), has a similar effort through his organization's University Municipal Water Consortium. The consortium is a joint effort of more than 25 Texas state, regional and local water providers and university researchers from Texas A&M, UT-Austin and UT-San Antonio, working with a statewide test group, he said.

"We are working with volunteer residential water customers throughout Texas to test out how they respond to different kinds of (water) information and technologies," McCracken said.

Through testing a few kinds of technologies in homes throughout the state, Pecan Street hopes to find out what technologies people like and what they respond to. Tests will evaluate sprinkler system controllers, such as ones that can be controlled on a smartphone or synced with weather data, or if auto-programming capabilities can help optimize lawn irrigation, McCracken said. This information will better determine how to increase users' satisfaction with these technologies and save water.

Pecan Street released in Spring 2015 an interactive mobile app, Pecan Street Blue, which allows the organization and its supported researchers, including Brumbelow, to carry out real-world research. McCracken said Brumbelow and a student, with field support from AgriLife Research, have conducted the most advanced research that's been done in the state on consumer water use and behavioral response.

Water users whose water provider is participating in the use of the Pecan Street Blue mobile app can download it through the Apple App Store or Google Play. A demonstration of the app is also available for anyone to download. More information about the app is at *pecanstreet.org*.

Water My Yard enables landscape conservation

Experts agree that the largest water user around most homes is landscape irrigation. The Water My Yard program (*watermyyard.org*) is another online tool for homeowners, providing watering instructions for users' specific locations and irrigation systems, based on data from nearby weather stations.

Water My Yard began in May 2013 when the North Texas Municipal Water District (NTMWD) asked Dr. Guy Fipps, AgriLife Extension agricultural engineer for irrigation and water management, for a straight-forward irrigation recommendation tool for homeowners, he said.

Fipps, also a professor in the Department of Biological and Agricultural Engineering at Texas A&M, took the district's ideas and translated them into a science-based approach. He and his colleagues then designed a website and mobile web app.

On the website, users confirm their location and select the photo of their sprinkler type as well as spacing and manufacturer. Based on that information and local climatic conditions, the site gives watering recommendations, including whether they need to irrigate, how often and how long. Current water restrictions in their area, if any, are also included. Additionally, users can create an account to receive weekly irrigation notifications by email, text message or both.

Fipps said other water recommendation programs tell homeowners the amount of water needed for the yard; it's up to consumers to figure out what that means and how long they run their sprinkler. "Water My Yard is unique in that it tells each individual consumer 'the irrigation recommendation is 15 minutes, twice for this week, for example,'" Fipps said.

Aside from the NTMWD 12-city service area, the Water My Yard service area includes the cities of Irving and Caldwell, Brazos County and 25 cities around Austin through the Lower Colorado River Authority. Other utilities and water districts have expressed interest as well, he said.

Experts' water efficiency and conservation tips

There is no single answer for the best way to conserve water in homes or landscapes; it's usually a combination of behavioral changes and awareness that impact individuals' water use, experts said.

A good place to start is knowing the top water users around the home.

McCracken said outdoor sprinklers are often at the top. "In fact, there's not even a close second." Showers use 10 to 15 gallons, dishwashers about 5 gallons and sprinkler systems frequently use around 1,500 gallons for one irrigation event, he said.

The AgriLife Research and Extension Center at Dallas demonstrates water-wise landscapes and technologies at its certified WaterSense home. Photo by Leslie Lee, TWRI.

Fipps said the biggest problem he sees with landscape irrigation in Texas is improper design, which results in excess water use.

"There are (licensed irrigators) out there who will design a system properly, but these tend to cost more than the low bid, and most people go with the low bid," Fipps said. "In 2009 Texas enacted new rules and regulations for landscape irrigation, and if the irrigation system is actually designed following regulations, it will be a good irrigation system."

For existing systems, homeowners need to be sure obvious problems, such as a broken or nonrotating sprinkler head, are corrected.

"Before someone has an irrigation system installed, they should ask: 'Do you have matched precipitation rates? Do you have head-to-head coverage? Do you have proper pressures?' And they should have the dealer show them that information. If the irrigation professional doesn't design the system like that, then they need to find another one," Fipps said.

In addition, Boellstorff said the best, yet hardest, thing homeowners can do to conserve water in landscapes is to change the way the yard is landscaped.

"That's where the rubber meets the road," she said. "It's one thing to do what the city tells you as far as putting your sprinklers on and off at a certain time, but it's another to rip out your favorite non-native plant and replace it with a native plant, or change your grass to another species."

Boellstorff suggested that if grass is required in a neighborhood, homeowners should make sensible choices for the climate and use water-efficient species. For example, in many areas of Texas, replacing St. Augustine grass with Bermuda grass will conserve more water, she said.

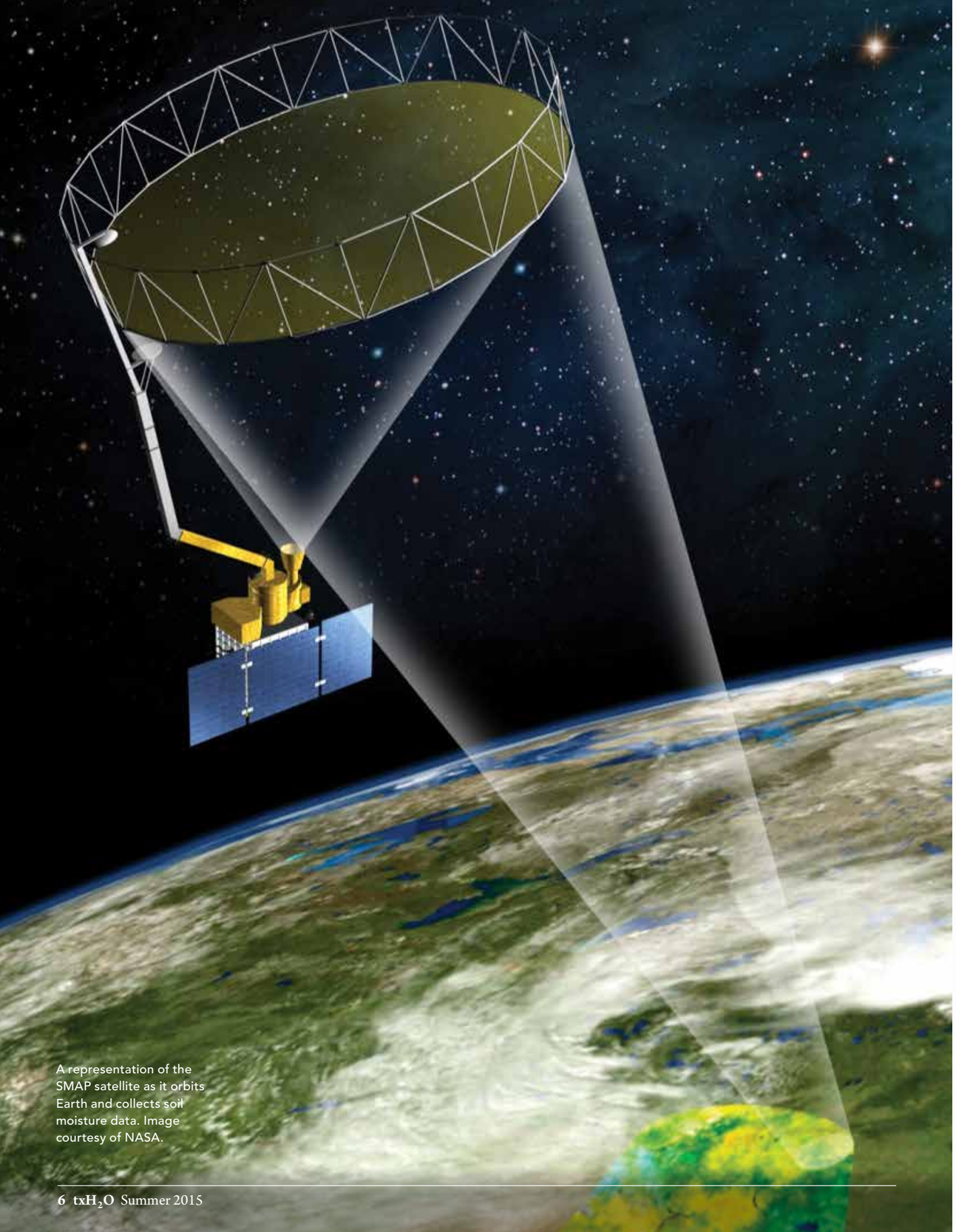
Berthold said a few things homeowners can do to more efficiently use or save water are taking advantage of cities' rebate programs; making sure fixtures are all low flow, updated and used properly; testing toilets for leaks using the common dye test; and simply being aware of water use when the tap is on.

"You can install all the low-flow appliances in your house you want to, but if you use them three times as much as the others, you won't have any conservation," Brumbelow said.

"Overall, people need to be aware of when they're using water and not take it for granted," Berthold said.

Brumbelow agreed. "I would say probably what matters most is that individual water users are really looking at those numbers to see what they're using. In the end, that's where the conservation actually happens is when people pay attention to their actual usage. There's really no substitute for that."

For more information and resources, visit *txH2O* online at *twri.tamu.edu/txH2O*.



A representation of the SMAP satellite as it orbits Earth and collects soil moisture data. Image courtesy of NASA.

Story by Sara Carney

SATELLITES, SENSORS AND SOIL

Research digs deeper into soil moisture mysteries

Many students learn in grade school that 70 percent of the Earth is covered with water. Ask anyone where to find this water, and they will probably talk about oceans, lakes and rivers. They might mention groundwater or frozen water trapped in glaciers. But, they probably won't mention water in soil.

Instead of running off into surface water bodies or percolating into groundwater aquifers, this water is stored in the soil. The amount of water retained in soil accounts for about 0.05 percent of the Earth's freshwater, according to the U.S. Geological Survey (USGS). While that percentage may seem small, it is enough water to fill 6.6 billion Olympic-sized swimming pools.

Soil moisture contributes to weather and geophysical conditions, such as drought and heat waves, and people rely on it for agriculture.

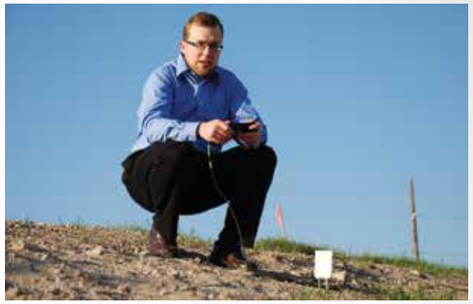
"Soil moisture is the basis of a lot of land management and land use decisions," said Dr. Cristine Morgan, a soil scientist in the Department of Soil and Crop Sciences at Texas A&M University.

Globally, soil is coming to the attention of many as a vital resource. The United Nations Food and Agriculture Organization declared 2015 as the International Year of Soils.

"As people start to take a holistic problem-solving approach to global problems, they are seeing the importance of soil," Morgan said. "The International Year of Soils is a result of others recognizing that we need to be paying attention to the soil."

And taking a holistic approach, they are. Scientists are beginning to understand soil moisture's role in the water, carbon and energy cycles, as well as its impacts on drought, flooding, crop yield and extreme weather and climate conditions.

Recent efforts by NASA, the University of Texas at Austin and Texas A&M use different monitoring strategies, including satellites and in-ground sensors, to tackle unanswered questions about soil moisture. ⇨



(Top photo) Dr. Steven Quiring is developing the North American Soil Moisture Database. Photo by Karen Riedel, College of Geosciences, Texas A&M University.

(Bottom photo) NASA's SMAP satellite was launched Jan. 31, 2015 at Vadenberg Air Force Base in California. Photo courtesy of NASA.

A view from space

It may seem counterintuitive to go into space to study something beneath their feet, but scientists are. Scientists can use satellites to see soil at a scale too large to observe from Earth. To get an unparalleled global glimpse of soil moisture, NASA launched the Soil Moisture Active Passive (SMAP) satellite in January 2015.

"SMAP is going to help us not only address key science questions, such as better understanding our water, carbon and energy cycles, but also a number of different applications, such as enhancing weather prediction; improving flood, drought and wildfire forecasting; and enhancing crop prediction models," said Dr. Erika Podest, Earth scientist at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California.

What makes SMAP so unique is how well it can "zoom in" on soil moisture while still remaining accurate. "Before SMAP, most of the satellite missions measuring soil moisture were at a very coarse resolution," NASA JPL Research Scientist Dr. Narendra Das said.

While data from those satellites was helpful in producing some climate and weather models, it wasn't enough to produce real-time data for things such as agricultural monitoring and forecasting, Das said.

The "Active Passive" part of the satellite's name refers to the instruments onboard, he said. SMAP's radar actively sends microwaves to Earth, which echo off the Earth's surface and return to the satellite for interpretation. The echo's characteristics, such as strength, tell SMAP the amount of moisture in the soil and whether the land surface is frozen or thawed. Understanding freeze-thaw cycles will help scientists better define the length of the growing season at northern latitudes and understand the carbon uptake of vegetation, Podest said.

At the same time, SMAP's radiometer passively measures the strength of radio waves emitted from the ground. This quantifies soil moisture with higher accuracy than the radar but at a lower spatial resolution. The combination of the radar and radiometer optimizes spatial resolution and accuracy and is unprecedented for any satellite mission, the experts said.

Unlike soil moisture measurements on the ground that analyze specific points, the SMAP satellite provides a global picture, which captures soil variability. A complete global soil moisture map is made every three days.

"The reason that we are producing these maps every three days is to capture the dynamic nature of soil moisture," Podest said. "This will help us better understand the role of soil moisture in regulating the water cycle and whether certain places are getting wetter or drier."

SMAP's mission is set for three years, but Podest said it is expected to collect soil moisture data for years to come, as is the case with many NASA satellites.

Todd Caldwell checking one of the sensors in the Texas Soil Moisture Observation Network.
Photo courtesy of Richard Casteel, photographer, www.capturingmilliseconds.com.

Uniting data from the heavens and Earth

Before the satellite can generate its own data, scientists must check SMAP's measurements against those of on-ground networks.

While there are many networks on the ground, most are sparse, with sensors that are spread out. While such networks are useful, SMAP also needs dense networks, or core validation sites. These networks have a higher density of sensors and allow SMAP to better characterize soil moisture at a higher resolution. According to Das, around 15 core validation sites exist in the United States.

These sites are helpful, but most were not set up with SMAP in mind, he said. So, geologist Dr. Todd Caldwell and his colleagues at the University of Texas' Bureau of Economic Geology stepped up and built the Texas Soil Moisture Observation Network (TxSON), a dense network of soil monitors in the Texas Hill Country. The network is the state's first dense network.

"NASA is trying to produce the best soil moisture map within a certain tolerance," Caldwell said. "And to do that, they need something to base it against, and that's what TxSON, as it is right now, is designed to do."

Besides helping SMAP calibrate and validate its data, TxSON also provides much-needed soil moisture data to the Texas Hill County, Caldwell said.

"We've got a whole bunch of soil moisture data now in a completely unmonitored part of Texas, where people didn't think there was a whole bunch of soil moisture variability," Caldwell said. It was previously thought Hill Country soil doesn't hold much moisture, but new data indicates that it can, he said.

Caldwell hopes TxSON can expand to other parts of Texas. Additionally, he foresees that someday the data will be translated into a form that is accessible to anyone who is interested, including land managers, river authorities and policymakers.

Soil moisture monitoring from coast to coast

TxSON is only one of many networks measuring soil moisture in North America, each created by a different entity with different research goals, using different measurements.

Comparing these datasets can be challenging. If a researcher wants to look at soil moisture in different areas of the country, they might find that they are comparing apples to oranges. Enter the North American Soil Moisture Database (NASMD).

NASMD integrates soil moisture data from across the United States, Canada and Mexico to create a comprehensive dataset for researchers and professionals. This data provides a historical look at soil moisture conditions, said Dr. Steven Quiring, a climatologist in Texas A&M's Department of Geography, who is leading the NASMD project.

"The goal is that you can go on a single website, enter in a particular location and figure out what soil moisture conditions are in your location and how they compare to the historical record and what the trends are," Quiring said.

The data gathered through NASMD will also help answer many of the pressing questions that climatologists have about the relationship of soil to the atmosphere and climate predictability. Soil moisture conditions can help predict extreme temperature conditions, he said. Also, soil moisture data may help answer whether wet soils lead to rainfall or dry soils do.

Directly observing and measuring soil moisture offers certain benefits over satellites. In-ground sensors can measure much deeper into the soil than satellites such as SMAP, which only measures the top couple of centimeters of the soil, Quiring said.

A companion project to NASMD being developed by Texas A&M and USGS will integrate several existing networks in Oklahoma and north Texas for real-time information on drought monitoring, Quiring said. A website will be created that farmers, ranchers and land managers can use to make informed decisions.

"In the long term, understanding land-atmosphere interactions and the role of soil moisture can help determine how the frequency and severity of drought may change in the future," Quiring said.

This project will serve as a testing ground to see if this is something that can be done at the national level, he said. A real-time system would facilitate disaster relief, and this data would help government officials in determining where to provide emergency aid.

A world of soil research remains

Despite recent strides made in soil moisture research, there is still much to be learned. "We know less about the soil than we know about space," Morgan said. "It's interesting how little we know considering how dependent we are on it."

Traditional challenges associated with measuring soil moisture have not gone away. But, the researchers said facing these challenges could be worth it if the data helps answer age-old questions such as, "Will it rain tomorrow?" "What crop yields can we expect?" "How severe will the drought be this summer?"

For more information and resources, visit *txH2O* online at *twri.tamu.edu/txH2O*.

Story by Kathy Wythe

Lone star water leader

The optimism, history and vision of ***Chairman Carlos Rubinstein***

Carlos Rubinstein, Texas Water Development Board chairman, in his office overlooking the Texas Capitol. Photo by Leslie Lee, TWRI.

To listen to Carlos Rubinstein is to understand his passion for water, particularly Texas water.

Whether he is speaking to a large crowd at a state water meeting or sitting around with friends on vacation, Texas water is almost always on Rubinstein's mind and a topic of conversation.

Rubinstein is chairman of the Texas Water Development Board (TWDB). He was appointed by former Gov. Rick Perry in 2013 after the Texas Legislature passed a bill changing the six-member, volunteer board to a three-member, full-time board. Involved in Texas water for more than 22 years, Rubinstein brought with him a wealth of experience and wisdom.

His chairman's office reflects both his years spent involved in water leadership and his personality. An old-fashioned, free-standing candy dispenser sits along a wall of windows overlooking the Texas Capitol. Plaques signed by officials recognizing his contributions to Texas water hang on the wall. He is especially proud of his Texas Water Commission-emblazoned leather chairs, reminders of Texas' water past. The commission was the precursor to the Texas Commission on Environmental Quality (TCEQ).

The charismatic, easy-going Rubinstein readily jumps from joking about his work habits to tackling seemingly overwhelming issues. And over the years, Rubinstein has undertaken some of the biggest water problems the state has ever faced.

Tackling Texas water planning

Arguably, the most pressing water issue facing Texas today is ensuring future water supplies amid its growing population, ongoing droughts and anticipated effects of climate change. The 2012 state water plan says that in 2060, the state will have 46 million people, double its 2010 population, and will be short 8.3 million acre-feet of water if the state does nothing in the meantime.

While some people approach this dreary outlook with skepticism or negativity, Rubinstein does not.

He attributes his optimistic perspective, in part, to the state's forward-looking water planning process. Since 1997, state water planning has been conducted using a bottom-up approach. Every five years, each regional water planning group revises its region's plan, charting water management strategies to meet the identified shortages for the next 50 years. These regional plans are then incorporated into the state water plan, which is designed to meet the state's water needs during drought.

Rubinstein said other states compare themselves to Texas when it comes to water planning. "You would be hard pressed to find another state that plans for a 50-year horizon and revisits the plan every five years," he said.

Because planning is locally driven, Rubinstein believes there is more ownership by those involved in the process.

"These regional entities understand what it means to them to not meet the goals and the needs we are going to have in the future," he said. "The fact that we get to revisit the plan every five years is a great opportunity to shore up the plan and also to incorporate changed conditions. Some (of the projects) in the water plan may drop out of the plan, and that is OK. Because we revisit the plan every five years, we may have better options."

Promoting new funds for water projects

In addition to the state's progressive planning process, Rubinstein's optimism has been reinforced by recent funding to move those water projects forward.

That funding is the $2 billion State Water Implementation Fund for Texas, or SWIFT, which the 83rd Texas Legislature passed and Texas voters approved in 2013. SWIFT, an affordable loan program, provides low-interest loans, extended repayment terms, deferral of loan repayments and incremental repurchase terms for projects in the state water plan.

From 1957, when TWDB was created, until now, the board has provided $15 billion in financial assistance, according to Rubinstein.

"In the next decade alone, with SWIFT, we are going to provide $8 billion worth of assistance," he said, noting that the amount is a third of the $27 billion needed over the next 50 years to fund the 2012 plan's water strategies.

In 2014, TWDB board members and staff traveled throughout the state, holding meetings about SWIFT and the rule for prioritizing projects to be funded. They held board meetings in Conroe, Lubbock, Harlingen, El Paso, San Antonio, San Angelo and Fort Worth and dozens of other meetings with communities statewide. The rule was finalized four months ahead of schedule, which Rubinstein called a "rewarding accomplishment."

"Because we went out and talked to the public before we developed the rule, we incorporated a lot of comments into the rule," he said. "When the rule came up for adoption, we didn't have a single person sign up to comment on the rule, and that shows the value of having gone and met with Texans."

Currently, the regional water planning groups and TWDB are working on the 2017 state water plan.

As part of Legislative changes made in 2013, regional groups have to prioritize their projects based on certain criteria. ⇨

Rio Grande. Photo by Danielle Kalisek, TWRI.

Rubinstein expects sustainability, viability and feasibility to play the biggest role in determining which projects are in the 2017 plan and future water plans. Considering those three criteria will help groups determine if they are "really banking on the right project to meet their needs," he said.

Rubinstein said the 2017 plan will have "better defined water conservation projects" that include associated capital costs. "The problem we have in the 2012 plan is several regions have conservation as a strategy, but there is no cost associated with it. And we can't loan money where there isn't a capital cost associated with it."

Until the 2017 state water plan is adopted, Rubinstein said TWDB is addressing that issue by providing communities and regional water planning groups the flexibility to amend their current plans. They can add capital costs for conservation or add or revise other water management strategies.

TWDB's staff is also making a concerted effort to push the water plan, its process and related data on TWDB's website and through statewide talks. Having this information online helps the public understand the planning going on in their region. "Putting the data on the web, particularly for those small, rural communities, will provide them the opportunity to access data in real time and help alleviate some of the resources that they're lacking," he said.

Raising awareness of water conservation

Rubinstein believes that the state's recurring droughts, including the most recent one, have brought greater awareness and ownership of water conservation to many cities and citizens.

Although a recent Texas Water Foundation survey found that only 28 percent of Texans know where their water comes from, the same percent found by a similar survey 10 years ago, he thinks the state has made progress in raising awareness of water and conservation needs.

"I know what the survey says, but there are parts of Texas that people clearly understand where their water comes from," he said. "You can't live in San Antonio and not know how reliant you are on the Edwards Aquifer; you can't live along the border and not understand what the Rio Grande means to you; you can't be from El Paso and not understand what the Hueco Bolson and the Rio Grande water coming from Colorado mean to you; and you can't be in Wichita Falls and not understand exactly where your water comes from."

This increased awareness, he said, has partly come from the media, but local media and communities need to play an even bigger role in getting people to understand the importance of water conservation. "It shouldn't take a period of dryness for you to get it, but, regretfully, that is what has occurred.

"You can't go into my neighborhood and not see signs flashing, reminding you every day that we are in Stage 2 water restrictions," he said. His landscape irrigation timers are set for Stage 2, and he intends to leave them on those settings or lower indefinitely, drought or no drought.

Serving as TWDB chairman is not his first high profile water position. Rubinstein came to TWDB from TCEQ where he was one of three commissioners. He began at TCEQ in 1989 as a petroleum storage tank investigator, working his way up through the agency to deputy executive director, before becoming commissioner in 2009. From 1995 to 2000, Rubinstein worked for the city of Brownsville, which included serving as city manager, returning to TCEQ in 2000.

Phil Smith, (left) construction manager for the San Jacinto River Authority's technical services department, stands with Texas Water Development Board Chairman Carlos Rubinstein (right), at the construction site of one of the river authority's projects to develop adequate surface water supplies. The board provided financial assistance for the project. Photo courtesy of TWDB.

Championing U.S.-Mexico water treaty

It was at TCEQ that the Mexico City-born, Brownsville-raised Rubinstein became a champion for another significant Texas water issue: the United States-Mexico Water Treaty of 1944.

The two countries negotiated the treaty to outline allocation of the Colorado and Tijuana rivers and the Rio Grande from Fort Quitman, Texas to the Gulf of Mexico. The Amistad and Falcon reservoirs were built as a result of the treaty, and under the treaty, among other requirements, Mexico is obligated to deliver an average of 350,000 acre-feet of water annually from Rio Grande tributaries to the United States, and the United States is obligated to deliver 1.5 million acre-feet of water from the Colorado River to Mexico.

The treaty worked well for more than 50 years, until the early 1990s, Rubinstein wrote in a recent Texas Water Journal commentary. "Since a drought in the early 1990s, however, Mexico has repeatedly—and what would appear to be also systematically—failed to meet its obligations in the 2 treaty cycles between 1992 and 2002, and is currently behind on its water deliveries in the current cycle that began October 25, 2010 and will end October 24, 2015," he wrote.

It took candid discussions beginning in 2000 by both the Mexican and U.S. governments about Mexico's incompliance during those treaty cycles, in which Mexico accumulated a 1.5 million acre-feet water debt, he said. In 2005 Rubinstein and others successfully managed to get Mexico to meet its water debt by what he called "creative management." The group looked at how to better use the water in the entire Rio Grande Basin, not just the portions of the river in the treaty, he said.

Now, Rubinstein, not one for backing away from a conflict, is seeking resolution to Mexico's current 318,304 acre-feet deficit (as of March 14, 2015).

The impact of Mexico's water debts, he said, has caused severe economic hardship for Rio Grande Valley farmers and cities. A 2013 Texas A&M AgriLife Extension Service study identified that a loss of irrigation water in the Valley endangers about 4,800 jobs and reduces agricultural output by about $395 million annually.

"The problem is not the treaty; it's complying," he said. Mexico needs to recognize the United States as a water user under the treaty, to set aside water for compliance and to deliver that water, he said. "It's that simple."

With recent discussions, especially with the new Texas Secretary of State Carlos H. Cascos, for whom Rubinstein said the treaty was a "passion," Rubinstein believes the two countries might be getting closer to resolving the issue.

"I do get a sense that we are getting closer and closer to that."

Serving as a watermaster

While at TCEQ, Rubinstein also served as the Rio Grande watermaster for nine years. In that capacity, he oversaw the river's water allocations below Amistad Reservoir. That job, in particular, put a face on the Valley's water problems for him and made Rubinstein even more passionate about water issues.

"For those of us who have been watermasters, we will tell you that the only good time to be a watermaster is when your reservoirs are full or when your reservoirs are completely empty," he said. "Everything in between is when you earn your paycheck. That is when you work with water users, and that is when you have to look a user in the face and say, 'I am going to have to cut you back.'"

During the droughts of 2009 and 2011, while Rubinstein was serving as a TCEQ commissioner, the agency had to order water right curtailments. "We curtailed 1,200 water rights in response to senior calls," he said. "When you understand what it is you are doing with that, yes, it makes you passionate about water."

Rubinstein has many relationships with others in the Texas water world, and they understand each other. "People may agree or disagree with what I did as watermaster. People may agree or disagree with what I did as deputy executive director relative to water rights. People may agree or disagree with what I did with water as commissioner," he said. "But that is good. It gives you a foundation of comfort that you know what you are talking about when it comes to water and that you have those relationships in the water world to be able to have those discussions."

Dr. Ron Lacewell, assistant vice chancellor for federal relations for Texas A&M AgriLife, worked with Rubinstein during his time as Rio Grande watermaster. "People naturally gravitate to Carlos, for he never met a stranger and always shows more interest in your ideas and issues than his own," Lacewell said. "He is a powerful, positive reflection on those he represents. Texas is lucky to have him helping plan for the future."

For more information and resources, visit *txH2O* online at *twri.tamu.edu/txH2O*.

Story by Leslie Lee

Disappearing habitat

As water and land management change in the Texas Mid-Coast, waterfowl feel the effects

A rice field is every duck's winter dream home. The managed wetland provides plenty of water and ideal habitat for ducks and other waterfowl. After harvest, leftover grain and other new plant growth provide an abundance of food, and the birds need it most that time of year. Storing up energy reserves before flying back north is essential to survival.

For most of the 20th century, the Texas Mid-Coast was heavily dotted with rice farms. Spanning roughly from Corpus Christi to Houston and as far north as Interstate 10 in Austin, Colorado and Waller counties, the Mid-Coast's soil and weather were favorable to rice production, and water delivered from the nearby Colorado and Brazos rivers made rice operations possible.

Waterfowl populations flocked to these farms each fall to begin overwintering, and year after year, Texas hunters did too. The region was once considered one of the best waterfowl hunting destinations in all of North America.

End of an era

"We had been real fortunate to have a strong rice industry along the Texas coast for a long time," said Kevin Kraai, Texas Parks and Wildlife Department (TPWD) waterfowl program leader. "Waterfowl took advantage of those valuable resources for many years."

"Anytime you have rice production, you have basically an entire rice prairie wetlands complex," said Ducks Unlimited Conservation Outreach Biologist Kirby Brown.

Beginning in the 1980s and accelerating around the turn of this century, a perfect storm of interconnected factors — urban and suburban growth upstream, intermittent drought and rural land use changes — began to affect the region's rice acreage and waterfowl habitats in coastal prairie wetlands and marshes.

"Rice farming acres have been declining for decades; it's not solely a recent phenomenon," Kraai said.

In 2011, Texas succumbed to a serious drought, and the region's agricultural and waterfowl outlook quickly changed.

Upstream reservoir levels fell, triggering water restrictions for downstream irrigation. Beginning in 2012 in the Lower Colorado River Basin and in 2013 in the Brazos River Basin, water allocations for downstream agricultural operations were cut off. No water has been released since the restrictions began.

In May 2015, heavy rains significantly raised lake levels in the region. However, river authorities will not make decisions on 2016 water releases for downstream agricultural users until Winter 2015-16.

"We've lost about 55,000 acres of rice in the Lower Colorado River Basin and roughly 18,000 acres in the Brazos River Basin since 2012," Brown said.

For every 10,000 acres of rice farms lost, the Texas coast loses its ability to support 120,000 waterfowl, according to the Gulf Coast Joint Venture (GCJV), a multistate partnership conserving priority bird habitat.

Former rice belt now conservation priority

Rice producers and related industries, rural economies, waterfowl populations, landowners, bird watchers and hunters have all felt the effects of this major shift in the region's way of life. Many conservationists hope for long-term changes in both conditions and water management. Until then, they're facing the present circumstances head-on, working to preserve and improve as much habitat and rural land as possible.

"We continue to see marshes become more salty, due to both reduced freshwater inflows from upstream and increased saltwater flows up through canals into marshes that have never seen saltwater before, degrading them and making them less suitable for waterfowl," Kraai said.

Freshwater wetlands have also been lost due to development and land use changes, drought, oil and gas exploration, urban expansion and agricultural changes from rice to other crops, he said.

TPWD conducts annual aerial surveys for population counts, in addition to collecting hunters' harvest data. Recent surveys show significant declines in waterfowl populations and hunter success, Kraai said.

"In 2013 TPWD counted 1.3 million ducks and geese along the entire Texas coast," he said. "That is a 61 percent decline from our recorded high in 1997 of 3.4 million waterfowl. We've seen an 84 percent decline of snow geese on the Texas coast since 1999, when the population was well over a million birds. Last year was the lowest number of snow geese counted on the Texas coast since 1960, and we only counted 181,000 birds."

TPWD is working to slow these changes, mainly with GCJV and its partners, including Ducks Unlimited, the U.S. Department of Agriculture's Natural Resources Conservation Service, the U.S. Fish and Wildlife Service and others.

"We're working very diligently there; it's by far our No. 1 priority in the state of Texas in terms of waterfowl management," Kraai said. "It's just an unbelievable challenge to keep that landscape viable for wildlife." ⇨

Blue-winged teal ducks on Lake Somerville, in Washington County. Photo by Kevin Skow, TWRI.

The most integral people for conserving rural land and waterfowl habitat in the Gulf Coast are private landowners, he said. "Private landowners themselves probably don't get the amount of credit they deserve for the work they do."

TPWD and its partners are using GCJV and North American Wetland Conservation Act funds to implement freshwater habitat restoration and improvements on both private and public lands in the region. They are restoring habitats by planting native plants that provide food and energy resources for waterfowl.

"We're especially prioritizing areas in what was historically rice country," Kraai said. "We're trying to overcome the loss of the waterfowl foods available from the rice industry."

If rice farms move, waterfowl move

Once one of the continent's most important waterfowl wintering areas, the Gulf Coast is no longer even the most important wintering area in Texas, according to TPWD data.

"Many of those birds have gone elsewhere, looking for the resources they need," Kraai said.

In 2013, for the first time ever, the Texas interior actually wintered more ducks than the Gulf Coast, he said. Many waterfowl are also now wintering in Central or North Texas, some surviving on stock ponds, Brown said.

Some rice producers and industries have moved from the Mid-Coast to the Chenier Plain, southeast of Houston, which has a historic rice base and more available water, Kraai said. Waterfowl populations are shifting and following the rice, he said.

As these dramatic population shifts unfold, the long-term impacts on waterfowl food and energy reserves, migration and reproduction are unknown. Hunters and guides are optimistic that conditions will improve in the Mid-Coast, but concerns are still growing, Brown said.

"We saw the duck numbers really decline enough this year that everybody was talking about it," he said.

Regional stakeholders go forward

As the region's water supplies, environment and populations continue to change, river authorities and water managers also have a myriad of difficult tasks in this water-strapped era: educating urban water users about conservation, enforcing drought plans and restrictions, and budgeting water to supply millions of users.

Regarding recent years' water cut-offs, Linda Campbell, former TPWD program director for private lands and public hunting, said, "The bottom line is that this is a water budgeting issue.

"It's a budget. It's a math problem. But, there's no easy answer."

The Lower Colorado River Authority (LCRA) announced in February 2015 that preliminary data showed the Highland Lakes in a new "critical period," with conditions surpassing the previous drought of record in the 1950s. Highland Lakes' water levels determine whether water will be released to downstream farmers or not.

In a news release, LCRA announced that it decreased its total reliable water inventory, or "firm yield," by about 100,000 acre-feet, to 500,000 acre-feet per year. One LCRA strategy for adding to the supply is building an off-channel reservoir. Lane City Reservoir in Wharton County will be completed in 2017, adding up to 90,000 acre-feet per year to the supply, according to LCRA.

"Having the capacity to store more water downstream will reduce demands on upstream supplies," Brown said.

Understanding the importance of water management and the true impacts of water release cut-offs on the people and natural resources downstream can be difficult for urban residents who don't have a connection to rural land, said Campbell, an Austin resident.

"If they're not duck hunters or coastal fishermen themselves, they may not understand the importance of freshwater inflows to marshes and estuaries along the coast," she said.

Some regional stakeholders have formed the Lower Colorado River Basin Coalition, which Brown co-chairs, and includes Ducks Unlimited, agricultural producers, National Wildlife Federation, five county judges, coastal fisheries business owners, Audubon Texas, Sierra Club, rice industry suppliers and others.

"We want to talk about the drought and how it's impacting everyone across the entire lower basin, not just rice farmers," Brown said, "because it impacts the river, the river resources, riparian areas, fish and wildlife in the river, as well as the bays, salinity in the bays and marine fisheries resources."

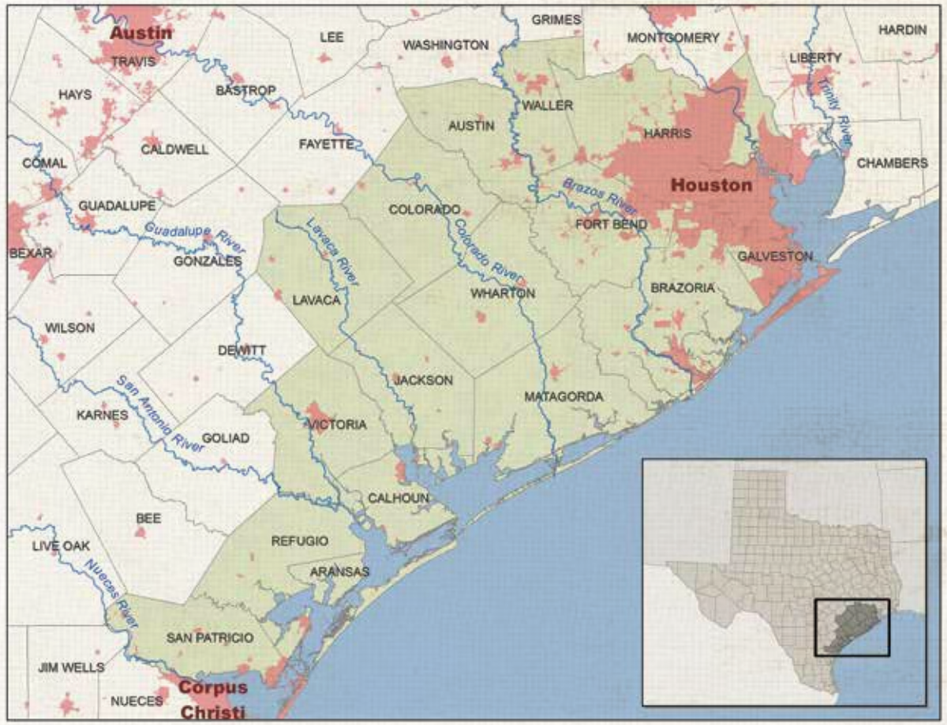
The coalition is supportive of the off-channel reservoir but focuses its efforts on calling for more "shared sacrifice" throughout the basin, he said.

"We've had some timely rain in recent years, and those rains from Austin down into the lower basin have been very good for both the river and the bays," Brown said.

As water supply and management conditions continue to evolve, Kraai said TPWD and its partners will focus on leveraging partnerships to conserve as much habitat as possible.

"We cannot work alone; the task is too daunting," he said. "We have to be realistic. We are probably not going to revert back to what that landscape looked like 50 to 100 years ago, but we're going to do our best to make it suitable for waterfowl."

For more information and resources, visit *txH2O* online at *twri.tamu.edu/txH2O*.



The Texas Mid-Coast stretches roughly from Houston to Corpus Christi. Map by Amanda Dube, TWRI.

Story by Kathy Wythe

CONSERVING THROUGH PARTNERSHIPS

New initiative targets water quantity, quality in Lower Rio Grande Valley

José Dodier, Jr. has lived along the Rio Grande most of his life. As a partner in the Don José Land and Cattle Company in South Texas' Zapata County and a longtime board member of the Texas State Soil and Water Conservation Board (TSSWCB), he is well aware of the challenges that land managers and agricultural producers face, especially in the Lower Rio Grande Valley. So, when he learned about a new water initiative for the Valley, he was thrilled.

The project — the Lower Rio Grande Valley Water Improvement Initiative — addresses the region's water quantity and water quality concerns. It is part of the Regional Conservation Partnership Program (RCPP), a new 2014 Farm Bill program that supports efforts between the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) and its partners to deliver conservation assistance to producers and landowners.

"Agricultural producers in Texas, for generations, have been doing the right thing," Dodier said. "There are technological advances that we need to implement, and it never ceases to amaze me how open they are to change, to trying new management practices that involve conservation. I believe this initiative is planting a seed that we will see benefits from for the next generation."

The Texas Water Resources Institute (TWRI) is leading the $3 million, five-year initiative, and TSSWCB is a key partner.

Partnerships promote conservation

Partnerships are fundamental to the new Farm Bill program. Partners will collaborate to coordinate conservation outcomes, according to NRCS.

"RCPP is a different approach to investing in natural resource conservation that empowers local communities and demonstrates the importance of strong public-private partnerships in delivering local solutions to tough natural resource challenges," said NRCS State Conservationist Salvador Salinas at a Jan. 15 news conference announcing the program. "NRCS and partners working through RCPP projects will help in bringing new ideas and technologies to production agriculture in the Valley."

Dr. Kevin Wagner, TWRI associate director, said the initiative focuses on enhancing agricultural water-use efficiency and improving nutrient management on the more than 300,000 acres of irrigated cropland in the Valley.

"However, our approach goes beyond on-farm conservation, although this is critically important, and includes regional planning, irrigation water delivery, monitoring, and education and outreach."

NRCS will distribute the $3 million to Valley agricultural producers to improve on-farm efficiency.

Wagner said that money is leveraged with more than $7 million of in-kind contributions from partners who have projects supporting the initiative's goals: TSSWCB, Harlingen Irrigation District, Rio Grande Regional Water Authority, Black and Veatch and Cameron County Irrigation District #2. Additional supporters include the Texas Water Development Board (TWDB), Texas Commission on Environmental Quality, Texas A&M AgriLife Research and Texas A&M AgriLife Extension Service.

TWRI is also working with local stakeholder groups, including the Rio Grande Regional Water Planning Group and Arroyo Colorado Watershed Partnership, as well as producer groups, such as Texas Citrus Mutual and the Texas Vegetable Association.

Wagner expects the list of project partners to grow throughout the initiative. "Our role is to facilitate the collaborations among all the groups already doing excellent water conservation and water quality work in the Valley."

Through existing planning efforts, such as the Rio Grande Regional Water Plan and the Arroyo Colorado and Brownsville Resaca watershed protection plans, he said the initiative is providing additional technical and financial assistance to Valley producers along with extensive outreach and education.

As the project advances, Wagner said the institute will track progress, such as number of acres with irrigation and nutrient management as well as miles ⇨

The waters of the Estero Llano Grande are part of the Arroyo Colorado, an ancient channel of the Rio Grande. TWRI has had projects in the Arroyo Colorado watershed for almost 10 years. Photo courtesy of the Arroyo Colorado Watershed Partnership.

of irrigation canals replaced, and evaluate how implementing conservation measures affect water quality and flows.

The initiative encompasses 1.59 million acres in Cameron, Hidalgo and Willacy counties and includes the lower Rio Grande, Arroyo Colorado and north Floodway.

"All these water bodies are important sources of freshwater inflows to the Lower Laguna Madre and ultimately the Gulf of Mexico," Salinas said.

Inseparable: Valley water quality, quantity

The Lower Rio Grande Valley was selected for a RCPP project not only because of its ecological importance and long-standing partnerships, but also because of its economic significance and the severity of its water supply and quality issues, Wagner said.

The Valley's population growth puts greater pressure on its limited water supplies, increasing the need for improved water-use efficiency.

"Between 2010 and 2060, population in the region is expected to grow 142 percent," he said. According to the 2012 Rio Grande Regional Water Plan, an additional 610,000 acre-feet per year will be needed by 2060. Significant unmet irrigation needs are expected if major improvements in water district conveyance systems and on-farm conservation practices are not achieved.

To support the initiative's water conservation goals, the institute is working with project partners on improved irrigation scheduling, better irrigation delivery and innovative irrigation technologies. For example, Cameron County Irrigation District #2 is converting 11 miles of open irrigation canals to pipelines and installing nine automated gates to its canal system.

Along with limited water supply, water quality problems also need to be addressed.

"Although addressing water quantity is the primary concern of this initiative, water quality and quantity are inseparable and intricately linked in the Valley," he said.

Wagner said those connections were illustrated by a 2012 AgriLife Research study that found the most important factor in determining nutrient loadings exiting a field was the volume of irrigation water runoff.

"What we can draw from this study is that improved irrigation water management, which will reduce irrigation return flows, will not only conserve water, it will also improve water quality."

The state has identified the Arroyo Colorado and Rio Grande as nonpoint source priority watersheds. "A reduction in nutrients in the Arroyo Colorado will help control excessive algal growth, increase dissolved oxygen levels and improve aquatic health in the Arroyo's zone of impairment," he said.

To achieve this reduction, the partners plan to apply nutrient and irrigation water management practices to 30,000 acres of irrigated cropland through this initiative and TSSWCB's water quality management program.

"Since the early 1990s, TSSWCB has invested millions of state and federal dollars as incentives to encourage nutrient and irrigation management implementation in the region, and the agency's current priorities include continued support," said John Foster, TSSWCB statewide programs officer.

Other planned high-priority practices include use of surge valves on furrow irrigation; conversion to narrow border flood irrigation for citrus; conversion of furrow or flood irrigation to drip, microspray or sprinkler irrigation; and installation of filter strips or wetlands to treat agricultural runoff.

"These innovations will decrease water use, improve productivity and reduce irrigation return flows, thus reducing nutrient and sediment loading to local water bodies," Wagner said.

Cameron Turner, TWDB team lead for agricultural water conservation, said the board has been very involved in improving water-use efficiency in the Lower Rio Grande Valley.

"This initiative helps facilitate the type of partnerships necessary to address the water needs in the region," Turner said, adding that TWDB is funding similar efforts that support the goals of this project. The Texas Project for Ag Water Efficiency through the Harlingen Irrigation District and Texas A&M-Kingsville Citrus Center's applied research on narrow-border flood are two examples.

Dodier said TSSWCB is also supporting the partnership through its support of TWRI's agricultural best management practices education efforts.

"To get all the agencies to work together on this initiative is great," he said. "The synergy that comes out of this is going to be huge."

For more information and resources, visit *txH2O* online at *twri.tamu.edu/txH2O*.

The RCPP is a competitive program that funded only 115 out of the 600 projects submitted throughout the country. In addition to leading the Lower Rio Grande Valley project, TWRI is a collaborator on the only other RCPP project funded specifically in Texas: the Texas Gulf Coast Stream and Wetland Initiative. That project, led by the Resource Institute, Inc., focuses on restoring and protecting headwater stream and wetland systems within a 54-county area that includes portions of six major rivers in the Texas Gulf Coast region.

Through the Lower Rio Grande Valley Water Improvement Initiative, agricultural producers will be encouraged to use polypipe for irrigation. Polypipe is one practice that can be used to conserve water and reduce field runoff. Photo courtesy of the Arroyo Colorado Watershed Partnership.

Story by Leslie Lee

Dr. Rabi H. Mohtar. Photo courtesy of Tom Campbell, Purdue University Agricultural Communications.

Quantifying connections

World-renowned Texas A&M researcher uses water, energy, food nexus to analyze resource problems near and far

In 2009, the Arab Gulf nation of Qatar, which imports more than 90 percent of its food, set out to improve its food security and established the Qatar National Food Security Program. Its government turned to a relatively new kind of analysis to test the feasibility of its goal: the water, energy, food (WEF) nexus.

"We know that the three resources — water, energy and food — form a nexus with quantifiable interconnections," said Dr. Rabi H. Mohtar, a Texas A&M Engineering Experiment Station endowed professor in the Department of Biological and Agricultural Engineering at Texas A&M University.

Mohtar and his research team used a nexus approach to analyze the nation's resources, quantify how those resources interact and help inform the government's next steps.

"We looked at the footprint of moving from the current baseline of 10 percent food production, into 20 or 30 percent," said Mohtar, who was serving as founding director of Qatar Environment and Energy Research Institute at the time. "What would be the water and energy footprint of that increased food production?

"In this case, energy wasn't a problem for Qatar, and water wasn't a problem because of desalination. We found that the limiting factor was the land footprint. Qatar didn't have the arable land needed to increase food production."

Nexus tool translates theory into analysis

Through studies such as the Qatar food security analysis, Mohtar has helped move the WEF nexus from idea to quantification.

"Policymakers will tell you, 'This is a neat concept, but what do I do with it?'" he said.

Mohtar's answer is the WEF Nexus Tool 2.0, a scenario-based computer modeling tool that can analyze nexus interactions for regions or small countries, applying the nexus theories and quantifications to real-world problems. Planners and analysts in water, energy and food, in both the public and private sectors, can benefit from using the tool, he said.

The tool requires three inputs for the region being analyzed, Mohtar said: a food portfolio, including local food production levels, food imports and agricultural production technologies; a water portfolio with data on water sources and supplies; and an energy portfolio, identifying energy sources for both water and agricultural production.

Mohtar said the tool enables users to identify a sustainable scenario in which the region could increase security of energy, food or water, without infringing on the others, and it also helps find the "bottlenecks" and challenges preventing higher production.

The challenges facing Texas' own water, energy and food resources are one of the main reasons Mohtar came to Texas A&M in January 2014, he said. His team is currently using the tool to analyze WEF nexus linkages in the hydraulic fracturing industry in Texas, quantifying both its benefits and side effects.

"Hydraulic fracturing has implications on energy security but also on water security."

The tool's purpose is not to tell policymakers what decisions to make, Mohtar said, but to quantify how each resource-related decision will potentially impact other resources. He believes in a holistic approach.

"We're not saying, 'You should do this or you should do that,'" he said. "What we're looking at is, if this is business as usual, if this scenario is the track you're moving forward in for securing water, energy or food, how does it impact the other resources?"

Mohtar said that his team's WEF nexus tool was among the first of its kind, but there are similar tools available, and analysts should choose the best one for their situation.

"I'm not saying 'This one tool is going to solve everyone's problems,'" he said.

Instead, he wants to promote the importance of "trade-off" analyses, in which resource-related decisions undergo preliminary scrutiny to quantify all potential effects on other resources.

"We need to be using these relevant tools to quantify impacts, so that when we move to secure one of these vital resources, we don't infringe on the others."

Analyzing Texas' water gap

According to the 2012 state water plan's projections, if the state does nothing in the meantime, Texas will be short 8.3 million acre-feet of water by 2060.

"So, how can you bridge that gap using different technologies, practices or policies, using different strategies that do not infringe on water or food?" Mohtar said.

In Spring 2014, Mohtar taught a WEF nexus graduate course that brought together students from all over the university, including students in political science, engineering and agriculture. The class focused on answering the question: How can Texas' water gap be bridged?

The students examined specific regulations, water pricing structures, conservation strategies, desalination technologies, groundwater management and wastewater reuse.

"Desalination does have an energy footprint and environmental implications," he said. "But, we cannot dismiss it in the future water portfolio for the state. I think that desalination is one of the strategies we need, as well as conservation, policies, groundwater management and recharge."

Bringing the nexus to Texas and the world

On a regular basis, Mohtar and his research team present the nexus tool to policymakers and researchers at meetings and conferences around the United States and world.

"We have a very active research group," he said. The team includes graduate and post-doctoral students in engineering, physics, political science and other disciplines.

Among various other global leadership roles, Mohtar served on the World Economic Forum's Climate Change Agenda Council from 2011 to 2014, the Board of Governors of the World Water Council since 2012 and the advisory board of the United Nation's Framework Convention on Climate Change – Momentum for Change Initiative since 2012.

In Texas, Mohtar's team is also working to educate the public and scientists about the WEF nexus and why it matters.

"Things are connected," he said. "Our food security is not independent from our water and energy security and visa-versa."

"The challenges in Texas are the same challenges faced in many other parts of the world. If we can solve them here and take leadership in terms of developing and using these tools successfully, then I think Texas can have a global impact in these areas."

For more information and resources, visit *txH2O* online at *twri.tamu.edu/txH2O*.

Story by Sara Carney

Jacob Green, TPWD fisheries technician, holds a recaptured paddlefish. Photo courtesy of TPWD.

IF YOU REBUILD IT, THEY WILL COME BACK

Re-establishing environmental flows in Caddo Lake brings back the paddlefish

When visitors travel to Caddo Lake on the Texas-Louisiana border, they may see people canoeing on the blue-green water, navigating between the towering bald cypress trees and the Spanish moss that sweeps down from the branches. They may see fishers catching largemouth bass and families hiking nearby trails. But what visitors might not see is a creature beneath the lake's surface that is older than the lake itself; in fact, it comes from the oldest animal lineage in North America.

Described by some as looking "bizarre" and "ancient," the American paddlefish lacks scales and has a long, spatula-shaped snout equipped with electroreceptors that detect the fish's next plankton feast. This fish can grow 5 feet long and live about 30 years, though some have reached 7 feet and lived 50 years.

After decades of absence, the paddlefish was returned to Caddo Lake in March 2014.

This return is not the first attempt to re-establish Caddo Lake's paddlefish population. In 1994 and 1998 more than a thousand paddlefish were unsuccessfully stocked in the lake. But, there is one crucial difference between this reintroduction and others: environmental flows.

(Left photos) U.S. Fish and Wildlife Service technicians surgically implant radiotransmitters in paddlefish before release. Photos by Dawn Orsak, Caddo Lake Institute.

(Right photo) John Blackman tracks paddlefish in Caddo Lake. Photo courtesy of TPWD.

Flows matter

The term environmental flows refers to the amount of water that must move through a freshwater body, such as a river, and the timing of this movement to maintain native biodiversity and ecosystem processes. Environmental flows affect virtually every aspect of a river's ecology, including water quality indicators, such as dissolved oxygen, pH, nutrients and temperature.

Historically, Caddo Lake had high flows into the lake in the late winter and early spring and low flows in the late summer and early fall. According to experts, these flows defined the lake's ecosystem, including native fish species, such as the iconic paddlefish.

By synthesizing available data, Texas A&M University scientists developed a report in 2005, which revealed the importance of seasonally variable flows to Caddo Lake's ecosystem. The report indicated that both plant and animal species are affected by flows, said Dr. Kirk Winemiller, an aquatic ecologist in Texas A&M's Department of Wildlife and Fisheries Sciences and an author of the report. For example, many fish species, such as the paddlefish, rely on high flow pulses as signals that trigger migration and spawning.

The dam that forever changed Caddo Lake

The majority of water flowing into Caddo Lake comes from the Big Cypress, Little Cypress and Black Cypress creeks. Along Big Cypress Creek, before reaching Caddo Lake, lies the Lake O' the Pines Reservoir, which was created by building Ferrell's Bridge Dam. This reservoir provides flood protection and water supply to Jefferson and surrounding cities.

The construction of Ferrell's Bridge Dam in 1959 reduced winter and spring high flow pulses as well as base flows that naturally occurred throughout the year, according to the Texas A&M team's report. This meant that some species within the lake no longer had the flows needed to maintain healthy populations, Winemiller said.

Experts believe it is possible to reduce flood damages and maintain water supplies while managing flows in a way that is beneficial to the environment, an issue frequently faced in managing dams. "That is the balance that people are trying to maintain across our ⇨

state and throughout the world," Winemiller said.

Through collaboration among a number of organizations, the Texas A&M team's recommendations to replicate key components of natural flows are being translated into action.

Working with flows

This attempt to restore flows in Caddo Lake and its tributaries is relatively recent. In 2004, the Caddo Lake Institute (CLI) teamed up with The Nature Conservancy (TNC) Sustainable Rivers Project and the U.S. Army Corps of Engineers to start the Cypress Basin Flows Project.

The project began with data collection by scientists, such as the Texas A&M team, to ensure that this effort would be as well informed as possible, said Rick Lowerre, CLI president.

Once there was enough evidence that changing how water is released would benefit the ecosystem, the project began flow changes in 2011. In agreement with the Corps of Engineers and the Northeast Texas Municipal Water District, the flows project was set for a five-year period, during which the flows will be adjusted by the Corps of Engineers to mimic natural flows.

"The Corps and other partners have really been working to implement some of the scientists' flow recommendations, those changes in operations of the dam, and to do so in coordination with the scientists, so they can monitor the responses downstream," said Andy Warner, program coordinator for TNC's Sustainable Rivers Project.

Sources agreed that the flows will likely never be fully restored to their original state, but they say there is no doubt that flows can be managed so both the needs of the environment and the people are met.

Caddo Lake's whistle-blower

Scientists cannot feasibly study every species in an ecosystem, so they often pick one or more indicator species to monitor ecosystem health. These species act like a whistle-blower, alerting scientists to potential ecosystem threats. Indicator species' population declines can be an early warning sign that factors such as pollution may be affecting the ecosystem. In Caddo Lake, a chosen indicator species is the paddlefish, due to its sensitivity to flows and threatened status, Winemiller said.

Paddlefish were once abundant in Caddo Lake, and in the 1940s and 1950s there was a commercial fishery for paddlefish at the lake. It wasn't until the Ferrell's Bridge Dam was built that paddlefish began to decline.

"The paddlefish was extirpated after the dam was built; that tells us something has happened," Winemiller said. The fact that previous reintroduction efforts that did not include flow changes were unsuccessful further indicates that the change in flows may be directly linked to the paddlefish's survival in Caddo Lake, he said.

The paddlefish's local extinction was merely a symptom of a changing ecosystem, he said.

"The whole project is really about more than just the paddlefish," said Tim Bister, the local fisheries biologist with the Texas Parks and Wildlife Department (TPWD). "The bigger picture is creating a more natural river flow throughout the year by having certain water releases from Lake O' the Pines mimic that natural river flow."

The paddlefish comes home

After the joint effort to restore natural flows based on scientists' recommendations, conditions were ripe for the paddlefish's return to Caddo Lake. "We've prepared the way this time," Lowerre said. "I think before they were just reintroduced without anybody thinking about what changes might be needed to encourage them to stay."

In March 2014, TPWD and the U.S. Fish and Wildlife Service (USFWS) released 47 young paddlefish from the Tishomingo National Fish Hatchery in Oklahoma into Big Cypress Creek. The fish were about 2 feet long and a year and a half old, Bister said.

Currently, these 47 paddlefish are being monitored via radio transmitters by USFWS and TPWD. Each time a paddlefish passes by one of the stationary towers near Caddo Lake, its location is recorded, Bister said. Tracking data is then uploaded to CLI's website, so that anyone can view their movement.

A major concern was that the paddlefish were going to escape over the Caddo Lake spillway, where the dam would block them from swimming back upstream. But this does not appear to be happening. So, when the Tishomingo hatchery asked if TPWD wanted an additional 2,000 paddlefish for Caddo Lake, Bister said, "Sure, let's get them in there!"

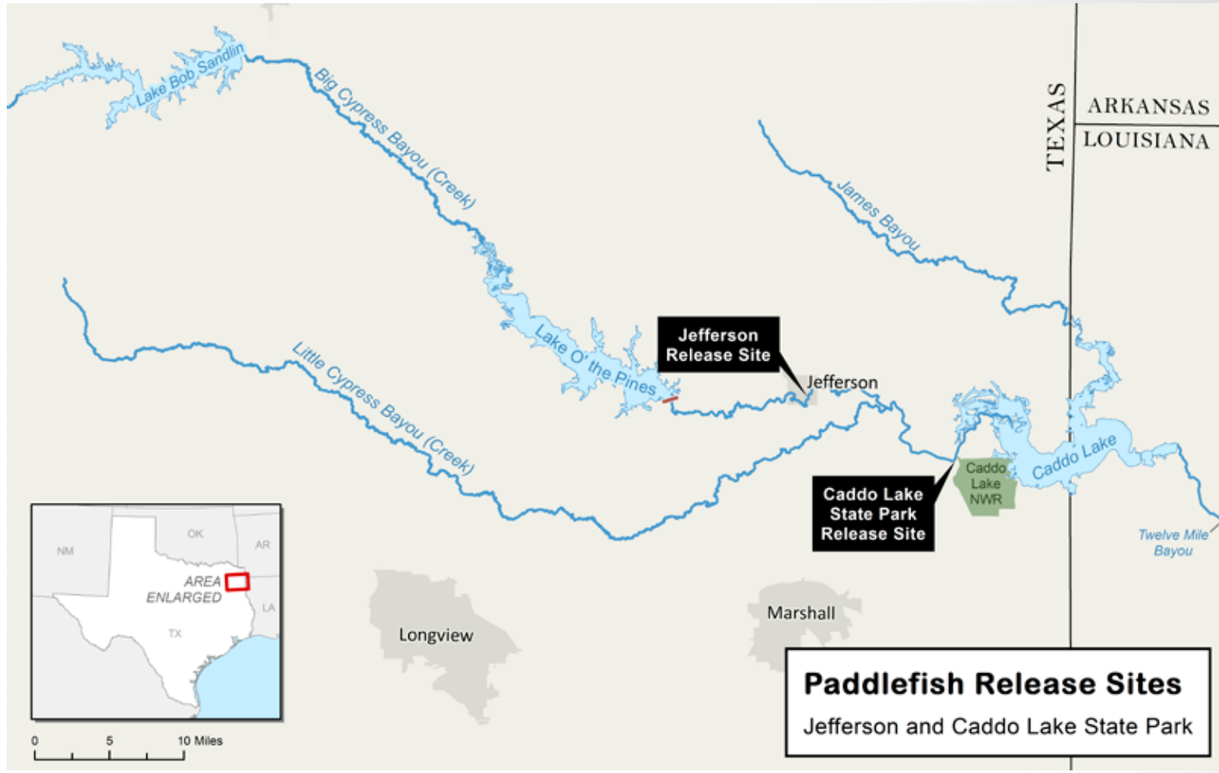
That September, those 2,000 paddlefish were brought from Oklahoma to Texas to join the first 47.

The paddlefish are expected to begin spawning at 7 to 8 years old. "I think having a healthy, naturally reproducing population of paddlefish will be a sign that the restoration work by all the partners is moving that system in the right direction," Warner said.

Paddlefish educate local communities

One of the greatest benefits from the paddlefish release was the educational opportunities it brought, the experts said.

"The paddlefish is a way to help explain why we are doing these environmental flow studies and trying to change the system," Lowerre said.



Map recreated by Amanda Dube, TWRI.

"Without the paddlefish, it's hard for people to envision what it means."

Several local schools have "adopted" and named paddlefish. Through CLI's website, students or anyone interested can monitor the activity of "Don the Fish," "Polly Sprinkles," "Flat Billy" and other adopted paddlefish.

The potential for paddlefish to educate people about environmental flows extends beyond monitoring their movement. In May 2014 Collins Academy in Jefferson hosted the first Paddlefish Festival, an educational event for local schools to learn about Caddo Lake. The event included nature walks, mobile classrooms and student presentations.

Educational opportunities are not just for kids. TPWD holds workshops at Caddo Lake State Park to teach visitors about Caddo Lake's history, the local plants and, of course, the paddlefish.

Efforts continue

The paddlefish restoration is simply the beginning, a way of reminding people of the value of Caddo Lake and its ecosystem, Lowerre said. CLI will continue to monitor flows and determine the best course of action for the paddlefish and the ecosystem as a whole.

While the paddlefish is a small piece within the Caddo Lake ecosystem, the Caddo Lake ecosystem is a small piece within Texas' ecosystems. "The Caddo Lake situation is a model for the rest of the state," Winemiller said. "Hopefully, in the future, we will see more cooperative efforts like this in other parts of the state."

Ultimately, both the paddlefish reintroduction and the flows projects are meant to preserve the ecosystem long term. Lowerre said, "We want this system healthy for not just this generation, but for generations to come."

For more information and resources, visit *txH2O* online at *twri.tamu.edu/txH2O*.

Texas A&M AgriLife Extension Service

Texas Water Resources Institute
make every drop count

2260 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

Scan code with your smart phone for more on *txH$_2$O*!