Texas

The Importance of Best Management Practices, Policy Analysis, and Modeling Future Projections for the Ogallala Aquifer in Texas

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Introduction

Texas is a large state representing diverse agroecosystems and climate conditions. Precipitation varies from over 60 inches per year in the Piney Woods region of eastern Texas and the Gulf Coast region, to less than six inches per year in the Chihuahuan desert or Trans Pecos region near El Paso in the west. In addition, the agricultural growing season can range from year-round in the south Texas lower Rio Grande Valley, to less than half a year in the northern Panhandle region. Thus, it is no surprise that Texas produces a diverse range of agricultural products and is one of the largest agricultural producers in the nation.

In the semi-arid to arid regions of western and northern Texas, precipitation is less than the crop water demand, so agricultural production requires irrigation to maximize profitability, and in these same regions, the only reliable source of water is groundwater. This is particularly true in the Panhandle region of Texas, which overlies the southern end of the Ogallala aquifer where the depth to groundwater ranges from less than 200 feet to over 350 feet and recharge is negligible. Groundwater supplies over 95% of the water for agricultural, municipal, and industrial uses in this region, with irrigation composing over 90% of water use. Thus, the Ogallala aquifer is a vital resource to support Texas' agricultural economy, where the High Plains region produces 78% of fed beef, 52% of dairy cows, 94% of hogs, 63% of cotton, 45% of corn, and 69% of ensilage for the state *(amarillo.tamu.edu/ files/ 2019/12/Impact-of-AgriBusiness.pdf*). Consequently, there is a great deal of concern related to declining water levels, having exceeded 100 feet over the last 50 years, and a concerted effort to minimize the rate of future withdrawals. Declining water levels have prompted actions to address the sustainability of water use to support the agricultural economy. An increased emphasis has been placed on understanding how to best utilize the Ogallala aquifer to provide the greatest long-term value to water users.

Science and Data

Extensive monitoring activities continue to characterize the status of the Ogallala aquifer in Texas. The Submitted Drillers Record (SDR) Database maintained by the Texas Water Development Board (TWDB) has nearly 80,000 lithological records *(www3.twdb.texas.gov/apps/ waterdatainteractive/groundwaterdataviewer)* which depict the sand thicknesses and depths of the aquifer. This information is used to map variations in water availability across the Southern High Plains of Texas. Growth in groundwater pumping in the region, particularly after the 1950s, led to the creation of the High Plains Underground Water Conservation District No. 1 (HPWD), which was the first Groundwater Conservation District (GCD) in Texas. Today, Texas has over 100 GCDs representing the importance of water conservation across the state. HPWD and other GCDs have been conducting annual groundwater monitoring campaigns that have yielded a rich water level dataset spanning several decades with measurements at over 10,000 locations across the Southern High Plains. In addition, there are automated water level loggers which report water level measurements on an hourly basis and help assess changing hydrogeological response in "near real-time." High resolution data are critical for monitoring aquifer response to drought and tracking losses in well yields over time. These datasets are publicly available *(hpwd.org/interactive-maps)* and extremely valuable to promote public awareness of groundwater resources in the region.

Research has elucidated recharge mechanisms and highlighted the important role that depressional wetlands (playas) play in recharging aquifers. Baseflow separation analysis indicates that surface water-groundwater interactions have diminished considerably in the last five decades coinciding with the large-scale groundwater withdrawal, which started in the 1950s. GCDs in the region have established pumping limits for wells that produce significant amounts of water (over 25,000 gallons of water per day or 17.5 gallons per minute), which are referred to as non-exempt wells.

Barring a few exceptions, direct metering of non-exempt wells or using alternative approaches, such as irrigation system capacity (based on center pivot nozzle packages, for instance) or electrical usage for pumping to estimate groundwater production, is now required or recommended by most GCDs.

Groundwater models have been developed by the TWDB to support groundwater policy and planning studies in the state, including the High Plains Aquifer System, which includes the Ogallala and deeper aquifers *(twdb.texas.gov/groundwater/models/gam/hpas/hpas.asp).* These models are used to guide regional groundwater planning endeavors and support regulatory actions aimed at maintaining the "desired future conditions" *(twdb.texas.gov/groundwater/dfc/index.asp)* of the aquifer as required by the statutes of the State of Texas.

Several GCDs have been part of focused studies to evaluate crop water requirements, and the most efficient methods to irrigate crops under water stressed conditions. State-funded programs, such as the Texas Alliance for Water Conservation (TAWC) and projects funded by the TWDB Agricultural Water Conservation Grants program *(twdb.texas.gov/financial/programs/AWCG/index.asp)*; federal funding programs, including USDA-NIFA, USDA-NRCS, and USDA-ARS Ogallala Aquifer Program (*ogallala.tamu.edu*); as well as GCDs have supported improved agronomic and irrigation practices. These efforts are supported by collaborative research efforts of the USDA-ARS (Conservation and Production Research Laboratory at Bushland and Crop Stress Laboratory at Lubbock) and universities (Texas A&M, Texas Tech, and West Texas A&M). Programs emphasize the understanding of deeper brackish aquifers as alternative water sources, quantifying crop water use (evapotranspiration); advanced irrigation technologies; optimizing management of limited irrigation resources for cropping systems; development of drought-tolerant and salt-tolerant crop cultivars; water efficient crop rotations; soil management; other best management practices; and development of irrigation decision-support software.

Policy

Texas is the only state overlying the Ogallala aquifer to legally uphold the common-law rule of capture, under which landowners have the right to pump (capture) the water beneath their property for reasonable use (Texas Water Code § 36.002). The rule of capture is commonly referred to as the "law of the biggest pump," but there are limitations. The Texas Legislature authorized the establishment of GCDs with authority to promulgate rules for conserving, protecting, recharging, and preventing waste of underground water.

The state government has provisions to exercise its right to control groundwater resources through the conservation amendment of the Texas Constitution. The amendment provides for the creation of GCDs to manage natural resources (Texas Water Code § 36.0015). Subsequently, groundwater management areas (GMAs) were established to facilitate planning between GCDs within a common area that share the resource. In 2005, GMAs were required to adopt Desired Future Conditions (DFCs), which amount to quantifiable goals for the future state of the resource (Mace et al. 2006). The individual conservation districts were tasked with developing local plans for meeting the applicable DFC. GCDs have authority to permit wells and establish and enforce rules (such as pumping limits and well-spacing requirements) to achieve their DFCs.

The most common DFC in the Texas High Plains is often referred to as the "50/50" rule, wherein at least 50% of the water in the aquifer available at the time of planning remains in place after 50 years. Its implementation has not been easy, and different conservation districts have taken different approaches, including putting in place groundwater production (pumping) limits. For example, the HPWD and the North Plains Groundwater Conservation District *(northplainsgcd.org)* have set a limit for allowable annual use of 1.5 acre-feet of water per contiguous acre per year with provisions for banking unused water to optimize its use. These pumping limits may be adjusted periodically as needed to support the DFC.

Producer Practice

The Texas High Plains produces the overwhelming majority of the state's beef, dairy, pork, corn, and cotton. Since the 1970s, feed corn and corn silage have been intensively irrigated to supply the Texas High Plains' extensive livestock industries. However, corn producers are finding it increasingly difficult to meet the crop water demands due to declining groundwater levels. Although the total seasonal water use of corn can approach 30 inches per year in the Texas High Plains due to the region's high evaporation demands, corn is still widely grown owing to high yields, historically high profit potential, and livestock demands. Although corn is still the Panhandle's primary irrigated crop, cotton acres have more than doubled in the last five years across the Panhandle as a method to extend irrigation resources. Conversely, cotton remains the predominant crop in the South Plains region of Texas (near Lubbock). Cotton requires less water than corn for profitable economic returns. As a result of the lower crop water demand, roughly half the South Plains' cotton acreage is not irrigated.

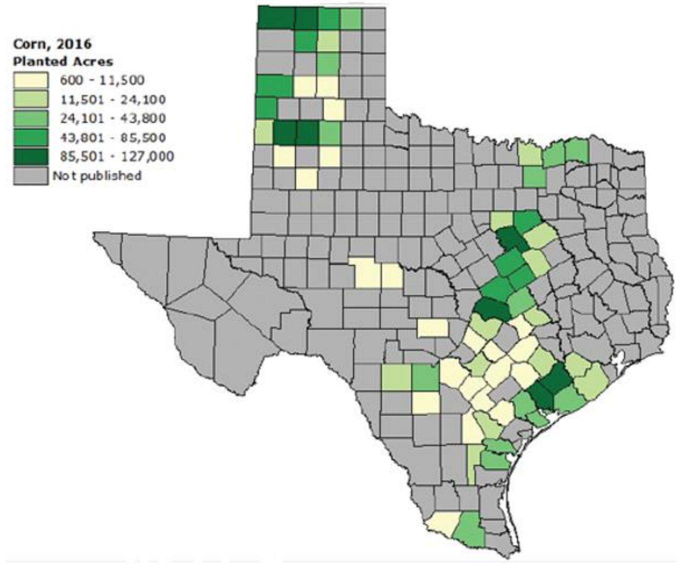

Figure 1. Planted corn acres by Texas county. Reference: NASS, 2017.

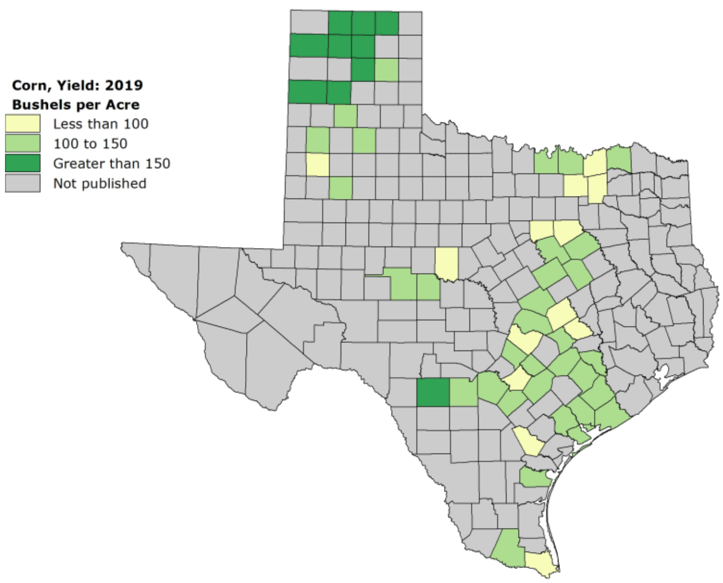

Figure 2a. Corn yields by Texas county, 2019. (Source: *https://quickstats.nass.usda.gov)*

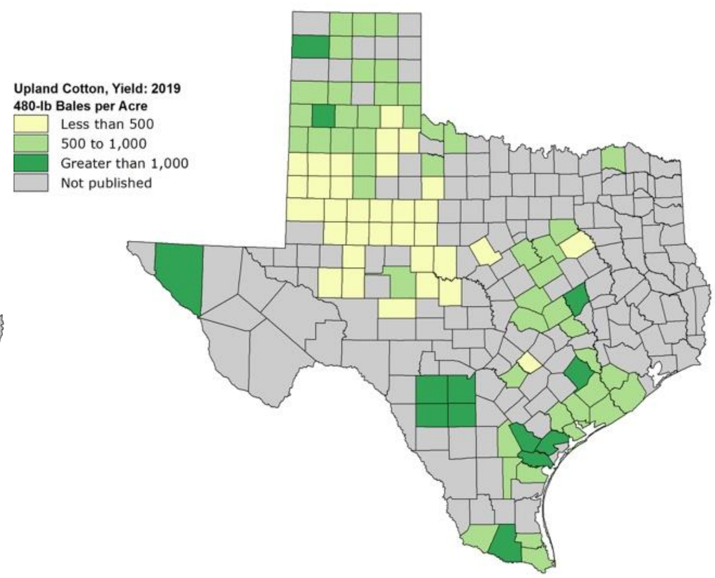

Figure 2b. Upland cotton yields byTexas county, 2019.

Producers have implemented strategies to mitigate limited and declining groundwater resources. Some examples include:

- Splitting irrigated fields into zones that grow different crops, such that part of the area is planted to limited-irrigation or dryland (rainfed) crops
- Irrigation methods shifting to the use of low-pressure center pivot irrigation since the 1980s, and more recently to subsurface drip irrigation, which can achieve higher application efficiency than surface irrigation or high-pressure sprinkler methods
- Using data from soil water sensors and/or crop-canopy temperatures to improve irrigation scheduling
- Employing online irrigation scheduling tools to allow daily tracking of rainfall and evapotranspiration demand and needs of the crops
- Shifting cotton production in the South Plains to very low irrigation inputs (deficit or supplemental irrigation) or to dryland production
- Adopting new crop types and varieties with increased drought tolerance, which maintain or improve yields with decreased water input
- Planting early-maturing crops to shorten the duration of irrigation, and planting later in the season to shift the periods of peak water demand out of the hottest periods

Producers across the Texas High Plains are notably progressive adopters of efficient irrigation technologies, especially in areas where well capacities have long been a limiting factor to crop production. Low-pressure center pivot irrigation systems and subsurface drip irrigation are well suited to Texas High Plains' crop production conditions, and well-established applied research and extension programs, industry expertise, and financial incentives (including low interest loan and cost-share programs) support the adoption of these technologies.

Moving Forward

Improvements in water and agricultural management practices have increased crop water use efficiencies and increased farm profitability. Improved irrigation technologies and agronomic management enabled producers to improve irrigation efficiencies by reducing irrigation rates on a per-acre basis, but this also allowed producers to irrigate greater acreage. Consequently, historical improvements in irrigated agriculture water use efficiencies have not necessarily resulted in a regional reduction in groundwater withdrawals. Thus, the future challenge facing the management of the Ogallala aquifer in Texas occurs at the intersection of technological advances, understanding the physical limitations of the resource, and the economics of agricultural production. Some of the most pressing knowledge and technology needs are:

- Improved irrigation management and decision support tools using site-specific, weather-based evapotranspiration estimates and/or in-field monitoring of soil and plant water stress
- Development of improved crop-water production functions (yield per water use relationships) that are specific to cultivars and hybrids of different maturity types and irrigation methods
- Refinement of water-efficient crop production strategies to improve in-season management responses to changing weather and crop conditions
- Improvement of variable-rate irrigation systems which allow for within-field adjustment of water application according to localized soil water capacity and crop yielding ability
- Understanding economics of agricultural and water management technology adoption at the farm and regional scales
- Predicting subregional groundwater supplies and economics according to water withdrawals, the mix of crop types, and irrigation considerations
- Refined strategies of cover cropping and reduced tillage for building soil health as a means to improve water infiltration and storage and rainfall effectiveness
- Identification of water-efficient options for crop diversification, such as high-value crops, and integration of forage and livestock enterprises to support producer profitability.

Producers serve on numerous commodity check-off and stakeholder advisory boards which provide vital linkages between problem identification, technology development, and technology adoption. There also has been strong public support for the testing, demonstration, and education of producers on the mechanics, agronomic management, and economic returns at the farm and regional scale. Thus, a key factor for the Texas High Plains Region to sustain the agricultural economy is to ensure that agricultural producers continue their engagement with higher education and public agencies to inform research priorities and collaborate with extension activities.

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