Oklahoma

2021 Ogallala Aquifer Virtual Summit White Paper

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Introduction

The Ogallala aquifer is a major aquifer in Oklahoma, underlying portions of nine counties of the Panhandle and northwestern region of the state. In the eastern Panhandle, the Ogallala formation often sits atop 250 million years old consolidated sediments. In the western Panhandle, a younger formation of shale and sandstone called the Dockum group overlies the red bed. Other formations include the Dakota Sandstone and Morrison Formation. The Ogallala aquifer supplies more than 98% of total water demand in the Oklahoma Panhandle. Other sources, such as alluvial aquifers and streams, contribute less than 2%.

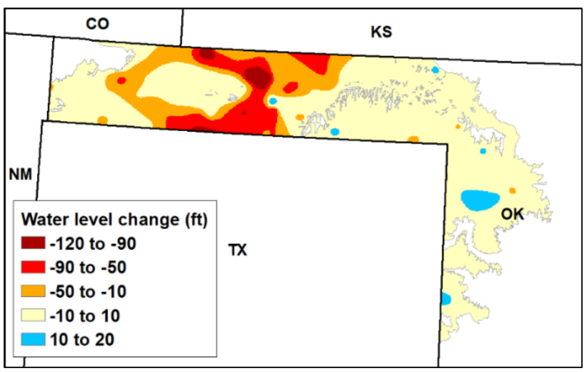

Figure 1. Water level changes pose threats to producers in the Oklahoma Panhandle because irrigation is the largest water user in this area.

Irrigation is the largest user of water in the Panhandle. Since the predevelopment period (prior to the 1950s), about 3,000 irrigation wells have been drilled into the Ogallala aquifer. The largest number of wells (over half) have been drilled in Texas County, followed by Cimarron, Beaver, and Ellis Counties. Based on 2007 crop mix data, there are approximately 230,000 acres of irrigated land in Cimarron, Texas, and Beaver Counties alone, requiring over 290,000 acre-ft of water per year. This is about 85% of the total water demand in the region. The major irrigated crops are corn and wheat, accounting for about three-quarters of the total irrigated area. The expansion of irrigated agriculture in the Oklahoma Panhandle has been a major driving force for economic development and prosperity of this region. This irrigated cropland is not only critical for grain production, it also supports major livestock production enterprises in the region such as cattle feedlots, dairies, and hog operations.

Science and Data

According to USGS analysis, from predevelopment (prior to the 1950s) to 2015 the Oklahoma portion of the Ogallala aquifer experienced an estimated decline in water level of 12.5 ft. This estimate is an area-weighted average with groundwater levels in some areas, such as Roger Mills and Beckham Counties, rising and other areas, such as parts of Texas County, declining over 100 ft (Figure 1). The Oklahoma Water Resources Board has also published data on Ogallala water level change over the period from 1966 to 2015, reporting average declines of approximately 80 ft. and 60 ft. for Texas and Cimarron Counties, respectively. In addition to issues with water level declines, there are concerns that pumping in some portions of the Ogallala Aquifer could induce upward movement of saline water that exists in the underlying Permian Formations.

Considering the importance of irrigated agriculture in the longevity of the Ogallala aquifer in Oklahoma, researchers with the Department of Biosystems and Agricultural Engineering at Oklahoma State University (OSU) have initiated several programs to 1) evaluate the performance of commercially available sensor technologies to optimize irrigation management and 2) audit water application uniformity and conveyance efficiency of irrigation systems in the Panhandle region. Most sensors tested to date had error rates less than 10%. Irrigation systems tested to date have averaged a coefficient of uniformity of 72% and a distribution uniformity of 60%, indicating poor uniformity and the need for full system maintenance and adjustment of nozzle packages. Water conveyance efficiency was 93%, meaning that about 7% of water was lost on average between the pumping point and the soil surface.

The OSU Plant and Soil Science Department is also working to identify production practices for corn, wheat, and grain sorghum that improve profitable irrigation management under declining well capacity scenarios to help producers adjust input rates, or adopt alternative crops that require lower irrigation rates such as cotton, grain sorghum, or forage crops.

Policy

Oklahoma groundwater law allows landowners or lessees to obtain a permit from the Oklahoma Water Resources Board to use groundwater at a determined rate based on the number of acres of the applicant's land that overlies an aquifer. According to this law, passed in 1972, those individuals who had a water right prior to 1972 would be allowed to continue to extract water at their previously permitted rate.

Temporary permits are issued for aquifers where the amount of stored water has not been identified, allowing for extraction of up to two acre-feet per year per acre of land owned or leased by the applicant. If a study has been conducted and the total water storage determined, the permittee is allowed to extract water at a different rate based on the area of land above the aquifer and a minimum basin life of 20 years. For the Ogallala aquifer, the rate of two acre-feet per year (AFY) per acre has been issued for groundwater use in the three Panhandle counties and 1.4 AFY per acre for the other counties overlying the Ogallala.

Agricultural producers in the Panhandle region have formed the Panhandle Irrigators Association to protect the property rights of members and to study proposed and enacted legislation, rules, and regulations. The Panhandle Irrigators also work to initiate, sponsor, and promote research to increase profitability of agricultural operations for its members. The association collaborated with other local groups in developing the Panhandle Regional Water Plan, which called for more financial and technical assistance by programs such as the county conservation districts' cost share and the councils of government to find new ways to extend the life of the aquifer in economically viable ways.

Producer Practice

The major change in producer practices in the Oklahoma Panhandle over the past several decades has been the type of irrigation systems used. Satellite imagery reveals the majority of irrigated fields in the region were under flood irrigation in the late 1970's, with only a few center pivot systems used. Over the next 30 years, however, most irrigated fields switched to center pivot systems. Today, the percentage of irrigated farms that are under center pivots ranges from 93% in Beaver county to 98% in Cimarron county. According to a new study by OSU, there are about 2,600 center pivots in the Oklahoma portion of the Ogallala aquifer, with an average area of 133 acres.

Compared to flood irrigation, center pivot systems can apply water in smaller amounts and more uniform patterns, resulting in reduced runoff and deep percolation. As a result of this increased efficiency, a significantly larger portion of pumped water is used by crops under center pivot systems. Currently, almost all center pivot systems are equipped with mid-elevation spray application (MESA), where nozzles are about halfway in between the main line and the ground. This setting significantly reduces wind drift and direct evaporation losses compared to traditional impact sprinklers. In addition, 66% of all center pivot systems operate on less than 30 psi of pressure, thus having smaller energy requirements compared to high-pressure systems. Thirty-two percent of center pivot systems in Oklahoma run on pressures between 30 and 59 psi and only 2% require pressures larger than 60 psi.

In addition to adoption of center pivots, many growers have transitioned to minimum tillage which has a great potential to improve soil health and consequently water storage.

Opportunities

To encourage water conservation, efficiency, recycling and reuse, the Panhandle Regional Water Plan recommends:

- Actively identifying incentive programs beneficial to water users;
- Promoting a culture of water efficiency by reducing unit water demands;
- Supporting research, development, application, and implementation of water-efficient technologies and practices (i.e. drought-tolerant crops, alternative crops, efficient irrigation technologies);
- Supporting initiatives and seeking funding to support eradication of salt cedar and other invasive species; and
- Encouraging water reuse programs and incentives.

Significant opportunities exist to adopt irrigation systems with higher efficiency than MESA center pivots, such as low-elevation spray application (LESA) and low-energy precision application (LEPA). LEPA and LESA systems have been developed and tested successfully in the Texas Panhandle, with the potential to minimize water losses to only a few percent. Drip systems (mainly subsurface or SDI) have also been used on a limited basis in the Oklahoma Panhandle. One issue that has contributed to the low adoption of drip systems is land ownership. For producers who lease the land, there is less risk in purchasing center pivot systems and then moving them to other locations at the end of a lease than to invest in permanent SDI installation.

Besides advancements in irrigation hardware, irrigation scheduling (improved management) plays a vital role in reducing irrigation losses and increasing water use efficiency. Based on data from USDA's 2018 Irrigation and Water Management Survey (IWMS), the majority of surveyed producers (84%) decided when to irrigate based on crop condition. Feel of soil was the second most widely used factor in irrigation scheduling, reported by 36% of growers. Use of soil moisture sensors was a decision-making factor for only 5% of growers.

Oklahoma Master Irrigator Program

Inspired by the North Plains Groundwater Conservation District's (Texas) Master Irrigator Program presented at the 2018 Ogallala Summit, Oklahoma established a comparable program to support increased adoption of precision irrigation tools and technologies. This program is the result of collaboration between OSU Extension, Oklahoma Agricultural Experiment Station, Oklahoma Panhandle Irrigators, Oklahoma Conservation Commission (OCC), Oklahoma Department of Agriculture, Food, and Forestry, Oklahoma Farm Bureau, Oklahoma Water Resources Board (OWRB), Oklahoma Water Resources Center (OWRC), and USDA-Natural Resources Conservation Service (NRCS).

The Master Irrigator program provides 32 hours of advanced training on irrigation water management, irrigation equipment maintenance, energy conservation, water conservation, and economics of irrigated agriculture. The program includes classroom training, peer-to-peer exchange of information between producers, and field demonstrations. With support from OSU, OCC, OWRB, and NRCS, participants completing the program are eligible for reimbursements of $2000 on purchase of soil moisture sensors, additional points on their NRCS Environmental Quality Incentives Program applications, and free of charge energy and irrigation system efficiency audits through OSU's Mobile Irrigation Lab (Figure 2). OSU's Mobile Irrigation Lab will also assist graduates with utilizing data from soil moisture sensors.

OSU's Division of Agricultural Sciences and Natural Resources provided funding for the hire of an Assistant Extension Irrigation Specialist to lead development of the curriculum and delivery of the program. OWCAP provided support for OSU students assisting with the Mobile Irrigation Lab and on-farm demos, as well as travel expenses for the OSU team and invited speakers to the training events. Further, funding from the OWRB provided needed equipment and supplies for the Mobile Irrigation Lab, sensors for the farm demonstrations, and in partnership with the OCC, provided soil moisture sensors for graduates of the inaugural course.

Figure 2. OSU's Mobile Irrigation Lab assesses producer's irrigation system water application and energy use efficiencies.

Testing Ag Performance Solutions (TAPS) Oklahoma State University

Inspired by the University of Nebraska-Lincoln, OSU launched a *Testing Ag Performance Solutions (TAPS)* program in 2019. TAPS hosts Farm Management Competitions, where participants compete in crop production and marketing. Each participant competes for the most profitable farm, most efficient use of water and nitrogen (N), and highest grain yield. Competitors make production, management, and marketing decisions. Production choices - such as crop insurance, crop/seed variety, planting density, marketing, irrigation amount and timing, N fertilizer amount, timing, and method - are made under conditions closely reflecting a farm business.

In 2019, participation in OSU-TAPS was limited to six producers, four from the Oklahoma Panhandle, one from north-central Oklahoma, and one from Nebraska. Competitions are conducted at OSU's McCaull Demonstration Farm where OSU recently installed a variable rate irrigation system, added FieldNet to its pivots, added its acreage under the FieldView app, and installed a variable frequency drive on one of its wells.

The first year proved to be challenging due to below average rainfall during the critical period of the crop season and the irrigation pivot being plagued with operational challenges. Grain yields ranged from 16 bushels per acre (control) to 207 bushels per acre. Net revenue ranged from a significant loss at the control plot to almost $400 per acre at the most efficient farm. This resulted in efficiency indexes ranging from <0 to almost 4.0. Despite the setbacks in 2019, the first TAPS season was a good learning experience for all involved and lessons learned will be used to help shape and improve future TAPS seasons and programs.

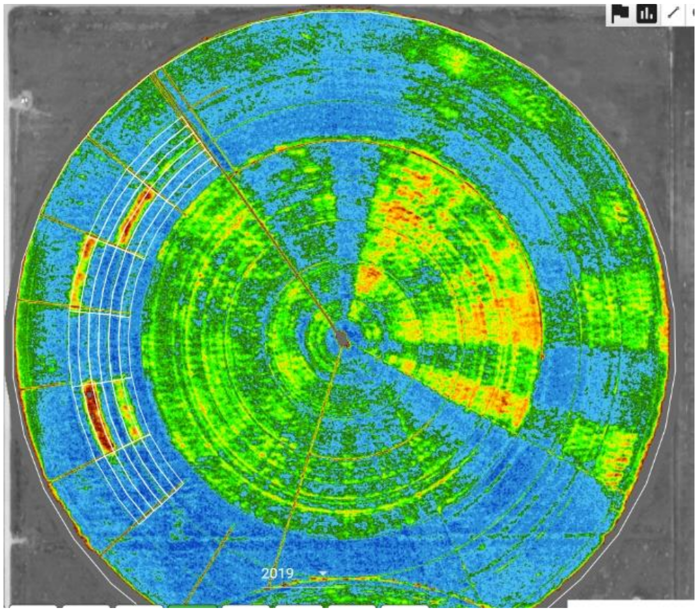

Figure 3. The airborne image of the OSU's McCaull Farm, showing the Normalized Difference Vegetation Index of the farm and TAPS plots.

The TAPS program continued in 2020, with 15 participants from Oklahoma (11), Kansas (3), and Nebraska (1). The results of the competition are being analyzed and will be released soon.

Groundwater Irrigation District Act

Oklahoma's Legislature passed HB2263 in 2019 creating the Groundwater Irrigation District Act to manage groundwater irrigation districts. This bill establishes requirements for a groundwater irrigation district, provides sanctions for permit holders, and sets guidelines for district boards. Producers in the Oklahoma Panhandle are now discussing how this bill can assist in their water conservation efforts.

Other Activities

A new project titled *Soil Monitoring through UAV-Assisted Internet of Things Wireless Underground Sensors* was selected for funding by the OWRC in 2019. This project will develop a proof-of-concept soil monitoring system with wireless underground IoT (internet of things) sensors and unmanned aerial vehicles (UAVs). Although this project is not being conducted within the Panhandle, its results will be applicable, providing knowledge about the performance and requirements of UAV-assisted IoT soil monitoring systems and how they can be used to conserve the quantity and quality of limited water resources in Oklahoma.

Another new project, *Increasing Water Productivity, Nutrient Efficiency and Soil Health in Rainfed Food Systems of Semi-Arid Southern Great Plains,* was funded by USDA-NIFA in 2019 to sustainably increase the productivity of rainfed cropping systems in the Southern Great Plains. OSU scientists are teaming with researchers at Kansas State University and the USDA-Agricultural Research Service in El Reno to work on increasing precipitation and nitrogen (N) use efficiency, reducing yield losses to environmental stresses and weed pressure, and restoring and enhancing soil health.

A third project has developed a GIS layer of all center pivots within the central and southern Ogallala aquifer regions. While similar products developed previously have been based on automatic land classification and thus prone to classification errors, this new layer was manually digitized using high-resolution satellite imagery (Figure 4). According to this layer, there are about 50,000 center pivots in the central and southern Ogallala regions, with about 56% of them being in Texas. Kansas accounted for 32% of the remaining center pivots. Oklahoma, New Mexico, and Colorado had 5%, 5%, and 2% of the center pivots.

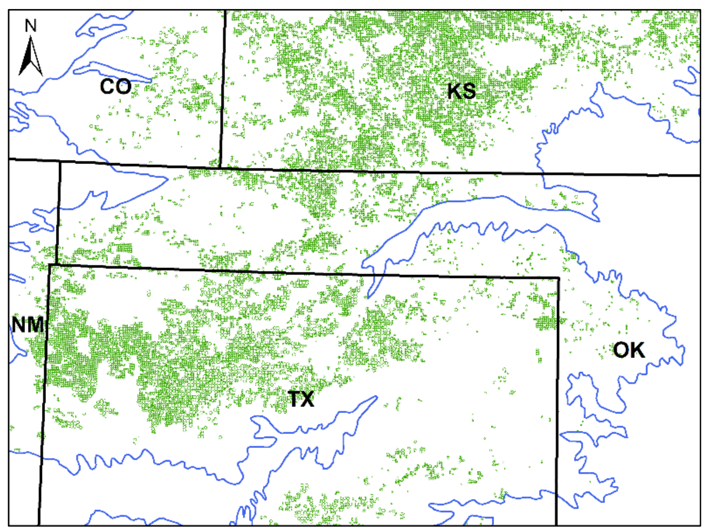

Figure 4. Digitized center pivots in the central Ogallala region.

Finally, in addition to providing cost-share of conservation practices in the Oklahoma Panhandle and beyond, partners at the OCC and NRCS have increased their emphasis on soil health education statewide.

Challenges and Questions

A major challenge that remains in the region is overcoming the attitude that neighbors will use water saved and conserved. This is a significant issue throughout the region, but particularly in the Oklahoma Panhandle which borders four other states.

Switching to cotton production (in addition to other new crops/varieties that use less water) could extend the life of the aquifer. However, many producers in the Oklahoma Panhandle are new to cotton production. Therefore, there is a steep learning curve for these producers to learn the irrigation management, plant growth regulator spraying, residue management, and other agronomics of cotton production. Moreover, there is no cotton gin available in the Panhandle. Thus, cotton must be transported great distances for ginning.

Milo is another promising alternative to corn in the Panhandle due to its lower water requirements and its comparability to corn as feed. However, yield potential of milo per inch of water applied is lower than that of corn. Milo is largely produced on marginal lands in the Panhandle leading to lower average yields, and higher risk of production than corn. As such, milo has greater insurance premiums than corn and milo prices usually trail corn prices by about 50 cents per bushel.

Digital technology is difficult to adopt as producers must go through a steep learning curve to adopt it. This is an issue especially for older farmers, who may not be as adept as their younger counterparts with technology. Additionally, in some cases the cost of new technological tools undermines their value.

Labor and time are issues in managing farm operations, especially for those managing 20-30 pivots. For example, many pivots are kept running even after a considerable rainfall event, because of inaccessibility to turn off each pivot due to labor shortage or road conditions. The farmer must decide whether to spend two days shutting the wells off and another two days turning them back on or to save that time and labor. In most cases, the choice is to save time and labor over conserving water. Use of electric pumps and new controllers which allow pumps to be shut down remotely could assist in these situations. However, many producers can't finance such system upgrades which would benefit conservation.

Multi-state collaborations could help address many of these challenges. More multi-state field days could help with adoption of new technologies. Furthermore, establishment of new markets and infrastructure could help with adoption of new crops, such as sorghum production for biofuel.