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Ogallala Aquifer – Lifeblood of the High Plains

Part I: Withdrawals Exceed Recharge

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Key Points:

- ***The Ogallala aquifer has been tapped faster than nature can replenish it. Overall, it has lost an estimated 8 percent of its water, albeit with wide variations. Wells in parts of Texas, for example, have dropped as much as 242 feet while some wells in Nebraska have seen 85-foot increases.***
- ***Within the High Plains, the two hardest-hit areas are Western Kansas and the Texas Panhandle, where almost 30 percent of their portions of the Ogallala have been depleted, largely due to widespread irrigation, drought, and low recharge rates.***
- ***Technological innovations, pumping cutbacks and restrictions, efficient irrigation systems and other innovations all have helped to slow the decline of the aquifer. But some sections of the Ogallala continue to be at severe risk of depletion.***
- ***To date, Kansas' and Texas' water laws have proved to be ineffectual in controlling and limiting withdrawals from the Ogallala for irrigation. Kansas is experimenting with some promising new laws involving so-called LEMAs, but they're still unproven.***
- ***As groundwater levels in the Ogallala recede, irrigation becomes more costly. Farmers in turn are adapting their cropping practices to the evolving condition of the Ogallala aquifer.***
- ***Farmers in the High Plains will continue to adjust and adapt to the Ogallala's depletion. Dry land farming will replace irrigated farming; irrigation will become more efficient; soil conservation techniques will grow in use; and improved drought-tolerant seed varieties will continue to be introduced.***
- ***Life expectancy predictions for the Ogallala Aquifer vary greatly. In a few places, the water is severely depleted, to the point where pumping is no longer economically viable. But in most areas, with technological help and careful management, the water will last for generations to come.***

This report provides an overview of the Ogallala's depletion and the potential impacts on farming and food production. A companion report will focus on legislative actions, technological innovations, water conservation efforts and other initiatives aimed at extending the life of this vital resource.

Introduction

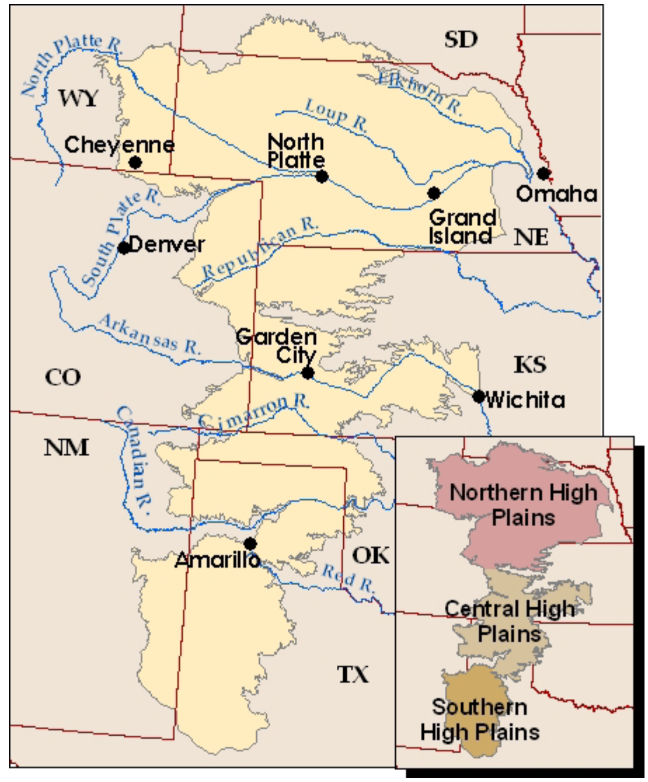
For more than six decades, the High Plains has reigned as one of the world's most productive farm belts, famous for its beef and grain. Water has transformed the region, which runs from South Dakota to Texas, into a colossal food factory, producing nearly one-fifth of the nation's wheat, corn and cotton.[1] Kansas, Nebraska, Texas and Colorado provide almost half of the nation's beef cattle, and irrigated crops account for more than $7 billion in sales annually.[2,3]

While high productivity defines the High Plains' past and present, uncertainty defines its future. The region's main source of water – irrigation water from the vast underground Ogallala Aquifer – was at one time thought to be inexhaustible.[4] Today, it's clear the Ogallala Is being tapped faster than nature can replenish it.

Since the 1940s, the High Plains Aquifer, consisting largely of the Ogallala, has declined by some 246 million acre-feet – equivalent to roughly two-thirds of the water in Lake Erie.[5] But the depletion is uneven, with some regions having been harder hit than others. Together, Nebraska, Texas and Kansas overlie more than 85 percent of the Ogallala's water, the lifeblood of the farm economy in all three states.[6] The aquifer in parts of Nebraska is expected to last hundreds of years; but to the south, it's increasingly depleted.[7] Texas has exhausted nearly 30 percent of its Ogallala water; and in parts of western Kansas, as much as 60 percent is gone.[8,9]

As groundwater levels in the Ogallala recede, irrigation becomes more costly, and farmers adapt their cropping practices accordingly. For example, they will shift to more efficient irrigation equipment and techniques; adopt soil and water conservation practices such as no-till and crop rotation; plant more drought-tolerant crops such as cotton and sorghum in place of corn and soybeans; or cease irrigating and shift to dry land farming. This is what successful farmers have always done – adapt to the ever-changing economic environment within which they live and work.

Exhibit 1: The Ogallala Aquifer



Land of Drought

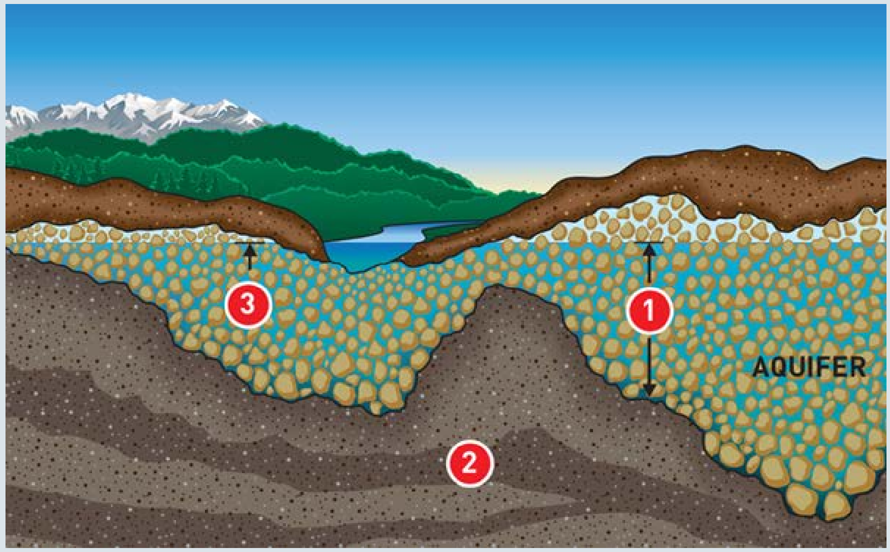
The High Plains, or western Great Plains, includes parts of South Dakota, Nebraska, Kansas, Colorado, Wyoming, New Mexico, Oklahoma and Texas. *(See Exhibit 1.)* This region is semi-arid, with mean annual precipitation ranging from 12 inches in the west to 33 inches in the east.[10]

Drought is a persistent threat. Climatologists estimate that Kansas farmers face a 35 percent chance of a severe drought year in any decade and a 100 percent chance over the estimated 40-year working lifetime of a farm.[11] In Texas, farmers and ranchers face similar odds and battled a ruinous drought that started in 2010 and only recently lifted in mid-2014, resulting in billions of dollars in agricultural losses.[12]

But what the High Plains lacks in rain, it generally has in abundance underground. The Ogallala Aquifer, believed to be North America's largest freshwater body, is so vast that if drained, it would cover the nation in 1.5 feet of water.[13,14] It was named after the Nebraska Panhandle town where in 1896, N.H. Darton of the U.S. Geological Survey discovered an ancient rock outcropping that he recognized as part of a multistate water-bearing formation.[15]

Like its size, the Ogallala's creation is epic, beginning in the Rocky Mountains millions of years ago. Water and weather eroded the mountains, carrying off rocky debris in streams and torrents, cutting deep channels west to east over 174,000 square miles.[16] Gravel, sand, silt, rain and snowmelt gradually filled the channels to create the aquifer, described as a "great rock sponge," containing some 2.96 billion acre-feet of water.[17] *(See Exhibit 2.)*

Exhibit 2: Water Capacity of an Aquifer



An aquifer is an underground body of saturated, permeable rock through which water easily moves. The water capacity of an aquifer depends upon its (1) saturated thickness, measured as the distance between the bottom of the aquifer, bordered by (2) bedrock, and (3) the water table, which is the uppermost surface of groundwater. An aquifer's saturated thickness varies throughout the aquifer, as well as from year-to-year, depending upon the differential rates of withdrawal and recharge.

Sources: Kristen French, OnEarth*, undated; and the Idaho Museum of Natural History.*

The Ogallala was largely untouched by the first settlers on the High Plains, who grazed cattle.[18] By the 1880s, farmers dominated. Some irrigated with diversions from the Platte and Arkansas rivers, and others used windmills to draw shallow groundwater from the Ogallala.[19]

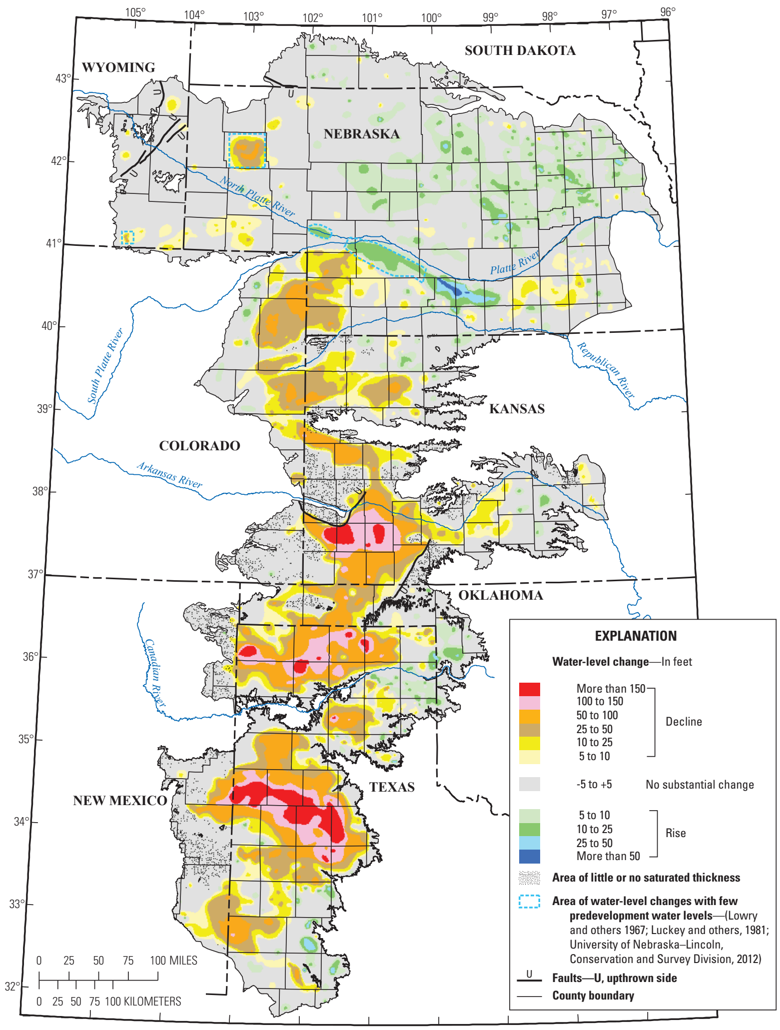
From 1880 to 1920, the federal Homestead Acts brought a massive influx of new farmers to the Great Plains. In the 1930s, poor cultivation, drought, large-scale erosion, and high grain prices triggered one of the worst environmental disasters of the century – the Dust Bowl. Homesteads, mostly 160 to 320 acres, were "too small to be economically viable," write economists Zeynep Hansen and Gary Libecap. "Because they were constrained by size, small farmers intensively cultivated their land, did not place portions in fallow, and did not diversify into pasture. Such cultivation made the soil more vulnerable to wind erosion and culminated in the Dust Bowl of the 1930s."[20] But the 1930s also brought electricity to farms in the region, along with powerful new submerged pumps. Farmers for the first time could seriously tap the Ogallala.[21]

When a major drought struck again in the 1950s, farmers stepped up their reliance on irrigation. Water wells proliferated, producers planted more, and agriculture on the High Plains was transformed.[22] The center pivot sprinkler, patented in 1952, accelerated the boom. The rolling, self-propelled sprinklers navigated hilly land, reduced evaporation, distributed groundwater more efficiently and required less labor than flood or open row irrigation. As a result, irrigated land in the High Plains grew exponentially.

But irrigated agricultural production has taken a toll on the Ogallala. Water tables in parts of the eight-state region began dropping, some precipitously.[23] Recharge, the natural movement of water into an aquifer from rain, snowmelt and streams, averages only one-half inch per year in the High Plains, and in parts of the region much of the rain falls during the growing season, when plant roots intercept the moisture.[24]

Depletion of the aquifer set off five-alarm headlines. In February 1979, the Wichita Eagle-Beacon newspaper published a series entitled, "We're Running Out," which

Exhibit 3: Water-level Changes in the Ogallala Aquifer, Predevelopment (ca 1950) to 2011



Base from U.S. Geological Survey digital data, 2001, 1:2,000,000
Albers Equal-Area Conic projection
Standard parallels 29° 30' and 45° 30', central meridan -101°
North American Datum of 1983 (NAD 83)

Aquifer boundary from Qi (2010); areas of little or no saturated thickness and faults from Gutentag and others (1984) and Cederstrand and Becker (1999a, 1999b)

aquifer. The most recent measurements show that High Plains water levels dropped 14.2 feet on average from roughly 1950 to 2011, with the Ogallala losing 8 percent of its water.[27]

Wide Variation in Depletion

In fact, groundwater depletion has varied enormously over the eight-state region, and not all areas confront the same degree of stress.[28] *(See Exhibit 3.)* Wells in parts of Texas, for example, have dropped 242 feet while some Nebraska wells have seen 85-foot increases.[29] Since 1950, water table declines averaged 13 feet in New Mexico and 9 feet in Colorado. South Dakota's groundwater is abundant, but high mineral concentrations and human-caused pollution have degraded its quality.[30]

Western Kansas, however, has lost an estimated 30 percent of its groundwater to irrigation, and another 39 percent will be gone in the next 50 years at current pumping rates, according to a four-year Kansas State University study released in 2013.[31] The widely publicized study predicted that agricultural production would top out around 2040 and decline after that, although with better conservation techniques, western Kansas could delay the peak until the 2070s. The greater use of new, drought-tolerant seed varieties will also ameliorate the situation.

Rex Buchanan, interim director of the Kansas Geological Survey (KGS), said his agency's research reveals that parts of the aquifer are effectively exhausted in Greeley, Wichita, and Scott Counties (in extreme west-central Kansas). According to a 2009 KGS forecast, "Other parts of the aquifer, in areas such as southwestern Thomas County, are projected to have a lifespan of less than 25

declared that irrigation "will be nothing but a memory in many large parts of west central Kansas in 8 to 10 years."[25] In May 1981, the Kansas City Times called the Ogallala drawdown "The Next American Crisis," reporting, "In at least five states pumping the aquifer, irrigation has peaked. By 2020, virtually all irrigation water in Kansas will be gone."[26]

It didn't happen. But people's concerns about the Ogallala were unallayed. In 1986, Congress ordered the U.S. Geological Survey to begin monitoring water levels in the

Groundwater depletion has varied enormously over the eight-state region, and not all areas confront the same degree of crisis.

years, based on past decline trends. However, the biggest share of the aquifer in southwest Kansas would not be depleted for 50 to 200 years. It is important to remember that these projections are based solely on past water-level trends, and future changes could alter the actual depletion rate."[32]

In an interview, Buchanan put it more forcefully. "There are an awful lot of parts of west central Kansas where the game is already over, or if not, it's close to being over," he said. "Large-scale irrigation will be impossible there as early as 2020." Buchanan said that southwest Kansas has seen the greatest drops in water levels, especially during the drought, "but the southwest started out with much greater saturated thickness, so they still have large amounts of water available."[33] However, drawing it from greater and greater depths becomes increasingly costly.

In Ulysses, a southwest Kansas community about 50 miles north of the Oklahoma border, Anthony Stevenson owns five pumps, but runs only two of them on 2,500 acres of corn, wheat and sorghum. This fourth-generation farmer quit irrigating some of his land because the water has been depleted, or what's left is too expensive to reach.

"In the late 1940s, my granddad drilled 100-foot wells and got 1,000 gallons of water a minute," Stevenson said.[34] Today, water tables have dropped so much, Stevenson said, he would have to go 500 to 600 feet deep just to get 250 gallons a minute. And at a cost of $175,000 for a new or re-drilled well, "Is the price really worth it?" Stevenson asks. "It's a constant calculation."

Stevenson is pumping half of what he used to. Close to three-quarters of his acreage is now dry land. But reducing his irrigation has come at a cost. Typically, in non-drought years, yields from dry land farming tend to be about 40 to 50 percent below those for irrigated acreage. Other western Kansas farmers have also had to make similarly dramatic changes to their irrigation schedules, said Buchanan. "Farmers used to flip a switch and leave their pumps on for three months; now, they do that just in times of high stress." Of course, increased pumping at these times of high stress accelerates the withdrawals from the aquifer even as the lack of rainfall diminishes its recharge.

Eight of Kansas' most productive agricultural counties overlie the Ogallala, and according to the 2007 U.S. Census of Agriculture, account for more than $4.7 billion in crop and livestock sales annually, or about one-third of total agricultural revenue for the entire state.[35] Irrigated cropland in the Ogallala region was responsible for $1.75 billion in corn production and $384 billion in retail beef production in 2012. The corn industry supports 25,000 jobs and adds about $1.2 billion to the Kansas economy every year, while beef production supports an additional 32,000 jobs and adds about $2 billion to the state's economy.[36]

Consequently, Kansas has much at stake in the future of its groundwater. Technological innovations, pumping cutbacks and restrictions, efficient irrigation systems and other innovations all have helped to preserve the aquifer and deflate the sky-is-falling predictions of the 1970s and 80s. "We can draw some encouragement from the fact that it didn't happen and a lot of that is attributable to necessity, the mother of invention," said Mark Rude, executive director of the Southwest Kansas Groundwater Management District 3. Water scarcity "pushes guys with high water costs to get more efficient and effective with every drop."

Many farmers have quit irrigating part or all of their land, switching to dry farming, hoping for rain, and accepting reduced yields and incomes. Others have switched to crops such as sorghum because it requires roughly two-thirds of the 14 inches or more of irrigation per acre that corn typically consumes in a growing season.[37] Still, corn is hard to give up. Even when it's selling at $4 or $5 a bushel, it's lucrative, and irrigation makes it more so.

Water Rights in Kansas: Not Immutable

Kansans readily acknowledge that they have a water problem. "Over eighty percent of the water used in Kansas is for irrigation, and nearly ninety percent of that water is groundwater, drawn mostly from the Ogallala-High Plains Aquifer. Because most of the Ogallala in Kansas is effectively non-renewable, Kansans faces a serious problem of groundwater depletion."[38] Kansas' frequent severe droughts exacerbate this problem; but even in the absence of drought, Kansans continue to withdraw water from the Ogallala aquifer faster than it recharges.

At the same time, Kansas' statutory water laws have both the scope and "teeth" needed to address this problem.[39] All individuals, companies, municipalities, and other users must obtain permission to consume groundwater for beneficial purposes by securing a water right. These water rights limit holders to an annual authorized volume, which cannot be increased or exceeded, The fundamental precept underpinning Kansas' water law is the doctrine of prior appropriation – commonly known as, "first in time, first in right." In the face of insufficient water to meet all existing water rights, the earlier dated water rights are assigned higher priority, and those with the newest water rights are the ones who must do without water.

Kansas' water laws have also created a "watchdog," the Chief Engineer of the Kansas Division of Water Resources, with the authority to regulate surface and groundwater rights according to the doctrine of prior approval. To maintain their water rights, right holders are required to file an annual water use report with the Chief Engineer listing how much water they pumped, the pump rate, place of use, point of diversion, and type of use. Noncompliance incurs penalties. In addition, if holders of groundwater rights suspect that junior users are infringing on their senior rights, they can petition the Chief Engineer to conduct an investigation. If the Chief Engineer finds that an impairment has occurred, he can order the rights to be administered. "Kansas thus has both the administrative and doctrinal tools to protect groundwater rights from impairment."[40]

> *"Water scarcity pushes guys with high water costs to get more efficient and effective with every drop.*

Kansas legislators expanded the state's water law in the 1970s to allow for the establishment of five Groundwater Management Districts (GMDs), which, together, overlie most of the state's portion of the Ogallala Aquifer. These GMDs are run by elected boards with the authority to tax, regulate water use within their districts, recommend policies to the state's regulatory bodies, and enforce groundwater rules within their districts.[41] If approved by the state's Chief Engineer, a GMD's regulations become binding and enforceable. Some GMDs have required farmers to install water meters and have banned the drilling of new wells in certain areas.[42] At the request of certain GMDs, the Kansas State Department of Agriculture has levied fines for overuse, but at least one state lawmaker has complained that the penalties are so small that they don't deter farms from over-pumping.[43]

Although Kansas' water law could be used to restrict over-pumping of the Ogallala and at least mitigate the problem of groundwater depletion, water right holders and the state's Chief Engineer have been reluctant to exercise the law's regulatory powers. The state's Assistant Attorney General, drawing on his years of experience in administering, analyzing, and formulating Kansas' water statutes, has offered three reasons why Kansans choose not to enforce their water statutes more forcefully:[44]

- He assigns much of the fault to the state's administered system of water rights. In effect, the state's Chief Engineer has granted legal water rights permitting withdrawals from the underground Ogallala that exceed the aquifer's annual recharge. As long as rights holders pump no more than their permitted allotments, the Chief Engineer has tenuous grounds at best for imposing an aggregate limit on pumping.

- Under Kansas' water law, the state's water regulators have no mandate to "save" the Ogallala from depletion. Hence, any actions that the Chief Engineer might take toward this end would be fraught with legal and political risks. Were the Chief Engineer to attempt to restrict withdrawals from the Ogallala by legally entitled rights holders in order to save the aquifer, a court could find that the ordered reductions in withdrawals amounted to an "uncompensated taking under the 5th and 14th amendments to the U.S. Constitution," entitling the plaintiffs to compensation. In addition, any such efforts on the part of the state's Chief Engineer would likely create a political backlash where irate Kansas voters might well attempt to circumscribe the Chief Engineer's existing regulatory powers.
- While many Western Kansas farmers are concerned about extending the aquifer's life, they are loath to press the Chief Engineer and the state's Division of Water Resources to invoke their regulatory powers to limit withdrawals from the aquifer for fear of the unintended consequences resulting from such actions. Within a "neighborhood" of groundwater rights, the imposition of a restriction on total withdrawals would have a cascading effect on the junior rights holders, creating animosity and political repercussions. Western Kansas farmers are loath to see their neighbors' crops wither for want of water and are also wary of the possibility of draconian reductions in authorized pumping.

In response to this political impasse and the need for remedial action, Kansas legislators enacted a new legislative bill in 2012 that provided for the creation of Local Enhanced Management Areas (LEMAs).[45] Under this statute, a local community of irrigators within one of the state's five GMDs can band together to create a water management plan aimed at reducing their aggregate withdrawals from the Ogallala by a specified amount that they themselves choose. Such plans must comply with the GMD's goals and must be submitted to the Chief Engineer for his approval. Once approved, the LEMA's proposed reductions in water use will fall equally on all water rights holders, in contravention to the state's doctrine of "first in time, first in rights."

Shortly after the adoption of the 2012 legislation, farmers in Sheridan and Sherman counties in Northwest Kansas banded together under the auspices of Groundwater Management District #4 to create the state's first LEMA – the so-called Sheridan-6 LEMA, or SD-6. Their plan was approved in April 2013 and calls for water rights holders within the SD-6 to reduce their irrigation pumping by 20 percent over the ensuing five years, where all rights holders must comply regardless of priority. However, the individual rights holders are allowed to decide how to achieve the targeted 20 percent reduction over the course of the five years, varying how much they pump in each of the five years – as long as the total usage complies with the 20 percent reduction for the five years. In addition, the SD-6 plan also imposes harsher penalties on non-compliance than would otherwise apply under existing state law.

How successful the LEMA program will be, remains to be seen. It will be several years before analysts can assess how much the 20 percent (five-year) reduction in water use will impair farmers' net returns from their crops. To some extent, the farmers themselves can mitigate the decline in net returns by using water more efficiently or by planting alternative crops that require less water than those previously planted. Success will also depend on whether the rights holders in the Sheridan-6 LEMA are willing to renew their commitment to reduce water usage by 20 percent in 2018 when the current plan expires. Success will also depend on whether the example provided by the Sheridan-6 LEMA inspires other communities of water users within the five GMDs that overlay the Ogallala to adopt their own LEMAs.

Water Rights in Texas: Strongly Favor Individual Landowners

Farmers in the Texas High Plains have seen a number of weather records in the past few years – none of them good. The single driest year in recorded Texas history was 2011, with an average of only 14.8 inches of rain.[46]

Temperatures also hit record highs that year in large portions of the Panhandle, with Amarillo reaching 111 degrees on June 22, 2011.[47]

To counter the drought, farmers irrigated more. Wells in parts of the Texas Panhandle dropped an average of 3.5 feet in 2011, with a median decline of 1.8 feet.[48] Another study in the same area, by the 16-county High Plains Underground Water Conservation District No.1, which runs roughly from Amarillo to south of Lubbock, showed an average decline of 2.56 feet – the third largest in the district's 61-year history and three times the average rate over the past decade.[49] In normal years, the Ogallala drops about three-quarters of a foot or a foot on average.[50]

But lack of rain isn't the only reason why almost 30 percent of the Ogallala has been depleted in the Panhandle. Widespread irrigation began earlier in the southern High Plains than it did in the north, and "irrigation pumpage averaged 30 percent higher in Texas than in Nebraska," according to a 2012 University of Texas study.[51] Nebraska also enjoys much higher recharge rates, mainly due to its sandier soil and Platte River seepage, the study's lead author, Dr. Bridget Scanlon, told the Texas Climate News. In addition, evapotranspiration is greater in the Lone Star state. In the past 60 years, the aquifer in west Texas has dropped around 100 feet, while in Nebraska, it has fallen on average no more than a foot, she said.[52]

> *Texas farmers have adapted to the higher cost of irrigated water.*

Another stress on the aquifer in Texas is its "rule of capture" law. Until recently, this law allowed landowners to pump as much groundwater as they wanted from beneath their properties. But today, Groundwater Conservation Districts (GCDs) exercise limited regulatory control over about 90 percent of Texas' underground water. Those landowners who live in areas of Texas governed by a GCD must abide by its regulations over well-spacing and groundwater production.[53] The rules, however, are under legal scrutiny. In 2012, when the High Plains GCD tried to impose pumping limits, local farmers rebelled, arguing that the limits violated their property rights. The GCD tabled the restrictions for the time being, rather than force the issue.

Self-interest makes farmers the best stewards of the land and water, argues John Ross, 68 years old, a veteran farmer who grows corn, cotton and wheat 15 miles southeast of Plainview.[54] Ross, who owns 25 wells, said he and his neighbors have invested in efficient irrigation equipment, converted parts of their operations to dry land, rotated crops, preserved moisture in the soil with no-till practices and otherwise conserved groundwater. Meters and fines, he said, will only make him and his neighbors resentful. "We're all adjusting ourselves," he said. "No one regulating our water has given us any consideration yet that I've spent hundreds of thousands to buy center pivots for my irrigated land. I did that for my own survival, and nobody gave me any money to do it."

The water district's president, Lynn Tate, is trying to strike a balance with farmers. "We've got to decide, as a group, what the rules should be," he said. "There are several decisions to make. We need to find the best ways to achieve these goals for every water user within the district."[55] Often, however, water users within a GCD fail to see eye-to-eye on these matters.

The Texas High Plains economy is largely dependent on Ogallala groundwater. The various crops grown in the area supported more than 103,000 jobs and generated more than $12.2 billion in economic activity in 2010.[56] But periodic droughts threaten that productivity. The Texas High Plains counties are today just recovering from an unusually severe drought that began in 2010 and only recently lifted in mid-2014.[57,58] *(See Exhibit 4.)*

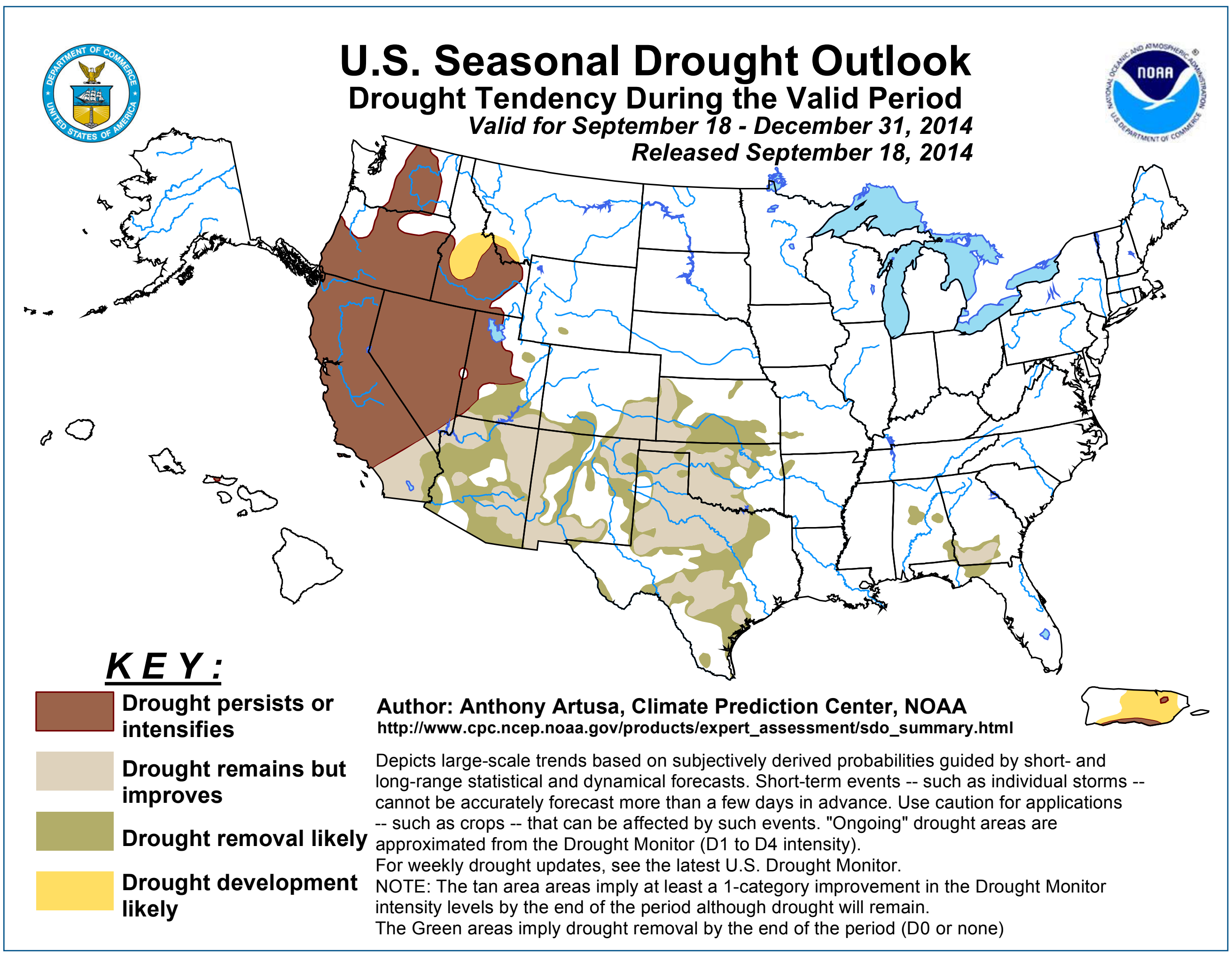
Meanwhile, Texas farmers have adapted to the higher cost of irrigated water. Many will plant more drought-tolerant crops such as cotton and sorghum. Others, like John Ross, will do more dry land farming. Already, 60 percent of farms south of Lubbock are dry land, predominantly growing cotton, according to the Texas A&M University Agricultural

Economic Department.[59] And farmers are economizing on their use of water. For example, another local farmer, Glenn Schur of Plainview TX, uses new irrigation technology to monitor and control the amount and timing of irrigation water. "It's an economic sustainability issue," he says. "Every acre-inch I can save puts money in my pocket."[60]

But as in Kansas, abandoning irrigation entails a cost. Yields from dry land farming are substantially below those for irrigated farming. Researchers from the Texas Tech University and Texas AgriLife Extension Service have estimated that highly irrigated land in the Texas High Plains yielded a gross output of $482/acre more than the dry land. For the whole region, the study estimated that converting all irrigated acres to dry land – admittedly, an extreme example – would result in annual net losses (including the indirect multiplier effects) of $1.6 billion in gross income, $617 million of value-added, and nearly 7,300 jobs. Plus, the blow would fall hardest on rural communities where agriculture comprises roughly 75 percent of economic activity.[61]

Rural communities already are under stress. "We're seeing decreases in rural populations in the High Plains," said

Exhibit 4: Drought Intensifies in the West, but Eases Elsewhere



Scanlon. "And during droughts, some farmers are forced to fallow their land." These trends will likely accelerate insofar as water scarcity issues become more severe.

What's Ahead for High Plains Farmers?

Life expectancy predictions for the Ogallala Aquifer vary greatly across the region. In a few places, the water is depleted to the point where pumping is no longer economically viable. But in most areas, experts say that with wise management and technological help, the water will last for generations.

No one knows for sure, but experts predict the following trends:

- The cost of pumping, which has tripled in the past decade, will continue to escalate as groundwater has to be lifted from greater depths.[62]
- Drought-tolerant crops such as cotton and sorghum will replace corn and other water-intensive crops in some areas.[63] Farmers in western Kansas and the Texas Panhandle will rely increasingly on new, drought-tolerant seed varieties.
- Scientists at the major seed companies, along with their counterparts at the land grant universities, will continue to develop improved drought-tolerant seed varieties.
- Dry land farming will continue gradually to replace irrigated farming in some areas of western Kansas and the Texas Panhandle, resulting in lower yields.
- As groundwater levels recede, farmland values in the High Plains could also decline.
- Some farms will be sold to ranchers who will convert the croplands to pastures and raise livestock.
- In some areas, rural communities will shrink as cities grow and require more groundwater. In Texas, small and midsize farms – those under 2,000 acres – have been declining at a rate of 250,000 acres a year, according to the Texas A&M Institute of Renewable Natural Resources. From now until 2020, Texas is projected to convert more than 1 million more acres of irrigated farmland to dry land farming.[64]
- Irrigation technology and methods will continue to become more efficient, and soil conservation techniques, such as no-till and crop rotation, will increase.[65] Water efficiency efforts will increase significantly.
- New precision agriculture strategies will increase, including Global Positioning System technologies and site-specific management to apply the optimal amount of water and nutrients.[66]

The point is that farmers throughout Kansas and Texas will adapt to the evolving condition of the Ogallala Aquifer, as they must and as they always have. Following the invention and widespread adoption of the center pivot sprinkler in the early 1950s, farmers adapted their crop practices accordingly – first watering their traditional crops more intensively but then, over time, shifting to more water-intensive crops and expanding their irrigated acreage.[67] Today, as the groundwater level of the Ogallala recedes, farmers are adapting still – in part reversing some of their earlier adaptions. Their adaptability is what makes them so resilient.

Endnotes

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