FACING REALITY: AGRICULTURE
WITHOUT THE OGALLALA AQUIFER

A COMPARITIVE STUDY:

THE TEXAS PANHANDLE

&

WESTERN AUSTRALIAN WHEATBELT

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PROBLEM STATEMENT

Agriculture in the Texas Panhandle depends extensively on the Ogallala Aquifer for its water needs and is on path to be completely depleted. Once emptied, hydrogeologists estimate it could take over 6,000 years to fully recharge (Brambila 2014). Parts of the Texas Panhandle have already exhausted the aquifer for irrigation purposes. By 2050 the cost of extracting water from increasing depths could render the entire portion of the aquifer that lays beneath Texas economically exhausted. The high plains of Texas have no alternative aquifer, river, or lake that could provide similar volumes of water without being cost prohibitive. Despite this widely known forecast in and out of the region little research or planning exists for transitioning agriculture away from aquifer water. The only sustainable way forward is to return to “dryland” agriculture that relies natural rainfall swings. This research will contribute to this gap in policy and scholarly analysis through a comparative case study of the Western Australian Wheatbelt (WAW). It will illustrate what future agriculture yields and techniques could resemble in the Texas Panhandle and to suggest specific strategies for adaptation.
FORWARD

I have a personal connection to both regions. Growing up in a small farming community in Central Texas, naturally I had several family members involved in some way with agriculture. Even though the Panhandle is over six hours away from Williamson County, many people including me would visit several times during the year. Buying or selling equipment or seeing extended family, the region was not the forgotten part of Texas to me. Flash forward more than a decade. I completed my undergraduate majoring in water resources, took a gap year, and very curiously wound up in Western Australia. Shortly after arriving I found work 3 hours outside of Perth on a family farm. I spent the next six months helping with the summer harvest and handling 7,000 head of sheep over 18,000 acres in the Wheatbelt Region. Conditions were harsher than most I had seen in Texas. Labor, material, and fuel costs were double or triple what I knew. The most fascinating part, the area was thriving and with less rainfall, surface water, or a usable aquifer.

After studying the Ogallala Aquifer in college, my outlook on the region was grim. I thought that the area would have a similar repeat to the Dust Bowl after the water was gone. Once I experience the WAW I had hope for the Panhandle and wanted to share my experience with farmers back home.
INTRODUCTION

The Texas Panhandle Ogallala Region (TPOR) uses 90% of the water from the aquifer for agriculture which helps Texas’ farmers produce over two billion dollars’ worth of agricultural products every year. In addition, tens of thousands of individuals are directly employed on farms, and there are numerous other economic activities closely dependent on agriculture (Yates 2010). The panhandle also accounts for 15% of the entire United States’ beef production from feed lots (Cavazos 2011), and beef production is highly dependent on groundwater. The area’s future is not only important to Texas and the United States, but the entire world. If the panhandle was a country it would rank in the top 10 of beef and cotton production (Ernst 2013). It would also be in the top twenty in corn, wheat, and swine output (Colaizzi et al 2009). Scientists and people in the region know the aquifer is a finite resource that is being essentially mined for a one-time use, yet the extraction has not abated. Rates of depletion are at all record highs with no signs of slowing down.

This research has these main goals: Are WAW non-irrigated wheat yields and irrigated wheat yields in the TPOR comparable? If similar, are the two regions’ spatial characteristics equivalent? What policy recommendations for adaption can be put forward?

The hypothesis going in is that dryland farming, along with a mixed farming technique will allow the TPOR agricultural economy to survive with some adjustment to current practices. The comparison should fail to reject the null and show that farmers in the panhandle who cannot irrigate in the future should expect similar income to farmers in the WAW.
BACKGROUND

TEXAS PANHANDLE OGALLALLA REGION

The Texas Panhandle is in the top west part of the State of Texas, and its physical geography is unique to Texas. It has the undisputed north boundary of 36°30’ N. Its east and west boundaries are by most authorities the 100th meridian and the 103rd meridian, respectively (Rathjen 2017). The southern edge does not usually extend below 32° N. Most of the panhandle region is considered cold semi-arid (BSk) and humid subtropical (Cfa) on the Köppen climate classification. The boundary for the TPOR was created for this study using the 49 counties that have at least a portion of the aquifer underneath them. The TPOR defined as such comprised an area of 70,362 square miles or 182,236 square kilometers.

Native Americans inhabited the area for thousands of years before the final United States colonization after the American Civil War in the 1870s. With the country reunified and increasing railroad routes Anglos steadily moved into the area (Rathjen 2017). The discovery of oil in the 1920s enriched the area, but the 1930s Dust Bowl devastated the agriculture of the region. After WWII (1939-1945) new technologies for the first time allowed pumping massive amounts of water from the Ogallala for agriculture (Braxton 2009). In 1930 there were less than a hundred irrigation wells, and by 1954 there were nearly 30,000 wells irrigating over 3 million acres (Colaizzi 2009). The previously marginal farm lands were turned into a fertile oasis. The new-found water source, along with other factors, led to a dramatic increase in cattle feedlots as well (Rathjen 2017). Today, the area has a strong agriculture sector, vibrant business, petroleum industry, wind energy, and huge solar energy potential. However, it does face the same problem of population loss that many rural areas in the United States struggle with. The rapid decline of the Ogallala Aquifer is the existential threat that looms over the region.
Agriculture in the panhandle is heavily reliant on irrigation due to the arid climate receiving around twenty inches of rainfall each year. The lack of major rivers and lakes forces farmers to almost exclusively rely on the aquifer (Cavazos 2011). Farmers in the region earn on average nearly $500 more per acre over ordinary crops relying on rain fall alone (Yates, Smith, and Pate 2010). In 2006 cotton was the most abundant crop using irrigation, with nearly two million acres planted. In second place, winter wheat had around a million acres in irrigated. Other irrigated crops include corn, grain sorghum, peanuts, soybeans, and silage (Colaizzi et al. 2009).

Current Texas law allows owners with water rights to pump as much as they want, when they want (Texas A&M University 2014). As the water table drops, the cost of bringing water to the surface increases in conjunction with a decrease in total water quantity. Usually, irrigation must use extremely inexpensive water for it to be financially viable.

OGALLALA AQUIFER

The Ogallala Aquifer (sometimes called the High Plains Aquifer) is one of the largest bodies of fresh water in the world. As the Rocky Mountains formed toward the west, erosion carried sediment east creating a great plain with loose sand and gravel underneath (Steward and Allen 2016). Ancient rivers then filled the gaps between the sand and gravel creating the Ogallala Aquifer. Most of the water has been undisturbed for the last three million years (Little 2009). Due to surface conditions, climate, and geology, the aquifer overall recharges less than one inch a year (Tidwell et al. 2016). This effectively makes the water a finite source that is non-renewable. When it was first discovered in the United States Geologic Survey near the end of the 19th century, water could only be extracted in small quantities by windmill pumps. The vast quantity was known but the technology to extract it on a large scale was lacking. That
technology finally arrived after WWII (1939-1945) in the form of better pumps and center pivot irrigation systems (Tidwell et al. 2016).

The aquifer is split geologically in three areas, the Northern High Plains, the Central High Plains, and the Southern High Plains. While the whole aquifer is connected, it is divided into different formations. The Ogallala section accounts for three quarters of the total area, with several smaller aquifers making up the total (Smidt et al 2016).

The water is accessible from at depths ranging from 100ft to over 1,000 and has an estimated total volume of nearly 3 billion acre-feet of water as of 2011(Tidwell et al. 2016). An acre-foot of water is one acre of land covered in one foot of water or about 326,000 gallons. Three billion acre-feet is roughly the same size as Lake Huron. To put it another way, if the all the water was brought to the surface a foot and half would cover all 50 United States (Little 2009).

The aquifer lies under eight US states Nebraska, Texas, Kansas, Oklahoma, Colorado, Wyoming, New Mexico, and South Dakota (Colaizzi et al. 2009). Figure 1. illustrates the full aquifer boundaries and all eight states that sit above. Underlying over 110 million acres or about 175, 000 square miles (Tidwell et al. 2016) it is an area larger than the state of California. The latest survey of the entire aquifer was performed in 1980 by the USGS. Nebraska has the highest percent of the total aquifer area at 36%, the largest volume of drainable water slightly over 2 billion acre-feet, and the highest saturated thickness of 342 ft. Texas is second in total aquifer area of the eight states at around 20%, and volume of drainable water at 390 million acre-feet. However, Texas comes in sixth in average saturated thickness at 110 ft (Tidwell et al 2016).
Over 15 million acres of cropland were irrigated across the Ogallala Aquifer region in 2007 (Tidwell et al. 2016) with 97% coming from the aquifer (Smidt et al. 2016). The region accounts for around a quarter of the United States’ agriculture production, twenty percent of all its irrigated cropland, more than a third of the entire United States feedlot beef production and drinking water to over two million people (Tidwell et al. 2016).

WESTERN AUSTRALIA WHEATBELT (WAW)

Although the Colony of Western Australia was established in 1829, agriculture did not fully develop until after World War I. In fact, colonial records indicate that Western Australia was still importing wheat to feed its population until 1910. Given the difficulties of establishing a distant colony with harsh weather condition, agriculture producers have historically worked cooperatively with government agencies. Railroads, aqueducts, crop research studies, and land development plans were all directed with the intention of fostering agriculture. Today Australia is the 4th largest wheat exporting country in the world. With Western Australia its top wheat producing state, and the majority coming from inside the WAW, it is a breadbasket of the world.

The WAW varies in geographic location slightly depending on which Australian government agency is involved. The general area stretches over 150,000 square kilometers in the south west of the state of Western Australia. For this study the boundary is delineated by the Australian Bureau of Statistics with an exact area of 197,345 square kilometers or 76,195 square miles. In 2013 it had a population of around 75,000 with modest increases projected for the future. The economy is highly mixed with significant employment in forestry, mining, tourism, retail, and agriculture. However, agriculture is the dominate industry, accounting for a quarter of employment and valued over three billion dollars (Government of Western Australia 2014). Figure 2 shows the WAW boundaries used in this report.
Extensive irrigation with water from the aquifer began in the 1950s, and by the 1970s concerns about the sustainability of the resource began. The natural recharge rate was completely outpaced by withdrawals for irrigation. Water level declines over 100ft in Texas, Kansas and Oklahoma were observed by 1980 (Tidwell et al 2016). Some fears subsided when the water level fell at a slower rate in part due to new more efficient irrigation technology. However, at the same time gains were being made in efficiency, more wells were being installed, which caused further declines in water volume (Allen et al. 2007).

The aquifer, managed differently by each state, has different hydraulic characteristics in different locations, and future climate change impacts are unknown. What is certain is substantial areas have seen the aquifer decline so much that irrigation is no longer feasible (Cotterman et al. 2017). Across the aquifer, timelines to depletion vary from 25 years to some areas in the north that might sustainable. One report suggests that the southern and central portions will have less than 50% of their land that can support the irrigation by 2025 and 2065, respectively (Smidt et al 2016).

Groundwater law typically follows the rule of capture, riparian rights, prior appropriation, or a mix of the last two. Riparian rights (aka reasonable rights) follow that only a portion usually corresponding to the size of the surface area owned will be allocated. Many western US states use prior appropriation law to govern groundwater which states that the first person to “beneficially” use the water has the continuing right to that water. The rule of capture/absolute ownership place no restrictions on groundwater pumping (Cech 2010). It is sometimes called the
law of the biggest pump. If one neighbor has a larger or deeper well that causes someone adjacent to run out of water, it is perfectly legal. Texas is the only state that uses the rule of capture. A 1904 Texas Supreme Court case made the rule of capture official law and decided that surface water and groundwater are separate. Surface water is the property of the state and groundwater is the property of the individual landowner whose property overlays it. The owner does not need a permit to drill or pump and can use as much water as they deem necessary, even at the expense of their neighbors (Texas A&M University 2014). Some areas in the panhandle still have this completely uncontrolled form of the rule of capture. However, given the problems that arose from the rule of capture the Texas Legislature created locally based groundwater conservation districts GCDs as a way to regulate groundwater. The first GCDs were created over the Ogallala in the panhandle in the 1950s (Texas A&M University 2014). Several GCDs now very lightly regulate the groundwater of the area. However, they each have a different desired future condition that they want for their water and treat the aquifer as independent of the area outside their authority.

By one estimate more than half a billion acre-feet of the aquifer has been pumped out. The same research estimated that more than half of the 3 billion acre-feet left in the aquifer is too deep and has such marginal quality that it will not be used for irrigation (Glennon 2002). Other research states that that less than 10% of the total water has been used from before the advent of modern irrigation to 2011 (Tidwell et al. 2016). Overall the literature is promoting conservation through technology, innovation and crop changes. The reports conflict each other on the total amount of water that has been used, and when it precisely will run out for any given location.
WAW/TPOR COMPARISON & DRYLAND FARMING STRATEGY

There are no known case studies that examine similarities or differences between the TPOR and the WAW. Western Australia agriculture represents only a portion of the total Australian agriculture output which is wrongly considered a minor player when in the global market. The general impressions of the Australian continent being desert like, and the extreme geographic remoteness of the wheatbelt means even its existence is not likely known to many people in the United States.

The few agriculture comparison studies over the Texas Panhandle focus on the potential reduction in irrigation use or a complete switch to dryland farming (Yates, Smith, and Pate 2010). One study examines the possible impacts of using livestock in a more combined manner (Allen et al 2007). It determines that it could increase production over monocropping dryland farming alone. This is like what occurs in Australia, but, again, no other area is referenced or analyzed.
RESEARCH METHODS

The research only examined the 49 counties that overlay the aquifer completely or partially represented by TPOR, shown in figure 3. The WAW is delineated using the Government of Australia’s Bureau of Statistics boundaries. Figure 4 shows an equal scale side by side comparison of the two study areas.

The Mean Center Analysis tool in ArcMap was used to generate the geographic center of each area. Next, the nearest town large enough to have accurate weather data was determined. Using weather data from each town provides an extremely basic comparison between each area. See Table 4.

Climate data on the WAW was obtained from the Australian Government Bureau of Meteorology online. A Köppen climate map review found the WAW is comprised of Csb, Csa, BSk, and BSh climates. Using data from the Texas Natural Resource Information System the climate zones for the TOPR showed Cfa, BSk, BSh, and BWh climates.

The Census of Agriculture is a comprehensive report of all agricultural land that has more than $1,000 worth of animal or plant product sold in the United States. The US Department of Agriculture conducts the census once every five years, and, like the US decennial census, responses are required by law. Between reports, less comprehensive annual statistics are also available. The report segments Texas down to the county level. It has irrigated, and non-irrigated acreage planted, and total weight in pounds for every crop produced.

Yearly totals for each county in the TPOR were obtained from the USDA National Agricultural Statistics Service annual reports and entered ArcMap via an Excel spreadsheet. The
processes took a considerable amount of time. Without the aid of an advanced search tool on
the USDA website or knowledge of Python the values were entered manually. One at a time.
RESULTS

The numbers show that the TPOR is averaging 2,380 lbs. per acre of wheat harvested under irrigation. The WAW is averaging 1,492 lbs. per acre of wheat harvested land NOT under irrigation. So, the WAW is producing 38% less wheat per acre than the irrigated portions in the TPOR. This is in a range that would suggest a comparison could be drawn from the two areas. A decrease in revenue of 38% would be dramatic for any farmer, but likely survivable with the right planning and support.

The possibility of examining the added economic benefits of livestock in the WAW did not come to fruition. While there are data over livestock, it could not be determined how to analyze it during this research.

Table 4. indicates that spatially the two areas are more similar than dissimilar. Temperature, rainfall, Latitude/Longitude, and elevation of the mean center of the areas are very similar.
- **LIMITATIONS**

The study relies exclusively on secondary source quantitative data and does not tell the whole story. A survey of some type in conjunction with the hard numbers would help better explain the mentality of the farmers in the TPOR, which would greatly help the policy decision. The averages on irrigated acres of wheat planted sometimes varies from no acres planted to the following year over a hundred thousand acres planted. Why are the fluctuations so extreme? What programs have helped the farmers who have already lost their water supply? The questions go on with no answer. A simple phone interview with local stakeholders in the region could fill the gaps in the vast amount of quantitative data available.

Wheat compared to wheat is a good first comparison, but cotton is the main source of income and most likely water usage in the TPOR. Comparing wheat to cotton and every other crop must be completed to better predict the future. Farm size, demographics, government support, specific wheat varieties used, and climate impacts are critical to understand agriculture. Again, none were accounted for.
- DISCUSSION

The parallels with the WAW should provide clear evidence that the loss groundwater irrigation will not be the end of modern agriculture in the panhandle. For the last seventy years water from the aquifer has provided a cushion from drought and above normal crop yields. Farmers who survive will be the ones who recognize that they are going to have to diversify, work harder, and have some bad years.


https://services.arcgis.com/KTcxITD9dsQw4r7Z/arcgis/rest/services/Texas_Cities/FeatureServer/0.

https://services.arcgis.com/KTcxITD9dsQw4r7Z/arcgis/rest/services/Texas_County_Boundaries_Detailed/FeatureServer/0.


18


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<td>Average Annual Snowfall (inches)</td>
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Ogallala Aquifer

Figure 1
Western Australia - Wheatbelt

Figure 2
Figure 3

Texas Panhandle Ogallala Region (TPOR)

Map showing the Texas Panhandle Ogallala Region (TPOR) with a focus on the Ogallala Aquifer. The map includes a legend indicating TPOR - 49 Counties in orange and Ogallala Aquifer in blue. The map also includes a scale bar representing 0, 100, 200, 300, and 400 miles.

Legend:
- TPOR - 49 Counties
- Ogallala Aquifer

Created by Jacob Richter

WGS 1984
Figure 4
Geographic Distributions
TPOR Irrigated Wheat 2008-2017

Figure 7
Hot Spot Analysis
TPOR Irrigated Wheat 2008-2017

Figure 8