Texas

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Introduction

Texas has some of the most diverse climate conditions of any state in the United States. Precipitation can vary from over 60 inches per year in the eastern part of Texas near the Gulf Coast, to less than six inches per year near El Paso in the west. In addition, the agricultural growing season can range from year round in the lower Rio Grande Valley in southern Texas, to approximately a half a year in the northern panhandle region of the state. 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, much of the agricultural production requires irrigation to be profitable, 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. 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 one of the most important resources that Texas has to support its agricultural economy, especially related to its livestock industry, where the High Plains region produces 78% of fed beef, 60% of dairy cows, 94% of hogs, 63% cotton, and 41% of corn for the state.

However, there is a great deal of concern related to declining water levels across the Ogallala aquifer in Texas, with some areas declining by as much as 100 feet over the last half century. Declining water levels have sharpened the awareness of the Ogallala aquifer as a limited resource and prompted actions to address the sustainability of water use for a robust 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 that 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. Extensive use of groundwater in the region, particularly after the 1950s, led to the creation of the High Plains Underground Water Conservation District (HPWD), which was the first Groundwater Conservation District (GCD) in Texas (of which Texas now has over 100). 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.” Such high resolution information is useful to understand how the aquifer responds to droughts, to characterize the hydraulic recovery at the well and to evaluate losses in well yields over time. These datasets are publicly available and extremely valuable to help improve the public awareness of groundwater resources in the region.

Several scientific studies have been

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undertaken to elucidate recharge mechanisms and highlight the important role that depressional wetlands (playas) and associated annual infiltration 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 production, which started in the 1950s. GCDs in the region have established production limits for wells that produce significant amounts of water, which are referred to as non-exempt wells. Barring a few exceptions, direct metering of non-exempt wells or using alternative approaches, such as nozzling packages or electrical usage to estimate groundwater production, is now required or recommended by most groundwater conservation districts in the region. However, only aggregated groundwater production data (typically summed over a county) are made publicly available. A suite of regional groundwater flow models has been developed for the Ogallala aquifer dating back to the Regional Aquifer Systems Analysis program of the 1980s. Groundwater models have been developed by the TWDB to support groundwater policy and planning studies in the region. A comprehensive regional groundwater flow model at 0.5 mile x 0.5 mile resolution was recently developed and includes not just the Ogallala Formation but also the deeper (older) geological units of the High Plains aquifer. These models are used to guide regional groundwater planning endeavors and support regulatory actions aimed at maintaining the "desired future conditions" 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), have also conducted field studies to evaluate crop water requirements and improve irrigation efficiencies. These efforts are supported by comprehensive research programs of the USDA-ARS (Conservation and Production Systems Laboratory at Bushland and Crop Stress Laboratory in Lubbock) and university systems (Texas A&M, Texas Tech, and West Texas A&M). Programs emphasize the understanding of crop water use (evapotranspiration); advanced irrigation technologies; optimizing management of limited irrigation resources for cropping systems; development of drought-tolerant and salt tolerant crop varieties; water efficient crop rotations, soil management, and other best management practices; and development of irrigation decision support software.

Policy

Texas is the only state overlying the Ogallala aquifer to operate under the common-law rule of capture, under which the landowner owns the water beneath and has the right to pump that water. The rule of capture is commonly referred to as the “law of the biggest pump,” indicating that landowners face incentives to pump groundwater before their neighbors do. The rule has been modified to prevent waste, subsidence, and harmful or malicious use (Texas Water Code § 36.002).

Although the rule of capture alone may lead to increased use in some instances, legislative actions have been taken to help conserve and protect groundwater resources in Texas. The state government has begun to exercise its right to control groundwater resources through a change to the Texas Constitution, known as the conservation amendment. 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 are then tasked with developing their own plans for meeting the applicable DFC. GCDs have authority to permit wells, 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 the 50/50 rule, meaning that 50 percent of the current aquifer level would remain in the aquifer in 50 years. Implementation of this DFC has not been easy, and different conservation districts have taken different approaches. For example, the North Plains Groundwater Conservation District has set a limit for allowable annual use of 1.5 acre-feet of water per acre per year. Adjustments may also be made to the limit in order to reach the targeted DFC. In this particular district, the DFC is set at 40/50 for counties with higher historical water use and at 50/50 for all other counties (North Plains Groundwater Conservation District, 2015). In the HPWD, the allowable production rate is limited to 1.5 acre-feet per contiguous acre per year for all groundwater users.

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, regional corn producers are finding it increasingly difficult to meet the crop water demands necessary to maximize yield and profit as a result of declining water levels in the Ogallala aquifer. 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 potential, corn is still widely grown thanks to its high yields, historically high profit potential, and livestock demands. Conversely, cotton is 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, and northern Texas High Plains’ cotton acreage has more than doubled since 2015.

Various practices have been implemented by producers to stretch supplies of groundwater for irrigation such as altering the allocation of crop types and irrigation to their land and implementing technical changes that more precisely target water to the crops in space and time. Some examples of these practices are:

- Splitting center-pivot circles into sectors that grow different crops, such that part of the area is planted to lower water use, limited irrigation or dryland (rain fed) crops
- Irrigation methods shifting to the use of low energy precision application (LEPA)

since the 1980s, and more recently to subsurface drip irrigation, which can achieve 90-plus percent application efficiency

Monitoring water status using soil water sensors and crop-canopy temperatures, which help prevent excessive irrigation

Employing online irrigation scheduling tools to allow daily tracking of evapotranspiration demand and needs of their crops, with real-time updates that factor in rain events

Shifting cotton in the South Plains to very low irrigation inputs and dryland production

Adopting new varieties of cotton and corn with increased drought tolerance, that maintain or improve yields with decreased water inputs

Planting early-maturing corn hybrids to shorten the duration of irrigation, and planting corn later in the season to shift the periods of peak water demand out of the hottest periods in July and early August

Replacing corn by grain sorghum in the dryland or low-irrigation sectors, and opting for newer, early-maturing cotton varieties having enhanced yield potentials and lint quality

These changes in crop and water management practices have been rapidly implemented across the Texas High Plains, as producers in the region 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 an established "infrastructure" of applied research and extension programs, industry expertise, and financial incentives (including low interest loan and cost-share programs) support the adoption of these technologies.

Post-doc Amanda Cano (USDA-ARS and TTU) field sampling. Photo by Diana Vargas.

Moving Forward

Improvements in water and agricultural management practices have enhanced crop water use efficiencies across the region, but this improvement has increased farm profitability, which has contributed to increases in High Plains irrigated acreage in recent years. Consequently, historical improvements in irrigated agriculture water use efficiencies have not resulted in a regional reduction in groundwater withdrawals within Texas. 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, with some of the most pressing knowledge and technology needs being:

Improved irrigation management and

scheduling tools using location targeted weather-based evapotranspiration estimates and in-field monitoring of soil and plant water stress

Integrated multiple irrigation scheduling methods and data into user-friendly decision support tools

Development of improved crop water use functions that are specific to varieties, hybrids and irrigation methods

Development of water-efficient crop production strategies that allow in-season management changes due to changing weather and crop conditions

Development of variable rate irrigation systems which allow for within-field adjustment of water application according to localized soil water capacity and crop yield ability

Understanding the economics of agricultural and water management technology adoption at the farm and regional scales

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 and demonstration of technologies 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 its 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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