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Fall 2018

OGALLALA AQUIFER

Inside: Q&A with Ogallala Aquifer project managers, celebrating 40 years of center pivot and more!

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

Researchers in The Texas A&M University System have been working to better understand and manage the Ogallala Aquifer for around a half-century. To attempt to describe the Ogallala Aquifer requires the use of superlatives. In purely physical terms, it is one of the world's largest freshwater bodies, the only freshwater body in the United States that touches eight states, and the largest source of fresh groundwater currently known in North America. Before extensive pumping began, it contained more drainable water than Lake Huron. In social and economic terms, the Ogallala Aquifer is the lifeblood of the High Plains region. Before the vast resources of the aquifer were developed, the region was considered a desert, with little opportunity to support cities or agricultural production. Currently the region supports a population of over 2.3 million people and contains more than a quarter of the irrigated land in the United States, all relying on water produced from the aquifer.

However, another characteristic of the Ogallala Aquifer recognized several decades ago is that water tables in the southern regions (Kansas, Texas and New Mexico) are declining, and that there is not enough natural recharge to replenish the aquifer. Thus, the Ogallala must be managed as a finite source of freshwater. This realization has led water users and research organizations to work together to better understand the behavior of the aquifer and develop advanced technology and management practices to ensure that water from the Ogallala is used in the most beneficial manner practicable.

This issue of *txH2O* highlights the range of research activities across the Ogallala Aquifer region, focusing on two large research efforts supported by the U.S. Department of Agriculture (USDA). The Ogallala Water Coordinated Agricultural Project (Ogallala Water CAP), funded by the USDA's National Institute for Food and Agriculture, is a collaboration between Colorado State, Texas A&M, West Texas A&M, Oklahoma State, New Mexico State, Texas Tech and Kansas State universities. The University of Nebraska-Lincoln and USDA's Agricultural Research Service (ARS). The ARS-funded Ogallala Aquifer Program (OAP) is a collaboration between Texas A&M, Texas Tech, West Texas A&M and Kansas State universities and ARS. The projects presented in this issue are only a sampling of the vast amount of research that has been undertaken across the Ogallala, and I encourage the readers who are interested in learning more to visit the OAP website at ogallala.tamu.edu and the Ogallala Water website at ogallalawater.org.

As always, please join us as we work to "make every drop count."

John C. Tracy, Ph.D.
Director

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A satellite image of center pivot irrigation fields near Garden City, Kansas. Photo credit: NASA.

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make every drop count

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Center pivot irrigation is widely used in the Ogallala Aquifer region. Low energy precision application sprinklers help save money, water and energy. Photo by Kay Ledbetter, Texas A&M AgriLife Communications.

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Story by Kathy Wythe

Q&A

with Dr. Dave Brauer and Dr. Meagan Schipanski

Dr. Dave Brauer, (top), acting director for the Conservation and Production Research Laboratory in Bushland, Texas, and Dr. Meagan Schipanski, assistant professor in Colorado State University's Department of Soil and Crop Sciences.

The Ogallala Aquifer is the largest aquifer in the United States and one of the largest in the world. It overlies 111.8 million acres in parts of eight states: Texas, New Mexico, Oklahoma, Colorado, Kansas, Nebraska, South Dakota and Wyoming, an area referred to as the High Plains. For more than 80 years, the aquifer has played an essential role in the economic development of the High Plains by supplying water for agriculture and municipalities. Irrigating crops with aquifer water began extensively in Kansas and Texas after the 1950s drought. Today, the aquifer supplies water for about a quarter of U.S. agricultural production and more than 40 percent of U.S. feedlot beef cattle. More than 95 percent of the water pumped out of the aquifer is used for irrigated agriculture. It also supplies drinking water for 82 percent of the people who live within its boundaries.

However, water table levels in some parts of the aquifer are declining and, particularly in the southern half of the aquifer, recharge is small compared to depletion. With the decline of the aquifer, many fear the decline of the sustainability and continued success of the region.

The Ogallala Aquifer Program (OAP) and the Ogallala Water Coordinated Agriculture Project (Ogallala Water CAP) are two U.S. Department of Agriculture (USDA)-funded projects that are examining ways to extend the life of the aquifer and sustain agriculture and the rural economy. The OAP, funded by USDA's Agriculture Research Service (ARS) since 2003, consists of research and extension teams from USDA, Texas Tech University, Kansas State University, West Texas A&M University and Texas A&M AgriLife Research.

The Ogallala Water CAP, funded by USDA's National Institute of Food and Agriculture in 2016, consists of faculty from Colorado State University, University of Nebraska, New Mexico State University, Kansas State University, Oklahoma State University, Texas Tech University, Texas A&M AgriLife Research, Texas A&M AgriLife Extension Service, Texas A&M Engineering Experiment Station's Texas Center for Applied Technology, West Texas A&M University and ARS.

txH2O asked the two projects' leads to talk about the projects, their objectives, significant accomplishments and the future. Dr. Dave Brauer, manager of the OAP, is the acting director for the Conservation and Production Research Laboratory in Bushland, Texas. Dr. Meagan Schipanski, an assistant professor in the Department of Soil and Crop Sciences at Colorado State University, serves as the Ogallala Water CAP co-director along with Dr. Reagan Waskom, director of the Colorado Water Institute.

The USDA has funded these projects that focus solely on the Ogallala Aquifer. Why is the aquifer so important to warrant this attention by the agency and these universities?

Schipanski: The Ogallala Aquifer is such a critical resource that supports a large portion of U.S. agricultural production, both crops and livestock, as well as the communities that live above it. These water challenges are not unique to the Ogallala Aquifer so if we can figure out how to manage this shared resource, it will benefit other parts of the world and the United States that are facing similar water challenges. It is a complex problem. It is economics; it is a physical resource but it is also people's history, culture and community. That is part of why it is challenging and why it is so important to figure out solutions to engage people in these difficult conversations on how we take individual and collective actions to conserve groundwater.

Brauer: The Ogallala Aquifer area is one of the greatest agricultural production areas in the United States. Agricultural production, a mixture of both crop and livestock, accounts for more than 20 percent of agricultural output in the country. It is an integral part of the U.S. agricultural economy.

What are the specific agricultural challenges for this region now and as we move into the future?

Brauer: The problem with the challenges in the Ogallala Aquifer region is that they are very site specific. The amount of water in the aquifer before we started irrigating varied; the water demand varied. So it is really difficult to say what the challenges are for the region because of that. But, if we start to break the area down into subareas, then we can talk about some real specific challenges. A report in 2016 by David Steward of Kansas State University showed the projected changes in water and storage by state starting in 1900, or pre-development of irrigation, to 2100. Currently, Texas and Kansas have used about 40 percent of the water in the Ogallala underlying these states, compared to Nebraska that has used 1 percent. If you carry those trends out to 2100, Nebraska will still have over 90 percent of predevelopment water in storage. Kansas and Texas are going to be down well under 40 percent. So when we talk about the southern Ogallala region, the future challenge is going to be water availability. There will be places that don't have enough water in storage for the irrigation technology that we currently have. Other places will have some water but not enough to fully irrigate, and other places will have lots in storage. The challenge is having a suite of research and technology to address this site-specific water availability issue.

Schipanski: Groundwater is declining in the aquifer — not everywhere in the aquifer; there are places in Nebraska, for example, where it is not declining — but generally the aquifer is declining. Water quality is also becoming an increasing issue in many parts of the aquifer region. Warming temperatures, more intense rainfall and more prolonged droughts are predicted for the region; these are just going to exacerbate these challenges of maintaining the viability of our production systems as water becomes scarcer. The other challenges are more about the social and economic barriers to water conservation. These can include regional and federal policies and water laws as well as changing individual and collective mindsets. To address the challenges, we really need to think about how we view water both in the short term and, particularly, how we think longer term about conservation goals.

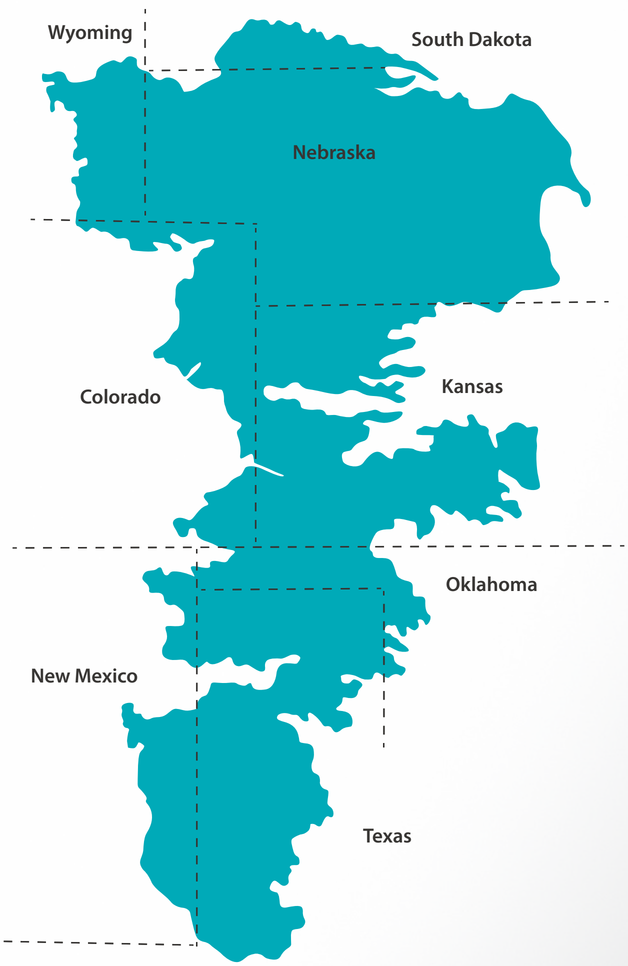
What are primary goals of your project and how do the two projects differ in their focus?

Schipanski: As a Coordinated Agriculture Project, our project specifically targets doing integrated research and extension across institutions to tackle a large issue or problem. So our goal is to foster innovative research and communications that leverages the expertise we already have and the partnerships we have with stakeholders across the state lines.

What we have been trying to emphasize is that what works in Texas may not work the same way in Nebraska, but there are lot of advantages to learning from each other that can spark new ideas, approaches or partnerships.

Brauer: The goals of the OAP were laid down by a federal appropriation bill and they are two-fold: to provide technology and information for water conservation for agricultural production and to provide tools and knowledge for scientifically based water policy development.

One of the big differences between the two projects is funding. The OAP began in 2003. We have had relatively stable funding since 2007-08. Having a stable funding source over a long period reaps certain benefits. It allows you to build teams. One of our priorities in OAP is that our investment in research and technology transfer activities is highly leveraged. Most of our funds do not go to new hires; they are targeted to take the existing infrastructures available at the research facilities at the participating universities and ARS and add a little to that so additional research can be done. ⇨



OGALLALA AQUIFER

Dr. Bauer, the OAP has been funded for 15 years. What are the most significant outcomes from the project to date?

One of the biggest accomplishments is that we have really built some nice teams across the four institutions; two teams in particular are the economic assessment and impact team and the technology transfer team. Building these multi-institutional teams is important. For example, Kansas researchers came out with some decision support tools, and it became apparent that it would be much more time-effective if we adapted the tools from Kansas to Texas rather than creating our own. So there is a synergy. The problems are site specific, so if you are able to pull together and synthesize information on a technology across a gradient of 400 miles from north to south, you are adding real benefits for our stakeholders.

Another successful output is from the economic assessment and impact team. This group looked at the economic impact of various agricultural industries. They also looked at water use and water availability and the potential effects of changes in groundwater availability for those industries. They gathered information and put it in a package that gets updated regularly. The other thing they have looked at is if certain water policies are implemented, what is the effect and how resilient are our agricultural systems to changes in water availability?

On the more technical side, research and technology transfer of irrigation technologies have been a big deal. As water declines, we need to add water in the right area at the right time. Much technology has been tested, including a great interest in mobile drip irrigation systems. Data from OAP teams in Kansas and Texas have shown that those systems work and can save water especially in a dry year. In both Kansas and Texas, the use of plant- or soil-based sensors for irrigation scheduling is much lower than it is in Nebraska. Both the technology and technology transfer is needed to increase the use of sensors, and OAP has been on the forefront of that.

Dr. Schipanski, the Ogallala Water CAP has been very busy in its short time of funding. What are the project's most significant accomplishments to date?

In terms of the science, we have engaged in synthesizing information across our team, both in terms of limited irrigation approaches and soil health science and how they relate to limited water systems. One of the most novel scientific outcomes from this project is that we are developing an ambitious, cutting-edge integrated modeling approach that is really stretching people beyond their normal disciplines.

We have our agronomists talking to our crop modelers talking to our economists and our groundwater modelers, trying to figure out how we can build a tool that will allow groundwater management districts to ask "what-if" questions, such as: "If we implement this policy or that practice, what are the impacts going to be on groundwater, crop production and economics?" We have made great headway in creating that model.

As far as outreach, we are a conduit for communications about the aquifer and have benefited from being a neutral party not linked to one state or region in particular. One of the most important outcomes so far is co-organizing the Ogallala Aquifer Summit with the Kansas Water Office in spring 2018 that brought together more than 200 ag water managers across all of the Ogallala states to learn about what is working and where cross-state communications and learning can move things forward.

How do you see your project addressing challenges going forward?

Schipanski: One of the key things we are trying to do is not only use cutting-edge science but at the same time work alongside producers and groundwater management districts to make sure that we are building approaches and tools that will help them determine their futures. It is important that we don't just do our science but do our science engaged with stakeholders, with back-and-forth communications, so what we are doing is relevant and actually useful to extend the life of the aquifer and help people identify transition strategies where groundwater is declining more rapidly.

Brauer: Challenges going forward are varied. Those of us working in the federal government are facing challenges from the administration and that affects how we operate and do business. Another challenge is OAP funding; although stable, it has not grown in 10 years. We have also seen real changes in how OAP funds were used over the last seven and eight years. Other challenges have been necessitated by changes in state budgets. Texas went through the recession later than most states but the state budget currently is in a bit of challenge because oil prices have dropped. This has really necessitated that a lot more of our OAP funds go to supporting long-term post docs rather than graduate students.

In terms of science and technology, we are always going to be changing and adapting and looking for what is best. The example I like to give is the research looking at leaf temperatures as a way to know when to irrigate. Researchers from ARS in Lubbock, Texas started this technology in the 1990s. It had to be hard-wired and was $20,000 per sensor.

Similar sensors are now down to the $100-$200 range and can be integrated with Wi-Fi signal. So you never know, what seems unreasonable today will be easily implemented somewhere in the future.

Other agricultural regions are facing issues similar to those in the Ogallala region. What lessons can be shared with these regions?

Brauer: Issues regarding water availability for agriculture are worldwide. It is a sad commentary, but agriculture's return on water does not generate as much money as other water users do. Therefore, it is difficult for agriculture to compete with water users. A lot of the lessons we are learning in the Ogallala region can be adapted to other areas, especially other semi-arid areas. Because of current trends in climate and weather, more and more people are looking toward irrigation as essentially an insurance program to offset drought and high heat conditions. Because many areas are facing declining water availability issues, ideas on how we gather support among water users and get them to have a collective thought or action is important and could be helpful to other regions.

Schipanski: Within the United States, Arizona and California are experiencing similar issues but there are also areas in Australia, India and South America. In South America, countries are actually increasing their adoption of irrigation so maybe they can use our lessons learned to sustainably manage their water.

It is currently predicted that groundwater in parts of the aquifer will be at levels that will make it uneconomical to pump water for irrigation by 2050. What do you envision agriculture will look like at that point?

Schipanski: There are areas in New Mexico where we can already see the future a bit, and we are seeing people irrigating smaller parcels or moving to dryland crops or pastures. If they are moving to smaller parcels, they are looking at higher value crops. For example, in Texas there is increased wine grape production. As we look forward, producers are going to need additional income streams, so there has been some interest in wind energy and other potential income streams. Diversifying could help soften that transition.

There is a growing awareness of the importance of soil conservation and soil health as we move toward more limited water, so we need to think about how we manage our systems with lower water to make them more resilient in terms of crop rotations and pasture mixes. In other regions, such as some areas of Kansas, groundwater is declining, but they have enough remaining capacity and recharge that they could extend the timeline of the aquifer through the adoption of technology and efficient water management without drastic shifts to, for example, dryland agriculture.

Brauer: Changes in agriculture will be an incremental change. Some areas are going to be harder hit than others are. People are only going to give up irrigation, fighting tooth and nail. If producers think they can pump enough water to get their crop established, they are going to leave the irrigation system in place. We are going to see a gradual decrease in water application per irrigated acre. Eventually when they are unable to pump anymore — technology says at 30 feet of saturated thickness — my prediction is that a lot of the land will go into dryland production. If you have been farming irrigated acreage, you already have the infrastructure to dryland farm.

When we look at income on a county-by-county basis, the counties that have animal agriculture are going to be less affected by the decline in the irrigation because the receipts from animal agriculture are so much greater. There are quite a few counties on the Texas High Plains south of Lubbock where confined animal feeding operations are minor so as irrigation goes out in those areas, those farm economies are going to be hit the greatest.

Are there any other thoughts you would like to share with our audience?

Brauer: What I want the readers to take home is that we need to have optimism; there are plenty of reasons from the past to have optimism. We are going to continue to find better ways to conserve water and use water wisely. We have challenges, but the tools are going to be developed to enable us to do a better and better job.

Schipanski: There are technologies and great examples of producers being incredibly efficient in their water use; however, efficiency can lead to more water consumption. So it is important to pair improvements in water-use efficiency with some agreed upon collective limits to achieve true water conservation. Our goal is that the Ogallala communities come up with their own solutions based on good science.

Story by Alexandra Hoskins

21st Century Irrigation

Researchers develop irrigation scheduling tools to help producers manage water

A producer who controls irrigation using a smart phone. A spreadsheet that uses weather data to predict when to water crops. Sensors that read how much water is in the soil. While some technologies may seem farfetched, especially in an agricultural context, they have been an integral, yet underused, part of water management for years.

Producers have long struggled with challenges in their irrigation practices. From water availability and unpredictable weather patterns to regulations from outside entities, it can be a challenge to irrigate crops.

Researchers from the states over the Ogallala Aquifer are working on new water management technologies to help producers irrigate more effectively and save water resources. These tools, which could conserve millions of gallons of water, will become vital to success as the population grows and water availability dries up, researchers said.

Using smart, precise technology to irrigate

The Dashboard for Irrigation Efficiency Management (DIEM) is a software tool that helps producers schedule field-specific irrigation that optimizes yield and water-use efficiency based on rainfall and irrigation availability. While other irrigation scheduling tools are available, the DIEM is unique because it looks at the available water and plans for the entire growing season, said Jim Bordovsky, agricultural engineer and senior research scientist at the Texas A&M AgriLife Research and Extension Center in Lubbock and one of the developers of the tool.

DIEM uses evapotranspiration data — the amount of water lost through transpiration by the plant and evaporation — to make predictions about when the producer should irrigate. The program also uses historical, almost real-time and future information from weather, soil and the crop being grown to recommend irrigation schedules, according to the DIEM website. Bordovsky said future developments will allow the program to include soil moisture sensor information to help with the accuracy of predictions.

Bordovsky said a four-year study that looked at irrigation timing and the effects it had on cotton crop yields led to the development of DIEM.

"The tool works by helping producers with limited irrigation capacity determine the best time to water their crops to obtain the greatest crop yield with the least water," he said.

The original software tool is available online and requires a computer and internet access to work. In spring 2018, a mobile application was released. It can be used on smart phones with internet access.

"The addition of a mobile application makes it easier for producers to access the tool when they are in the field," Bordovsky said.

By using DIEM, Bordovsky said producers are able to plan for the coming season and back up their intuition and experience with quantifiable data.

"This tool gives producers the confidence that the decisions they are making are correct."

While DIEM is an effective tool, it is not the only technology that uses evapotranspiration data to assist producers.

Irrigation scheduling tools, such as DIEM, KanSched and WISE, help producers with limited irrigation capacity determine the best time to water their crops to obtain the greatest crop yield with the least water. Photo by Kay Ledbetter, Texas A&M AgriLife Communications.

(left) Agustín Nuñez and Angie Moore of Colorado State University are sampling soil in eastern Colorado. Photo by Dr. Meagan Schipanski, Colorado State University. Drs. Gary Marek (far left) and Kevin Heflin wire an array of 84 soil sensors into a programmable data logger and test for connectivity on a winter day in 2018. Photo by Thomas Marek, AgriLife Research.

Researchers in Kansas have developed KanSched, an irrigation scheduling program that also uses evapotranspiration data to determine the ideal watering time for crops. KanSched was first developed in the early 1990s as an Excel spreadsheet. Currently, KanSched is available online without a desktop program. KanSched is used as a backbone by other mobile applications to build their scheduling applications, but a KanSched mobile application has not yet been developed, said Dr. Jonathan Aguilar, assistant professor and extension water resource engineer at Southwest Research-Extension Center in Kansas.

"There is less clicking [on the computer] and more swiping [on a smart phone] now," Aguilar said. "This makes the need to develop a mobile application more urgent."

Aguilar said the program was developed for Kansas but it is applicable in other states and abroad, adding that requests have been made for a metric version.

Aguilar said the reason for KanSched's popularity is the producer's ability to know when they need to irrigate based on the tool's ability to estimate how much water is still in the soil profile. KanSched uses evapotranspiration data, the crop type and irrigation amount to guide the user toward the best water management step. Recent versions of KanSched make it easy to input rainfall and evapotranspiration data, allowing producers to easily manage multiple fields in the program.

"Communication between producers and extension researchers helps improve KanSched," he said.

When the program was first developed, Aguilar said extension researchers were able to work with producers to teach them how to use KanSched and a personal computer, simultaneously. This relationship helps producers use new technology to better manage their crops and keeps extension researchers updated on producer concerns. The program was developed to be user-friendly enough that anyone could use it to schedule irrigation.

"The name came from 'anyone can schedule' shortened as KanSched, which conveniently ties in with the state where it was developed, Kansas," Aguilar said.

This play on words reminds producers that scheduling irrigation and using best management practices with KanSched is as simple as a click on the computer.

While a mobile app is in the works, other technologies have already established a mobile platform.

The Water Irrigation Scheduler for Efficient Application (WISE) was developed in Colorado to assist producers with improving irrigation water management, according to its website. Since 2014, WISE has been available online and as a mobile application.

WISE uses field capacity, wilting point and a threshold soil water level between the two to ⇨

determine the irrigation schedule. Field capacity is the maximum amount of water the soil can hold after natural drainage. Wilting point is the minimum amount of water at which the plant leaves droop (wilt).

Soil moisture deficit, the difference between field capacity and the actual amount of water in the soil, is also used.

A study on the impacts of WISE found less water usage after implementation. The study, conducted over three growing seasons between 2010-2012 in a sprinkler-irrigated corn field, showed that in 2011 the total irrigation was reduced by 27 percent. The producers used more water when they did not use WISE, according to the study by Dr. Allan Andales, associate professor and extension specialist in irrigation and water science at Colorado State University.

Early in its development, WISE went through many rounds of stakeholder testing and feedback. This information helped researchers make the program more user-friendly and accommodate producer needs. In 2016, WISE won the Educational Materials Award for Digital Decision Aids from the American Society of Agronomy. In 2018, it received an Educational Aids Blue Ribbon Award from the American Society of Agricultural and Biological Engineers.

Going forward, continued feedback helps researchers improve WISE so that more water can be conserved through irrigation practices.

As technology grows and conservation becomes "smarter," it is vital to obtain accurate readings from the soil.

Sensing soil moisture

Researchers and producers use soil water sensors to better estimate water available to plants and help with irrigation scheduling. While using these sensors properly can be challenging, the information learned through research is applicable in the field for producers today and in the future.

Dr. Robert Schwartz, soil scientist at the U.S. Department of Agriculture's Agricultural Research Service Conservation and Production Research Laboratory in Bushland, Texas, said one of the factors affecting the lack of sensor use by producers is the need for sensor calibrations specific to soil conditions in a field. Sensors must be calibrated to match the soil type; otherwise, moisture readings can be misleading. Research into developing calibrations for different soil types helps improve sensor accuracy. Soil type, including the amount of clay in the soil, temperature and electrical conductivity of the soil can all affect soil water sensor accuracy, he said.

"Another challenge is that having data from a few installed soil water sensors may not be representative of the quantity of water within the soil profile throughout the entire field, which can cause considerable uncertainty in determining the available water for crops and scheduling irrigation," Schwartz said.

One benefit of using soil water sensors is the ability to observe how deeply irrigation and rainfall moves into the soil and the pattern of daily crop water use. Schwartz said other monitoring systems and programs cannot give a daily picture of the available water status; this is where soil water sensors can excel. The ability to see how water is being used by crops and then replenished by irrigation is valuable, real-time information that can only be approximated by other systems, he said.

"Currently, using soil sensors for scheduling irrigation may not be practical for producers because of accuracy concerns, but continued research and advances will help soil sensors become a more widely used tool in the quest for water conservation in irrigation," Schwartz said.

To get the clearest picture, it is still important to use many different tools when irrigating, he said.

"Soil water sensing should be integrated with other water management technologies for the best results," Schwartz said. "We should always try to avoid using a single technology to manage irrigation."

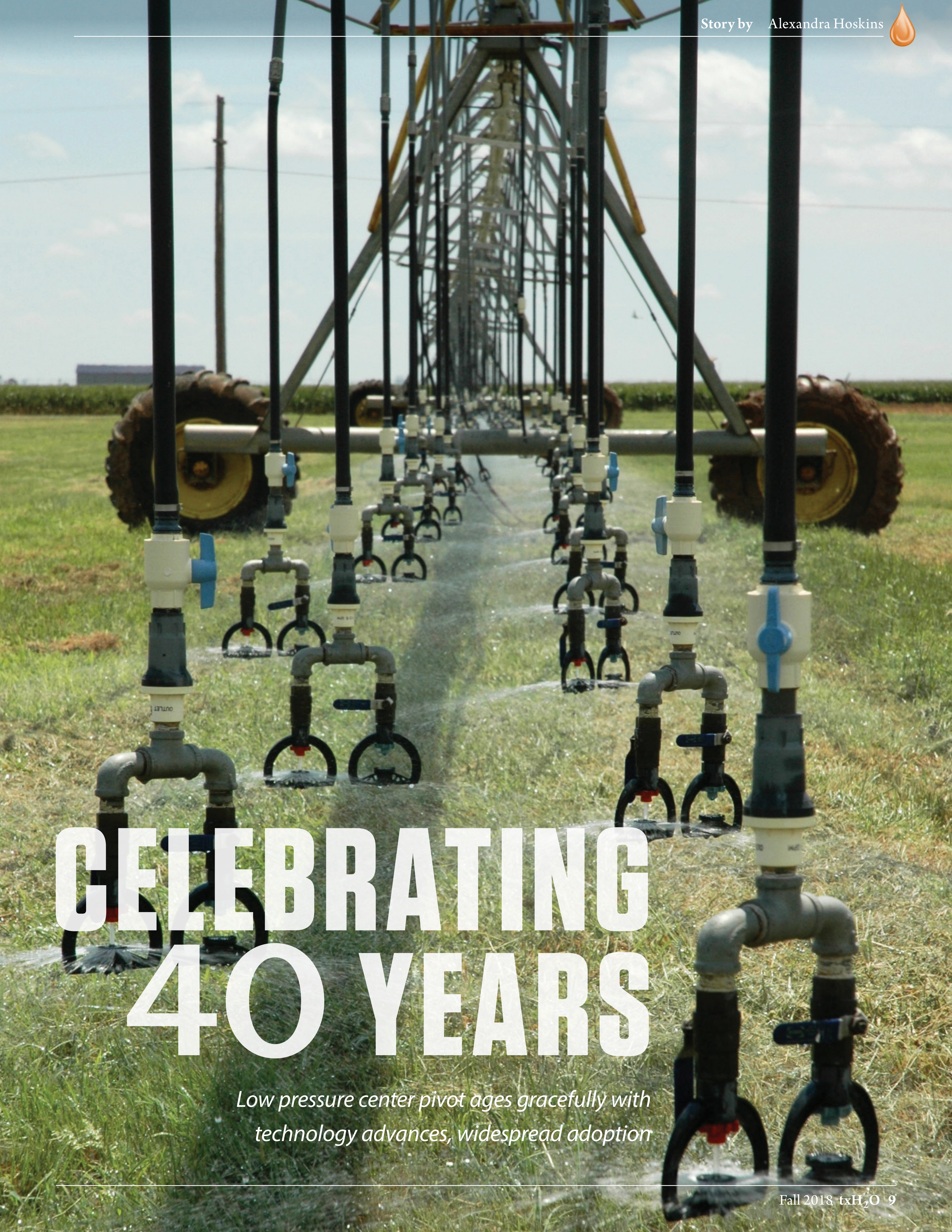
Nothing replaces common sense

From mobile apps to spreadsheets and sensors, irrigation is becoming more technologically advanced by the year. Researchers are working on cutting-edge technological assistance to increase crop production and help producers conserve water, while making these technologies user-friendly and accessible.

"These irrigation technologies have been around for many years, but the adoption rate of soil and plant technologies by producers is very modest," said Dr. Saleh Taghvaeian, assistant professor and extension specialist at Oklahoma State University. "The value of demonstrating to producers how these tools operate and can prevent unneeded water use is important for increasing adoption."

Technology is certainly helpful, yet it is still fallible. The sentiment echoed by the researchers is that many different technologies working together is always better than one, but sometimes the best tools are the producers themselves.

"Nothing can substitute going out into the field and seeing what is going on," Schwartz said. "You could think that sufficient water is available to crops based on sensor readings, but then go into the field and realize that the area where the sensors are installed is an anomaly and the rest of the field is being under-irrigated."



CELEBRATING 40 YEARS

Low pressure center pivot ages gracefully with technology advances, widespread adoption

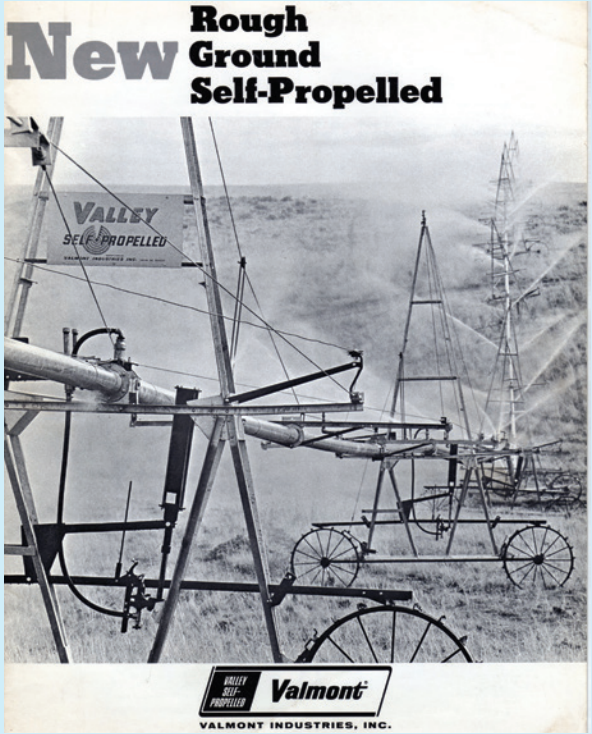
About 75 percent of the producers in the Texas High Plains use center pivot systems. Photo by Kay Ledbetter, Texas A&M AgriLife Communications.

A group of researchers from the Ogallala Aquifer Program (OAP) are celebrating 40 years of low pressure center pivot irrigation in 2018 with field days, publications and educational presentations. The goal of the celebration is to promote the adoption of efficient irrigation technologies and recommended management practices to help producers make the most out of their center pivot systems.

From summer field days in Texas and Kansas to special technical sessions at annual conferences, researchers are providing producers with updates from locally relevant research programs and highlighting the latest in emerging technologies. The OAP team is celebrating the past and present of center pivot irrigation, and looking forward to the future.

The early days of center pivot irrigation

Back in the early 1950s, Frank Zybach, a farmer and inventor, sought a better way to irrigate without using flood or furrow irrigation. He developed an irrigation machine and applied for a patent.



This photo from a 1969 brochure from Valmont Industries, Inc. illustrates center pivot irrigation models at that time. Photo courtesy of the Irrigation Museum, Irrigation Association.

His patent for the "Zybach Self-Propelled Sprinkling Irrigation Apparatus" was approved in 1952. While he developed the idea, the rights did not remain with Zybach for long.

Robert Daugherty, a Nebraska businessman, bought the rights for the center pivot design from Zybach in 1953. After this purchase, Daugherty worked on improving the system through his company, Valley Manufacturing, now known as Valmont Industries. The company engineers worked to increase the reliability of the system and upgraded the motor to electric, according to the company's website.

Center pivot irrigation systems use a movable platform outfitted with pipes and sprinklers to deliver water to crops. Modern systems are powered using electric or hydraulic motors, while the earlier systems used water power. The entire system pivots around a central point, resulting in a distinctive circle pattern when viewed from above.

Developments to center pivot technology have helped maximize the investment in irrigation through increased crop productivity and reduced energy use, according to a 2004 Texas Water Development Board Report.

Most of these newer, advanced technologies are low pressure systems that use less energy. Low pressure systems in use today are low energy precision application (LEPA), low pressure in-canopy (LPIC), low elevation spray application (LESA) and medium elevation spray application (MESA). These systems maximize water efficiency by placing sprinkler heads closer to the soil surface — between 12 to 18 inches for LESA systems — reducing evaporation losses during application. By reducing evaporation losses, more water gets into the soil where it is available for plants and not returned to the atmosphere.

Today, center pivot irrigation technology has become widely accepted by the agricultural community with many producers using these irrigation systems, according to Dr. Dana Porter, Texas A&M AgriLife Extension Service agricultural engineer at the Texas A&M AgriLife Research and Extension Center in Lubbock.

"About 75 percent of the producers in the Texas High Plains use center pivot systems," Porter said.

Moving to lower energy systems

Porter said the transition to low pressure center pivot irrigation began in the late 1970s, when center pivot systems became more widely accepted by producers and high energy costs amplified the importance of energy and water efficiency. There is a high cost to pump water and drill new wells when the water table is low, which is the case in the Texas High Plains, she said.

With limited water especially in the Ogallala Aquifer region, producers rely on innovation to continue using the same resource to grow additional crops, increase productivity and save money.

"Producers are quick to adopt technologies that will improve their net returns," said Dr. Freddie Lamm, research agricultural engineer with the Kansas State University Northwest Research-Extension Center. "Water is often a limiting factor and producers are keenly interested in technologies that will improve crop water productivity."

Low pressure center pivot systems fit well in the Ogallala region, as they are readily applicable for the cropping systems as well as for a variety of soils and the large, open spaces.

"Low pressure center pivot irrigation is especially well suited for the Texas High Plains," Porter said. "The technology was developed in this region and large fields in the area make it practical to use."

Lamm said future advancement of center pivot will rely on optimizing water application for varying topography, and soil and crop conditions that differ in a given area.

Much of this innovation is driven by the motivation to use water efficiently.

"There are many drivers to irrigation innovation, but the foremost influences are economics and declining water resources for agriculture," Lamm said.

The future of low pressure center pivot irrigation

Innovation continues for center pivot irrigation, including new technologies and ways to manage the amount of water distributed by the system.

"Science-based irrigation scheduling and smart irrigation systems will continue to evolve," Lamm said. "Incorporating knowledge from these systems ⇨

with producer training on optimum irrigation will improve operation and management of irrigation systems."

While developments in technology have made systems easier to control and contributed to better water use, there are still hurdles to cross in the race toward water conservation.

"Researchers in the public and private sectors are working on exciting research in irrigation," Porter said. "New developments in irrigation technology will benefit the irrigation industry and end users."

These new developments are leading to increased crop production and water conservation, while considering the importance of irrigation system management.

"The most important thing we have learned in the past four decades was basically known at the outset," Lamm said. "When management is insufficient, the irrigation efficiency can be just as poor as when the older technologies were used."

Over the past 40 years, the system has seen significant advances. The use of technology and science-based data will certainly continue over the next 40 years and help future producers manage water more effectively than ever before.

When producers rely on good management techniques and embrace innovation, there is reason for celebration.

Low pressure center pivot systems fit well in the Ogallala region, as they are readily applicable for the cropping systems as well as for a variety of soils and the large, open spaces. Photo by Dan Donnert, K-State Research and Extension.

Story by Sarah Richardson

Living Life with Less Water

Researchers help farmers conserve water with field days

At the Summer Crops/OAP Center Pivot Irrigation Field Day in August 2018, researchers discussed three field crops under one center pivot sprinkler system. Photo by Kay Ledbetter, Texas A&M AgriLife Communications.

If someone asked you what your biggest fear was, it probably wouldn't be running out of water.

For farmers across the Ogallala Aquifer region, this fear could become reality within the next 30 years.

The aquifer's decline has had a big impact on producers in the Ogallala region, especially for Barry Evans, a cotton and grain sorghum farmer in Kress, Texas in the Texas Panhandle.

"I started farming in 1992, and when I first began, I was 100 percent irrigated, and now I am 16 percent irrigated and 84 percent dryland, so it's been drastic for me," Evans said. "It's been a complete change of mindset, a total change in the way we do things."

This new mindset has been a necessary solution when irrigating with water from a declining aquifer.

"My hope is that we can use the aquifer to the best of our ability and that we don't waste it," Evans said. "There is no doubt that conserving water is important for future generations."

Evans and other producers rely on outreach programs such as the Texas Alliance for Water Conservation (TAWC) to know how much and where to water their crops. Based at Texas Tech University and funded by a grant from the Texas Water Development Board, TAWC is a partnership of producers, technology firms, universities and government agencies working to extend the life of the Ogallala Aquifer, the largest aquifer in the United States.

"Their research is a data collection that tells us where our maximum water-use efficiency is," Evans said. "From field days, I've learned where the best place is to apply my water and how much to concentrate it. The information they put together is extremely beneficial."

Having a field day

TAWC organizes field days in the Lubbock area. These field days are an opportunity for farmers, consultants and scientists to gather and transfer information on water-saving methods.

Dr. Chuck West, professor in the Department of Plant and Soil Science at Texas Tech and TAWC project administrator, said field days are a traditional way for researchers and producers to communicate.

"During field days 50 years ago, we had a hay ride pull producers around to different stops on a research farm and each stop would have a professor showing side-by-side comparisons of crops with data," he said. "We still do that, but now we are diversifying the kinds of presentations.

"It's not just researchers who are showing off their results; we have producers who have actually tried these things saying, 'This is what I've tried in the field and here is what actually works,' and representatives from companies that manufacture and install irrigation technologies and crop consultants that help producers keep up with trends and data," he said.

West said TAWC hosts a field day in the summer and a water college in the winter where consultants, researchers, producers and climatologists speak. Other TAWC outreach methods include social media and its website with fact sheets and video interviews from these events. ⇨

Field days are an important communications tool for researchers and extension specialists to interact with producers. Recent field days include (clockwise starting with top left) the Kansas State University Southwest Research and Extension Center Field Day at Roth Farms outside of Garden City, Kansas; the Clovis Ag Science Center Field Day in Clovis, New Mexico; the Texas Alliance for Water Conservation Field Walk in Lockney; and the Summer Crops/OAP Center Pivot Irrigation Field Day in Bushland, Texas. Photos courtesy of Dr. Dana Porter, AgriLife Extension; Darrell J. Pehr, New Mexico State University; Dr. Chuck West, Texas Alliance for Water Conservation; and Kay Ledbetter, Texas A&M AgriLife Communications.

Dr. Dana Porter, Texas A&M AgriLife Extension Service agricultural engineer at the Texas A&M AgriLife Research and Extension Center at Lubbock, said field days offer producers social and educational opportunities.

"With new irrigation technologies and strategies, seeing is believing and field days continue to be a valid way to connect with producers," Porter said.

Porter said field days and other informal meetings foster communication between producers, agribusiness, researchers and educators. "Sharing stories of what works and what doesn't work, asking questions, expressing concerns and offering suggestions help us all address issues more comprehensively," she said.

"Researchers gain a better understanding of what is happening and what is needed in the field so they can do a better job of finding solutions. Producers can get clarification and context to help them realize greater benefits from technologies or even help them to decide whether a given tool or strategy makes sense for their operation."

Rethinking communication methods

With resources more available than ever, the internet has caused an evolution in communication preferences.

Dr. Brent Auvermann, professor of agricultural engineering and center director at Texas A&M AgriLife Research and Extension Center in Amarillo, said as a result, researchers are squeezing more valuable information into shorter presentations at field days.

"We are having to retrain ourselves away from the 20-30 minute presentations," he said. "Producers don't have as much time, so you've got to get to the point and get to it quickly."

His philosophy on communication is that more in-person interaction is needed, not less.

"It's easy for us to hide behind a computer screen, but we have to humanize agriculture again," he said. "On crop production and water-related things, we rely heavily on the field days, but we are rethinking them from the ground up."

Auvermann said researchers and extension specialists are not just reaching out to producers anymore but are also reaching out to the consumer.

"We've got to re-establish the linkage between the consumer and the water that we are pumping in agriculture, which provides what the consumer is buying at the grocery store," he said.

"We are one of the biggest Texas A&M AgriLife Research and Extension centers in the state, and it's easy for us to get so busy that we feel like we don't have time for our neighbors right across the boundary of our property," Auvermann said. "We really have to take that seriously about remaining engaged in a personal way with our neighbors. It has proven to be quite an exciting challenge to modernize our outreach."

When problem-solving, Auvermann said it is important to dialogue in a way that is more collaborative and less one-way in the communications process. "You're collaborating but you're also asking good questions and listening closely at the same time where you give and take to figure out what works best overall," he said.

Producers these days have bigger land areas and are technologically savvy.

"They have higher expectations of us, and they have other options for their agricultural education, so we are in a highly competitive educational marketplace and we have to adapt to that," Auvermann said.

Dr. Jonathan Aguilar, assistant professor in biological and agricultural engineering at Kansas State University, reaches out to producers in Kansas through Water Technology Farms, which are demonstration farms that allow the installation and testing of the latest irrigation technologies on a whole-field scale.

"The technology farms have been a good partnership between the industry, producers, research and extension in terms of sharing data," he said, adding that the technology farms successfully encourage peer-to-peer education among the producers.

Aguilar said when farmers are asked how to conserve water, they have multiple perceptions on how to address the issue. "It is not just researchers or extension people that are talking to producers, it is also their peers talking about how they perceive some of the technologies that they are trying."

Operation collaboration

In addition to field days, researchers arrange field walks to collaborate with producers, comparing the progress of crops throughout the growing season.

West said a field walk is like an informal field day on a local farm.

"We spend two hours talking about how the producer is managing a crop while implementing one of our recommended procedures," West said. "We might visit the same field two to three times throughout the summer so the visitors can see how the crop has progressed."

In Nebraska, other methods of collaboration include the Testing Ag Performance Solutions (TAPS) program, co-developed by University of Nebraska-Lincoln's Dr. Daran Rudnick, assistant professor and irrigation management specialist; and Dr. Matt Stockton and Chuck Burr, both research and extension specialists and educators.

"The TAPS program engages producers, industry, university and government entities through a farm management competition, where participants compete for the most profitable farm and highest input-use efficiency," Rudnick said. "These competitions let farmers test out new and developing technologies, tools and methods without buying them first and taking a risk on their own farm."

Aguilar, Auvermann, Porter, Rudnick and West are collaborators with Ogallala Water Coordinated Agriculture Project (Ogallala Water CAP) team that is based in six of the eight Ogallala region states. All but Rudnick are also part of the Ogallala Aquifer Program (OAP), which involves researchers in Texas and Kansas. Both programs were created to share research and best management practices for optimizing water use across the Ogallala region and sustain food systems.

"We interact with people from other states and from other universities to contribute all of our skills together so all of the states within the Ogallala Aquifer can benefit from each other," West said. "We have the same mission, the same stakeholders, the same audience, the same challenges and problems that we're addressing to help our producers.

"It's all terribly interesting and important work we're doing and I love this job. I'm thrilled to be part of the scene where agriculture is so important."

Story by Kathy Wythe

Mixing It Up

In the Ogallala Aquifer region, one size (of farming) doesn't fit all

Farmers in the Ogallala Aquifer region are using diversified cropping systems such as integrating different crops into the crop production cycle and managing the crops' planting dates and irrigation. Shown is a Texas A&M AgriLife Research center pivot system in Bushland with multiple crop studies in 2018. Photo by Thomas Marek, AgriLife Research.

The saying goes one size fits all, but for producers in the Ogallala Aquifer region of the High Plains one size, or system, of farming doesn't necessarily fit all.

With the decline in the aquifer's water levels and reduced well capacities in much of the region, more producers are increasingly transitioning from what have historically been intensively irrigated crops to diversified systems to safeguard against loss of income and water.

Today's diversified systems integrate different crops into the crop production cycle or incorporate annual crops, livestock and forages into the system.

For example, a producer with an integrated cropping-livestock system might have a field of annual crops and a field of annual forage grown for livestock feed plus an area of perennial grassland. The livestock can rotate between the grass and forage and, after harvest, can graze the residue left in the crop fields.

In a typical livestock integrated system in the Ogallala Aquifer region, livestock graze on forage and cover crops in the spring before being turned out onto rangelands, and then rely on forage and grain stubbles supplemented with hay or silage in the fall and winter.

Experts in the Ogallala Aquifer Program (OAP) and the Ogallala Water Coordinated Agriculture Project (Ogallala Water CAP) are conducting research and working with producers to find the right fit for their land.

Integrating different crops into rotation

Producers are always looking at different strategies to optimize the limited water they have and maximize their profits. Incorporating different crops and managing the crops' planting dates and irrigation needs into their operations is helping.

"Integrated crop management is a key strategy to extending the life of the Ogallala Aquifer, especially in the Texas High Plains," said Dr. Jourdan Bell, an agronomist at the Texas A&M AgriLife Research and Extension Center in Amarillo and a member of the OAP team.

Bell said that the southern Texas High Plains was traditionally a cotton monoculture and the northern Texas High Plains was in continuous corn production for the last 40 to 50 years. ⇨

Texas A&M AgriLife Research's center pivot sectors illustrate long- and short-season grain sorghum hybrids (foreground), and corn (behind the sorghum). Photo by Thomas Marek, AgriLife Research.

"Now, because of declining aquifer levels and lower well capacity, we are seeing diversification in cropping practices, she said. "Today, cotton is frequently grown in rotation with corn in the northern Texas High Plains.

"Diversifying the cropping systems allows the producer to incorporate a profitable, drought-tolerant crop that uses less water than irrigated corn crops," Bell said.

To accomplish this, some producers are splitting center pivot circles into sections and growing different crops to match water availability to irrigation demands, Bell said.

For example, a producer may plant corn on one-half of a center pivot circle and cotton on the other half.

"A producer might not have the well capacity to fully irrigate a full circle of corn but has enough well capacity to irrigate 60 acres or half of a circle of corn and plant the other 60 acres with cotton," Bell said. "Cotton has a lower water requirement so a producer can apply a reduced amount of water to the cotton. That really minimizes the in-season pressure on those irrigation wells."

While there would be a greater water savings by converting the full-irrigated circle to cotton, Bell said northern Texas High Plains' producers recognize the value of a grain crop such as corn in a rotation. Corn, or grain sorghum if the producer no longer has the irrigation capacity, brings significant benefits to the soil and long-term viability of the cropping system that cotton, a low residue crop, does not. A low residue crop tends to increase erosion and decrease soil quality.

Bell said another strategy to optimize water use and yield is managed deficit irrigation where the crop water use is synchronized with the crop's reproductive stages. She said this approach differs from a deficit irrigation strategy where irrigation is typically applied throughout the growing season at a fraction of the full irrigation demand.

"When we schedule irrigation based on growth stages, we are essentially looking for the greatest return on the investment," she said. "Previous research in grain sorghum supported by the OAP demonstrated that concentrating irrigation resources during critical reproductive growth stages can result in a greater yield in drought years."

Another option, Bell said, is to consider alternative planting dates and hybrid selection to minimize water use. For example, producers may plant a long-season corn hybrid on one-half of the circle earlier in the season and then plant a shorter-maturing corn hybrid on the other half of the circle later in the season. This shifts the time of peak irrigation demand for half of the corn crop to later in the season.

Bell said this strategy means there is not equal stress on the full circle at the same time.

"Producers can concentrate water on the earlier planting in the circle and for that other half, hopefully they have shifted reproduction development to later in the season, where temperatures are milder and there is more precipitation," she said. "This allows producers to coordinate production with the environment."

Having flexibility in crop rotation and variety selection not only helps producers save money and increase profits, but it also maximizes production per unit of water applied, Bell said.

Adding forage crops and livestock into the mix

Integrating forage crops and livestock in a traditional cropping system brings an added component into the mix that provides an additional income source.

Dr. Chuck West, professor in Texas Tech University's Department of Plant and Soil Science and a member of the OAP and Ogallala Water CAP projects, is looking at integrating perennial and annual forages and cattle production into the Texas High Plains now dominated by irrigation of annual crops.

"What is really waking us to putting cattle back on what once was irrigated land is that with the reduction in the supply of water, producers can no longer produce the annual crops at the full yield potential on all their acreage," he said.

West said that adding livestock and forage crops into the farming system means that some of the highly irrigated land can transfer to a lower irrigation level needed for forage production or perhaps even go to dryland production.

"We want to move toward a more diversified landscape where, instead of having large continuous acres of cotton or corn, we have more diversity with annual crops, forage crops and livestock on improved pastures," he said. "As the pumping capacity of wells declines, producers can target the remaining irrigation capacity to fewer areas of high value crops."

As producers diversify, West said they need information about the productivity of forages and the water needed to establish the forages.

He said research done by his predecessor, Dr. Vivian Allen, identified improved forages that are drought tolerant and have good yield potential.

For some producers, planting native perennial grasses that once populated the High Plains on some of their land makes sense, West said, adding that some nonnative grass can produce even more.

His research has shown that a specific variety of the nonnative old world bluestem grass works well in transitioning a farm that was predominantly annual crops to an integrated operation. Producers can establish the bluestem with limited water in six to eight months and then stop irrigation or go dryland on it once it is well established. They can then shift that water source to a neighboring field that needs it.

Another, somewhat surprising, forage West is studying is alfalfa.

Although alfalfa has been used for decades as an extremely high quality forage for dairy production and as a hay crop for cattle, West said it is notorious for being a high water-consuming crop. He is looking at alfalfa from a different perspective: as a low water-using plant grown alongside old world bluestem. In their research, his team first established the bluestem then planted alfalfa into the grass, giving the alfalfa low to modest irrigation.

"What you end up with the following year," West said, "is a field that has 20-30 percent cover of alfalfa plants and the rest grass."

Since the alfalfa plants are not densely planted, they are not competing with each other for water. They produce a deep root system, enabling them to find water below the root system of the grasses. By planting among perennial grasses with less water, West said, the alfalfa is forced to be frugal with water.

Another way using alfalfa has worked quite well, West said, is to have a small pasture of just alfalfa grown near bluestem or other grasses. Cattle are moved into the alfalfa every week for two days for limited grazing and then moved back to the grasses. ⇨

Cattle can graze on forage and cover crops in the spring before being turned out onto rangelands. Photo courtesy of the Ogallala Aquifer Program.

Improving soil health with integrated systems

It's not just water savings and profits that drive the Ogallala region producers to introduce integrated cropping and livestock systems; integrated systems are tied to better soil health. Healthier soils, in turn, can store more rainwater and crop production is increased.

Farming practices used in the Ogallala region over the last century — conversion of grasslands into croplands, intensive cultivation of the same crops year after year and high intensity of grazing cattle on grasslands — have created challenges. Production potential has gone down, soil organic matter and nutrients have been depleted, and water-holding capacity has decreased, causing the soil to be less resilient and productive and more prone to wind erosion when left bare.

Dr. Rajan Ghimire, assistant professor in New Mexico State University's Department of Plant and Environmental Sciences and an Ogallala Water CAP researcher, said soil health and fertility in the region are largely associated with farming practices that focus more on short-term profits at the expense of long-term soil and environmental quality.

"Our soils cannot produce what we used to get in the past with the same level of input," Ghimire said. "We have increased efficiency in crop production technologies, but the magnitude of those improvements has not equaled the improvement in yield."

Ghimire said since soil is the foundation for agriculture, it is important to improve that foundation, which will increase production and save water. He compared the benefits of healthy soil to a healthy human. "If we are healthy, we can do a lot more work than if we are sick," he said. "Likewise, healthy soil can provide a variety of ecosystem services, including soil water conservation, crop production and agroecosystem resilience."

In his research, Ghimire has compared grazed native grassland, native grassland that has not been grazed for 50 years and cultivated sorghum fields to see if there is a difference in soil health.

His research showed that the grasslands, both grazed and ungrazed, had healthier soils, with 18 percent more organic carbon and 13 percent more nitrogen in the soil profile than the cultivated sorghum field. The grasslands had almost double microbial mass and enzyme activity, other indicators of healthier soils.

He also looked at the difference between grazed and ungrazed croplands to determine the effect of livestock on soil dynamics in cropped fields. In the grazed cropland, organic matter increased about 12 percent and the microbial mass increased 40 percent when compared to the ungrazed cropland.

Ghimire attributes the healthier soil of the grazed grassland and cropland to the livestock mixing in the leftover grass mass or crop residue as well as urine and manure into the soil. "Livestock hooves may have brought crop residues in contact with soil, while the urine and feces of the grazing animals contributed to nutrient cycling," he said. "This increases the residue decomposition and enhances the soil organic matter storage in the grazed croplands."

Maintaining the Ogallala Aquifer region's viability

Bell, West and Ghimire said changes have to be made to maintain the Ogallala Aquifer region's economic viability. Transitioning to integrated systems is one option; it increases resiliency and decreases risk.

"There are a significant number of producers who have incorporated integrated systems into the production systems just because it minimizes their risk by increasing their diversity and helps conserve water," Bell said. "They want to ensure they can irrigate in 10 or even 20 years."

"I foresee greater adoption of high-value crops on smaller irrigated acreages to increase the dollar return on the diminishing water," West said. This can include wine vineyards, specialty crops for food and herbs and high-value seed production.

Ghimire believes that farming will definitely change in the future with water becoming more and more limited.

"I have faith in research," he said. "So much is being done; we will find better, more efficient ways to use water and improve soil health and production technology."

"Farmers do try to do everything in their ability to be good stewards of the aquifer and manage their water so they are not wasting it," Bell said. "They recognize that their success is dependent on the longevity of the aquifer."

While integrated farming seems like a positive transition, it's not an easy one.

"I see many positive changes with integrated livestock systems but at the same time it is a little bit challenging," Ghimire said. "Many farmers are set up for crop-only systems; they have invested in tillage equipment, fertilizer applicators and irrigation systems. It is one business. With cattle, it is more complicated; they need to manage cattle and crops."

"It's really hard to say there is one strategy that is going to be a one size fits all solution," Bell said.

Jourdan Bell

Texas Panhandle agronomist

Agronomists are plant and soil scientists, but beyond crop production and profitability, the goals of an agronomist are conserving natural resources and protecting the environment.

In the Texas Panhandle, Dr. Jourdan Bell works with producers to improve soil-plant-water relationships while conserving natural resources.

"Water and soil are our most important natural resources," said Bell, regional research and extension agronomist for Texas A&M AgriLife Research and Extension Center in Amarillo. "As an agronomist, it is important to assist producers with crop production practices that conserve soil and water resources."

For farmers dependent on the availability of groundwater from the Ogallala Aquifer in the Texas High Plains, the challenge is having enough water.

"The Texas High Plains is an agricultural-based economy, so optimization of agricultural production is important at many levels," Bell said, "but the future of High Plains crop production is dependent on how well we conserve soil and water resources today."

Lifelong resident of the Texas Panhandle

Bell's family was in the cattle feeding industry, farming and ranching in the Amarillo area. "I grew up understanding the importance of agriculture, specifically understanding how important water is for agricultural production," she said.

This long-term exposure to agriculture led Bell to pursue a bachelor's degree in general agriculture in 1997 and a master's degree in plant, soil and environmental science in 2000 from West Texas A&M University.

While getting her bachelor's degree, she worked as a student employee in Amarillo with Texas A&M AgriLife Research under Dr. Brent Bean. After graduating, she began working as a research technician at the U.S. Department of Agriculture's (USDA) Agricultural Research Service (ARS) Conservation Production Research Laboratory (CPRL) near Bushland.

There, she said, she gained valuable research experience in manure and nutrient management, irrigated and dryland cropping systems, tillage and forage systems, all with an emphasis in soil science and crop water use.

In 2007, she had the opportunity to go back to school to work on a doctorate in soil science at Texas A&M University.

She lived in College Station for a year to complete course work and fulfill the residency requirement before returning to Bushland to begin her dissertation research funded by the USDA Ogallala Aquifer Program.

"However, as I was completing my dissertation research focusing on irrigation strategies in grain sorghum, the Texas High Plains was gripped by the extreme drought of 2011-12. 2011 was the driest year on record across Texas," she said. "I learned so much about crop physiological responses to stress, soil water and irrigation scheduling during those two years."

In 2014, Bell earned her doctorate in soil science from Texas A&M and accepted her current position as an agronomy specialist at the Amarillo center.

The power of the environment

During Bell's time at Texas A&M, Dr. Kevin McInnes in the Department of Soil and Crop Sciences was her advisor. McInnes along with her co-advisor Dr. Robert Schwartz with CPRL were instrumental in her foundation in soil physics and environmental biophysics.

"Crop production is driven by the soil, water and environment," she said. "However, on the Texas High Plains, the environment often overrides agronomic practices." ⇨

The Panhandle has a variety of severe weather conditions throughout the year from extreme blizzards, drought and dust storms to tornados and crop-damaging hail.

"It is so important as an agronomist and soil scientist to learn how we can manage our practices, minimizing the effect of environmental stresses as well as minimizing our impacts on the environment," Bell said. "I've always had an appreciation for the region; it goes back to being raised on the Texas High Plains, always understanding and appreciating the power of the environment and that the value of water is key."

Soil: a farmer's water bucket

One of the key aspects of Bell's research and extension programs is evaluating production practices to increase soil-water storage and minimize evaporative losses.

"The soil is our bucket; however, bucket sizes vary across the Texas High Plains," Bell said. "As we move south of Amarillo, soils are sandy, and the soil's water-holding capacity is limited. Sandy soils can't store as much water as the clay loam soils of the northern Texas Panhandle.

"As an agronomist, it is important to consider soil texture when making agronomic recommendations, especially related to crop water demands," Bell said. "While irrigation is necessary to stabilize production across the entire High Plains region, there are often specific irrigation considerations that should be made depending on crop and soil texture to optimize water productivity.

"And because the water in the Ogallala is declining across the region, there is not room for error when making irrigation decisions."

Motivated by water sustainability

Her research interests have always been motivated by the challenges that producers in the Texas Panhandle face, particularly their dependence on the Ogallala Aquifer.

"One of my goals working with producers is to help them manage their resources to ensure not just profitability but also the sustainability of these resources," she said.

Bell said crop production on the Texas High Plains is dependent on conserving water for the future, for as many years as possible.

Dr. Jourdan Bell, AgriLife Extension agronomist, enters data from a study testing the effectiveness of an herbicide on grain sorghum. Photo by Kay Ledbetter, Texas A&M AgriLife Communications.

In parts of the Ogallala Aquifer, the water table has declined to levels where the irrigation capacity is no longer sufficient to meet even a fraction of the crop water demands. Additionally, Bell said precipitation across this region is extremely variable. As water depletes from the aquifer, it becomes more expensive to pump.

"Because the Ogallala underlies eight states, we are looking at very different management strategies of this resource across the Ogallala Aquifer region from Nebraska to the Texas High Plains," she said. "Ultimately, some producers will transition back to dryland farming, and it is anticipated that where well capacities are depleted, we may see some cultivated land return to grasslands for grazing."

But, Bell said, there are still pockets of strong water on the Texas High Plains, and in those regions, producers will continue to irrigate. "Consequently, it is important that we continue to improve agronomic management, improving crop water-use efficiencies and extending the life of the aquifer," she said.

"When we talk about helping producers be profitable, it is important not just for the producers but for our small towns and rural economies," she said. "When we have a greater number of successful producers, there is a trickle-down effect."

Producers hire people in their local communities, which benefits the small, rural towns.

"Being from the Texas Panhandle, I personally find it very important to ensure the success of our farmers as well as our small towns. Everybody in the Texas High Plains is indirectly related to agriculture."

Thomas Marek

An engineer's engineer

Thomas Marek, senior research engineer with Texas A&M AgriLife Research and Extension Center in Amarillo, has spent his entire career doing what engineers do: designing, testing and then redesigning.

Known as 'an engineer's engineer,' his in-depth skills in irrigation enable him to design, build, maintain and use structures, machinery and electrical systems, conducting field operations on a commercial-scale research farm, all while leading his own highly successful agricultural irrigation research program.

"I do not just design it; I am one of the engineers that designs it, builds it, tests it and then writes about it," he said.

It all started at Texas A&M

A Bryan, Texas native, Marek chose his college major while looking through a Texas A&M University course catalog.

"During my junior year in high school, I sat in the front seat of a pickup truck and went through the syllabus curriculum and when I saw ag engineering, I knew what I wanted to be," he said. "So I enrolled at Texas A&M when I graduated from Bryan High School, and two years later I was in a work study program."

During the work study, Marek's first jobs were designing carrot and onion harvesting machines.

"I was always very good at building things, so the fact that I could build things and then go test it in the field and break it and figure out why it broke and then rebuild it and make it better, that's always kind of intrigued me," he said.

Marek received his bachelor's degree in 1975 and master's in 1977, both in agricultural engineering.

"I got interested in soil, water and irrigation when I was at Texas A&M working with Dr. Donald Reddell, professor of agricultural engineering, and Dr. Terry Howell, an assistant professor at the time. We were doing surface irrigation research in the Brazos River bottom when I heard they needed an irrigation engineer in Amarillo, and I was fortunate enough to get the job."

Howell went to work for the U.S. Department of Agriculture's Agricultural Research Service (ARS) in California but came back to the ARS Conservation and Production Research Laboratory near Bushland, Texas in 1983, Marek said.

It was then that Marek and Howell partnered to build large weighing lysimeters, which precisely measure the amount of water it takes to grow a crop. These world-class lysimeters became the basis of advanced state-of-the-art irrigation research for Texas and beyond.

Marek said the weighing lysimeters are essentially very, very large "flowerpots," being 10 square feet and 8 feet deep, and each weighing about 100,000 pounds.

"They sit on a very sensitive weighing scale and can measure or weigh the water it takes to grow a crop on top of it. The scales are sensitive enough that we can see the wind blow in the output data," he said. "What's measured in that large, monolithic block is representative of the rest of the field around it, giving the most accurate regional crop water-use values known to date." ⇨

A pioneer of irrigation technology

A registered Texas professional engineer, Marek was named a Texas A&M University Regents Fellow in 2015 and he is the 2018 recipient of the American Society of Agricultural and Biological Engineers John Deere Gold Medal award. These awards are evidence of his successful 45-year career.

Of Marek's many achievements, he said his most significant may be his part in converting high-pressure impact sprinkler systems to lower pressure, saving irrigated producers millions in energy costs.

"Back in the day, the overall thought was that the Ogallala Aquifer was unconfined and would never run out, and nothing was further from the truth," Marek said. "It is a confined aquifer, and we have been depleting it for effectively 50 years."

Marek said the initial center pivot irrigation systems would pump about 1,200 gallons per minute on a quarter-mile system and used impact spray nozzles on top of the system operating at 100 pounds per square inch (psi) or more. "The energy cost of that was substantial, but today we use much less," he said.

"We needed to find a system that was lower energy. The manufacturing of the hardware had to change along with cultural practices," he said. "We changed those high impact nozzles that required 100 psi and put them closer to the ground on hoses to operate at 10 psi, not spraying water as far into the air."

He said in the late 1970s, the breakdown of irrigation was about 15 percent center pivot irrigation and 85 percent irrigation or surface flow. "Today, those percentages are reversed.

"I have been in irrigation a very long time and watched it develop, particularly for the Texas North Plains region. The changes that we've seen with center pivot systems represents a massive step forward in efficiency and technology."

Making a Texas-sized difference

Marek considers co-developing the Texas High Plains Evapotranspiration Network (ET) to be another one of his significant achievements. "For 20 years, we developed an ET network with multiple stations across the Texas High Plains," Marek said. "That put data in the hands of producers and every morning they knew how much water their crops were using."

Dr. Dana Porter, AgriLife Extension agricultural engineer in Lubbock, was extensively involved in the design, operation and management of that network, he said.

"What we try to do is optimize how much you can stress a crop through daily irrigation management from both a production and profit standpoint.

Thomas Marek, Texas A&M AgriLife Research agricultural engineer in Amarillo, points to an advanced datalogger that monitors soil sensors in a research field at Bushland, Texas. Photo by Kay Ledbetter, Texas A&M AgriLife Communications.

We take a lot of high tech and make it simpler for the producer and the crop consultant to use," Marek said.

Implementing conservation management strategies can be as simple as crop conversion or implementing advanced technology to use less water, keeping producers profitable, he said.

"This is what I've been involved in for over 45 years, and from a research standpoint, this is where we have been; so where are we going?"

Keep moving forward

Marek said two things motivate his work — making a real difference and leaving things better than he found them. "This includes improving the tools and technologies that are used to assess performance with our systems," he said. "Today, we are integrating advanced machine-learning algorithms into our control systems and that's pretty high-tech stuff for agriculture."

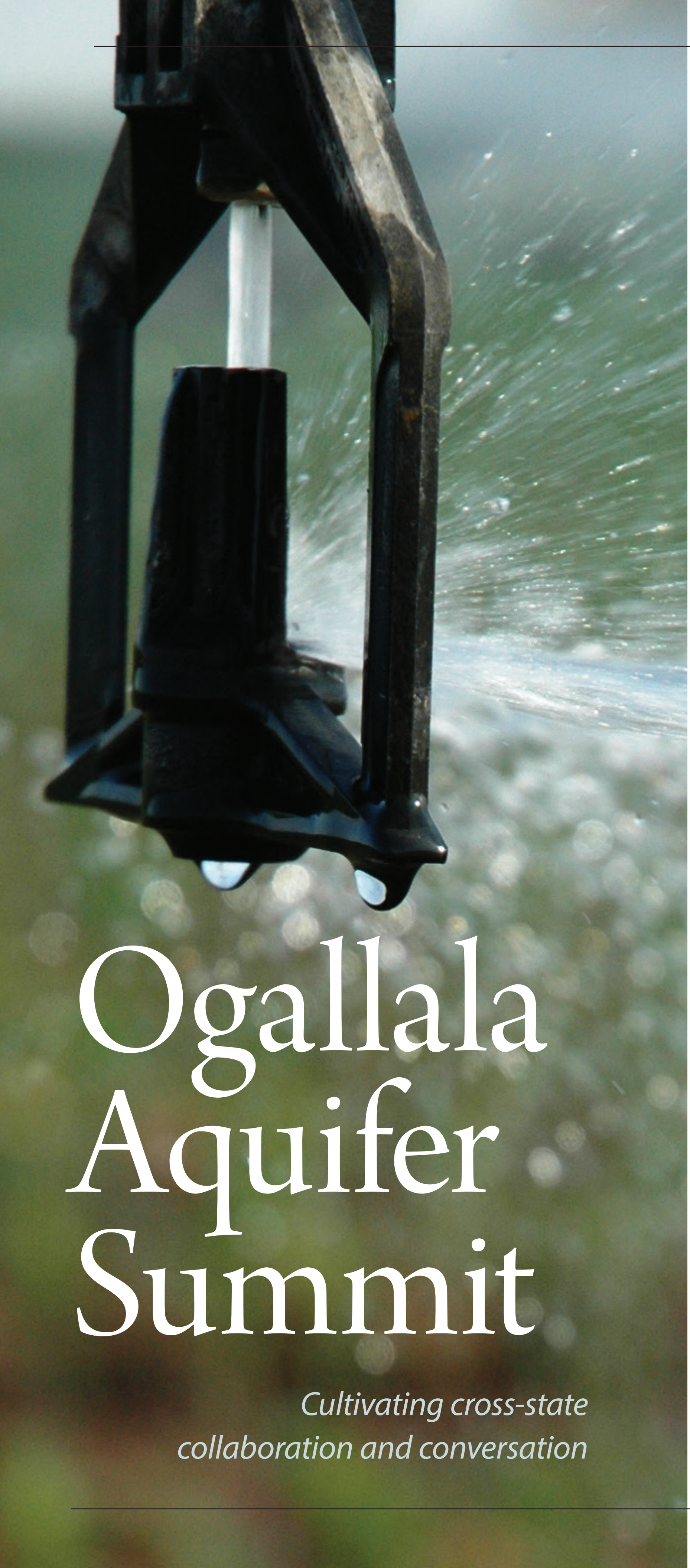
Unmanned aerial vehicles (UAVs) have a promising potential in moving irrigation management forward. Marek said UAVs are used in the fields to assess crop performance and show things that cannot be seen with the human eye.

"We've saved a lot of energy and water and made a lot of money for producers in the state of Texas and elsewhere. We have done that through both the development and implementation of advanced technologies and put that information in the hands of the producers. That's pretty significant."

At the Amarillo center, Marek continues to serve as research project leader and principal investigator on irrigation water management, crop water-use efficiency and evapotranspiration projects.

"I have had the luxury, the pleasure and the privilege to not only watch all of this but to be a direct participant and that's been satisfying," Marek said.

Story by Amy Kremen



Ogallala Aquifer Summit

Cultivating cross-state collaboration and conversation

Editor's Note: Amy Kremen is the project manager for the Ogallala Water Coordinated Agriculture Project (Ogallala Water CAP) (ogallalawater.org), funded by the U.S. Department of Agriculture's National Institute of Food and Agriculture (USDA NIFA). In this article written for txH2O*, she provides an overview of and key take-aways from the Ogallala Water Summit.*

Earlier this year, the NIFA-funded Ogallala Water CAP partnered with the Kansas Water Office to bring together more than 200 water management professionals from all eight Ogallala region states for the Ogallala Aquifer Summit. The main goals of this event were to:

- build cross-state relationships among a wide range of water management stakeholders,
- encourage information exchange, drawing heavily from and building on the experience and expertise of producers, and
- identify opportunities for collaboration within and across state lines to boost the impact of efforts being made to help address the region's water-related challenges.

Assigned seating ensured that people representing different states and stakeholder perspectives would meet and interact. Panels, keynotes and facilitated workshops covered different aspects of "what's working" in agricultural water management within three main topic areas: producer practice, contributions from science and policy developments.

Participants discussed practical aspects of agricultural water use in relation to different factors, including differences in evapotranspiration rates going from the Northern to Southern High Plains and variation in the aquifer's saturated thickness across the region.

At the summit's final capstone workshop, the expertise of participants was integrated with information shared at the meeting. Groups at the tables were tasked with identifying and prioritizing actionable, cross-state collaborative activities with the potential to benefit the Ogallala region long term.

Making the most sense (and cents) out of water conservation-oriented practices

The capacity to monitor and manage water use in crop and livestock systems is advancing rapidly, but adoption lags as producers and ag lenders weigh the potential benefits of integrating different technologies or crop/livestock management strategies in their operations and determine how they might pencil out.

Having opportunities to test out practices and technologies in a risk-free setting and learn from producer peers, tech company leaders and related ⇨

research results from universities and USDA's Agricultural Research Service (ARS) are hallmark features of several excellent programs currently active across the High Plains region. These include the Texas Alliance for Water Conservation, Kansas' Water Technology Farms and the Testing Ag Performance Solutions program led by University of Nebraska-Lincoln Extension's West Central Research and Extension Center in North Platte. Steve Walthour of Texas' North Plains Groundwater Conservation District (NPGCD) presented on its Master Irrigator Program. This 32-hour intensive irrigation education program is conducted over four one-day sessions and trains participants — producers, farm managers, crop consultants and others — in advanced conservation irrigation management and on water- and energy-saving conservation practices that can build soil health and enhance farm profitability.

As a next step, a multistate working group met in September 2018 to focus on replicating and establishing Master Irrigator programs in other Ogallala region states. The group discussed how to adapt the baseline curriculum and other necessary criteria for establishing and sustaining a high-quality program based on NPGCD's insights gained and lessons learned in managing its program. This group also explored interstate collaborative opportunities to leverage cost-share funds to support producers who complete these programs.

The topic of soil sensors provides a good example for several barriers and opportunities related to achieving greater water conservation and water-use efficiency that were identified at the summit. Participants noted how the relatively low adoption of soil sensors, available for the past decade or so but used by only approximately 10 percent of High Plains producers, points to how important it is for any technology or management strategy to be easy to implement, use and/or fix, and deliver tangible benefits that improve an operation's bottom line. When earlier versions of soil sensors and data loggers did not meet these criteria, they were abandoned by early adopters whose experience may ultimately have contributed to discouraging others from trying soil sensors. Soil sensors are now receiving renewed interest for various reasons, including improvements in product design and utility, the influence of testimonials from producers who have been successful using the technology and engagement by university-led research and extension that has helped to validate this technology.

It's never too early to train tomorrow's water leaders

High school student Grace Roth's stirring summit talk, "A Call to Action on Water Conservation," prompted discussion of the importance of offering young people training opportunities and enlisting their help in encouraging urban and rural shifts in mindsets and habits toward greater prioritization of water conservation and general improvements in water management. Participants noted how harnessing the energy, communications skills and natural motivation of young people to see their communities thrive long term could be very beneficial for the region.

Summit participants suggested building on and networking with already existing programs such as Texas 4-H2O Ambassadors and Kansas Youth Water Advocates to enhance professional development opportunities and support greater "water literacy" among high school students in the Ogallala region. This topic will be reviewed and action steps elaborated on as part of a "youth day" that will take place in conjunction with the fall 2018 Kansas Governor's Water Conference in Manhattan, Kansas.

Many partners but no single pathway for addressing water issues

Not everyone envisions extending the use of the Ogallala Aquifer to support irrigated agriculture indefinitely as being practical. In the Texas High Plains where the aquifer tends to be shallower, for example, some stakeholders believe it's imperative to focus on supporting a productive transition to dryland systems in anticipation of further aquifer level decline. Data shared by Jim Butler of the Kansas Geological Survey (KGS), however, indicated that producers may be able to prevent further aquifer declines in western Kansas by reducing their water use by about 30 percent relative to present levels.

Because water is so essential, achieving common goals related to water management involves the input and engagement of a wide range of stakeholders, including producers, tech company representatives, crop advisors, academics, and local, state and federal agencies, ag lenders, multinational companies, absentee landowners and others. Finding opportunities to keep getting people together and to develop a regionwide vocabulary is needed. This will increase the visibility and effective communication that goes beyond describing the serious water-related challenges faced by the Ogallala region and delves more into how these challenges are being addressed, since these approaches and solutions serve as examples and, in some cases, inspiration for others in the region.

Going forward, participants stressed that finding ways to keep multistate conversations going is important. In academic and tech circles, this is currently happening with people inviting each other to give talks at field days, ag expos and other events. Planning is underway to hold a second Ogallala Aquifer Summit aimed at getting a broader circle of stakeholders, including ag lenders, crop consultants, energy companies, multinational companies and state entities focused on water quality and quantity, on the same page by exchanging information about water management challenges and solutions. Representatives from the Ogallala Water CAP team and the Kansas Water Office are also sharing what happened at the summit with a wider audience. A summit-focused talk was well received at the American Water Resources Association's summer conference on "The Science, Management, and Governance of Transboundary Groundwater" in July 2018. Additional summit-related presentations to state-level water planning groups and at multistate meetings are planned.

While litigation and other disagreements over water rights and water management are inevitable, the concept of using agricultural water management as a tool to increase resiliency, flexibility and producers' capacity to mitigate risk is ripe with opportunity for cross-state exchange and engagement. A good example of this is discussions that touched on the increasing involvement of producers in "traceability" programs that reward them — and help buffer them somewhat from the impacts of market instability — for tracking their effective water management and stewardship of soil health. Other examples covered at the summit included limited irrigation crop insurance, splitting pivots, moving from static to dynamic irrigation scheduling and shifting attitudes away from maximizing yields to maximizing return on inputs used. All merit ongoing education and communication regionwide because of their important role in helping producers weather regional shifts in temperature and precipitation frequency and intensity.

Last thoughts on the summit

Summit participants unequivocally stated that local development and administration of water use-related policies is highly preferable to outside intervention from states, federal-level actors and other entities. They also noted, however, how important it is for policies, whether local, state or federal, to actually work in tandem to support on-the-ground practices effective at improving agricultural water management. Participants emphasized the importance of having good data on water use and water levels for effective management, both on the farm and for planning at the local, district, state and federal levels. One related topic deserving ongoing attention from Ogallala region stakeholders is the potential for water-use efficiency gains achieved in the future through successful implementation of technologies and other management practices to actually result in greater overall water use, rather than increased water conservation. Participants also stressed the need for local, state and federal support for research and educational programs focused on managing Ogallala water-related challenges, including expanding and building on the success of the ARS-funded Ogallala Aquifer Program so researchers based in Ogallala states in addition to Kansas and Texas can participate. There are many valuable activities and conversations to pursue to guide shifts in practice from today's status quo; as Butler of KGS noted during his presentation, "Heavy use of the Ogallala Aquifer has led to significant depletions. If we do nothing, we know where we're going to end up."

For the summit's report, recordings of the summit panels and media coverage, visit: http://ogallala-water.org/2018-ogallala-aquifer-summit/.

Ogallala Water Summit interactive workshops on identifying current opportunities and barriers to achieving greater water conservation and water-use efficiency in the Ogallala region were supported by facilitators and note takers at each table. Photo by Amy Kremen, Ogallala Water CAP.

Story by Kathy Wythe

LOOKING AT THE BIGGER PICTURE

Studies examine link between health of Ogallala Aquifer and region's economy

Back in the early 20th century, before groundwater wells were drilled, before center pivot irrigation was used and before modern urban development, much of the High Plains region in central United States was rolling sand dunes covered with native grasses. The agricultural industry consisted mostly of grazing cattle and dryland crop production.

In the ensuing years, developments in groundwater pumping and irrigation technology allowed water from the Ogallala Aquifer, which lies beneath much of the High Plains, to be used to irrigate crops, changing the appearance and economy of the area. It became known as "the bread basket of America" with fields of irrigated wheat, corn and cotton and a robust agricultural-based economy.

Today, the High Plains region provides about 30 percent of all U.S. crop and livestock production, according to the U.S. Department of Agriculture (USDA), with about 40 percent of jobs in the High Plains directly or indirectly tied to agriculture. Irrigation accounts for approximately 90 percent of groundwater withdrawals from the Ogallala Aquifer with withdrawals exceeding recharge rates in most areas.

As water levels in the Ogallala Aquifer continue to decline, reducing producers' ability to irrigate crops, what will happen to this robust economy and the agricultural industries the nation depends on so much?

Many are asking this question, in particular researchers from two USDA-funded Ogallala Aquifer projects. They are trying to understand the current picture to help predict the economic future of this nationally important region.

Dr. Jordan Suter, associate professor at Colorado State University (CSU) and a member of the Ogallala Water Coordinated Agriculture Project (Ogallala Water CAP), said a large portion of the Ogallala Aquifer region — particularly in the southern and western part — doesn't have access to surface water and has little precipitation coupled with high temperatures.

"In those particular areas, the Ogallala provides an input that is critical to maintaining the agricultural economy that exists there today," he said. "There is no substitute."

Already producers are making changes — switching crops, adding livestock and implementing more efficient water conservation technologies. Likewise, groundwater management districts are implementing pumping limits.

Looking at the bigger picture

Dr. Bridget Guerrero, assistant professor at West Texas A&M University, said when examining the link between the sustainability of the Ogallala Aquifer and the economic health of the High Plains region, one has to look at the bigger picture.

More than 10 percent of all wheat grown in the United States each year is produced in the Southern Ogallala region. Shown is a wheat harvest in the Texas Panhandle. Photo by Kay Ledbetter, Texas A&M AgriLife Communications.

"When you look at overall agriculture in the High Plains region and you think about the economy, it's not just about producers or those businesses that have that agricultural label," said Guerrero, who is a researcher with the Ogallala Water CAP and the Ogallala Aquifer Program (OAP). "It is also the banking industry. It's where farmers spend their money, where they shop for cars and shop for groceries.

"It really becomes a more complex problem when you think about all the individual businesses that are touched or impacted by agriculture," she said.

As part of the OAP, Guerrero co-authored a series of six publications with Dr. Steve Amosson, a recently retired Texas A&M AgriLife Extension Service economist, and others. They evaluated the economic impacts of different agricultural industries as well as the industries' impact on water use in the southern Ogallala region.

"As the region's leaders consider water conservation strategies to prolong the life of the aquifer, they will need to evaluate the water use and economic impacts given the water use of each of the different industries," she said.

The group analyzed the cotton, beef, dairy, swine, feed grains and small grains industries, using the computer analysis program, IMPLAN (IMpact analysis for PLANning), which estimates direct, indirect and induced effects.

"If you are talking about water conservation with agriculture being the biggest water user, you need to look at agriculture from every standpoint," Guerrero said. "Yes, agriculture is a big water user, but it is a main economic driver also."

In the publications, she said they evaluated the different agricultural sectors in terms of dollars generated per acre-foot of water used. Confined animal feeding operations (CAFOs), which includes beef, dairy and swine, have the highest value, creating more jobs and generating more dollars overall compared to crop production.

"However, all the agricultural sectors of the economy are interrelated and crop production is an important input into CAFOs, especially dairies that rely on locally grown silage," she said.

Dr. Bill Golden, research assistant professor at Kansas State University, also works on the two Ogallala Aquifer projects. He agreed that although feedlots, dairies and meatpacking plants all contribute significantly to the economy in the Southern High Plains, crops are still important commodities.

"Crops are normally considered low-value water users and generate fewer dollars per acre-foot, but that doesn't mean that producers should quit using water for crop production," he said. "We need to be growing irrigated crops, but we need to make sure we are using the water for irrigated production as efficiently as we can use it." ⇨

Studying groundwater conservation practices

Eight states share the water in the Ogallala Aquifer: Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas and Wyoming, and each state has its own methods to deal with groundwater. Ogallala Aquifer researchers are studying alternative ways to manage it to save water.

For example, Kansas is exploring local enhanced management areas, or LEMAs, as a way to reduce groundwater consumption and extend the life of the Ogallala. In a simple explanation, Golden said producers voluntarily get together and discuss ways to reduce water use, coming up with a groundwater conservation plan. The groundwater management district then submits the plan to the state's chief engineer, who reviews and approves the plan. Once approved by the chief engineer, the LEMA plan becomes law, effectively modifying prior appropriation regulations, also known as the "first in time, first in right" doctrine.

Golden said research results suggested that the LEMA framework will provide benefits to both agricultural producers and rural communities. There are two LEMAs in Kansas to date, and producers within these areas have reduced water use while maintaining their profits and yield.

However, Golden cautioned, using LEMAs as a water conservation policy may only result in short-lived reductions in groundwater consumption with water saved today eventually being used by someone else.

"Even with rather severe reductions in groundwater use today, some areas will remain over-appropriated and water saved today will eventually be used and the water resource exhausted," he said.

In Colorado, Suter along with other researchers at CSU developed a hydroeconomic model to help understand how the profitability of agriculture would change over time as the aquifer levels change. Their research focused on the Republican River Basin in Colorado, which is over the western part of the Ogallala Aquifer.

"Formulating the hydroeconomic model is challenging because it involves linking economic decisions about what crops get planted and how much water is applied to those crops with the hydrology of the aquifer itself and how it responds to changes in water use," Suter said. "It is a pretty novel framework that we have set up and can be used to try to predict longer-term outcomes."

He said the research team was able to generate a baseline scenario looking at 50 years in the future and determine how profits of producers can be expected to change at different areas within the basin by implementing various conservation strategies, such as restricting the amount of pumping during a season or charging a pumping fee. They found that some producers would not see much decline in their profits while producers in other areas would see a decline because of having limited water.

While recognizing the results are based on a model, Suter said their research provides numerical outcomes that are better than pure speculation, which he hopes allows the different management districts to weigh the costs and benefits of various groundwater conservation strategies.

"The Ogallala Aquifer is large and shared; there is a lot of variation in the amount of water available at any one point on the map," he said. "Some areas are going to feel the pinch more than others, and we were able to highlight that in some of our modeling results."

Suter said the model provides a "menu of sorts."

"We are not trying to give specific recommendations on exactly what policies should be implemented, but rather say, 'Here are the tradeoffs that you face and here are the outcomes for the various policy scenarios that could be implemented,'" he said.

Researchers in the Ogallala Aquifer Program have developed crop species and varieties including wheat that have lowered water requirements. Photo courtesy of the Ogallala Aquifer Program.

Although Suter's work was focused on the Republican River Basin, he said the basin somewhat mirrors the entire Ogallala Aquifer region and the challenges of producers in the basin are similar to what producers in Texas and parts of Kansas are experiencing.

The CSU researchers coupled with other researchers in the Ogallala Water CAP are generating similar types of models for Texas, Oklahoma, Kansas and Nebraska to better illustrate the variety of outcomes that could occur throughout the Ogallala Aquifer region.

Future economic picture

In the agricultural industry publications, Guerrero said they considered the future growth of agriculture in the southern Ogallala Aquifer region. "What we envision for this region is that we are going to have this transition from irrigated to dryland crop production," she said.

CAFOs also have room for growth in the future, especially feedlots.

"If the fed beef industry experiences growth, it wouldn't be hard to import the grain from other regions to support their input needs," she said.

The region is grain deficit and is already importing about 35 percent of feed grain demand.

"We need to make sure all those industries survive, so we need to use water as frugally as we can," Golden said. "If we continue the way we are today, there will be less irrigated crop production in 40 years than there is today."

Golden said since the aquifer isn't uniform — some areas, such as areas in southwest Kansas, have 200 years of water left; others, such as other localized areas in west-central Kansas, have 10 years left — the change to less irrigated crop production will be a gradual process. Kansas already has thousands of acres that are no longer irrigated, and producers are trying to convert back to dryland or re-establish native grasses.

Guerrero said commodity groups and stakeholders are considering the best strategies producers can implement when their available water is reduced or restricted to keep their operations viable.

"We are really trying to look at ways to keep producers as profitable as possible when they are facing these limits with water," she said.

Grain sorghum is one of the primary dryland crops in the semiarid regions of the Southern Ogallala region. Photo courtesy of Texas A&M AgriLife Communications.

Researchers at K-State Research and Extension are finding ways to retrofit center pivot sprinklers with mobile drip irrigation tubes. Photo courtesy of K-State Research and Extension.

Irrigation consortium to help equip farms of the future

Four universities that are part of the Ogallala Aquifer Program and the Ogallala Water Coordinated Agriculture Project are involved in a new group that will advance irrigation innovation to equip "farms of the future," according to officials.

The Irrigation Innovation Consortium was launched in 2018 as part a five-year, $5 million grant from the Foundation for Food and Agriculture Research (FFAR), a nonprofit organization established through bipartisan congressional support in the 2014 Farm Bill.

The consortium is a collaborative research effort to accelerate the development and adoption of practical water- and energy-efficient irrigation technologies and practices through public-private partnerships.

Partners in the two Ogallala projects — Texas A&M AgriLife Research, Colorado State University, Kansas State Research and Extension at Kansas State University and the Robert B. Daugherty Water for Food Global Institute at the University of Nebraska — are members. California State University, Fresno as well as industry partners, Irrigation Association (IA), Jain Irrigation, Lindsay Corporation, Northern Water and Rubicon Water, are also founding partners.

Dr. Reagan Waskom, director of the Colorado Water Institute at Colorado State University and lead for the consortium, said the consortium is specifically focused on innovation in irrigation technology in both the agricultural and urban sectors and fulfills an important role for the future of irrigation.

"Big changes are coming to the world of irrigation technology as the 'internet of things' and 'big data' transform the decision process," Waskom said. "Producers need a trusted source of research-based information to use these technologies."

He said there is also a huge need to develop the irrigation work force both domestically and internationally and to educate the next generation of irrigation professionals.

The consortium plans to build a program where new irrigation technology can be developed, fostered, tested and demonstrated to end users.

"Single university programs are just not adequate to address the geographic and technical scale, the pace of industry change and the scope of information needs in the user sector," he said. "We need a network of universities working together to meet these needs."

The consortium has funded 15 projects within the five universities and is seeking additional industry partners to work alongside the universities as research and training programs are developed, Waskom said.

The executive committee is comprised of Waskom, Deborah Hamlin of the Irrigation Association, Dr. LaKisha Odom of the Foundation for Food and Agriculture Research, Dr. David Zoldoske of California State University, Fresno, Dr. Christopher Neale of the Daugherty Water for Food Global Institute at the University of Nebraska, Dr. Daniel Devlin of Kansas State Research and Extension, and Dr. Brent Auvermann of Texas A&M AgriLife Research. Dr. Stephen Smith of Wade Water LLC and Buena Vida Farm is the executive director of the consortium.

For more information, visit the consortium's website at https://irrigationinnovation.org/.

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For more information on the Ogallala Aquifer projects, visit their websites: ogallala.tamu.edu and ogallalawater.org