WATER USE BY CONFINED LIVESTOCK OPERATIONS AND ETHANOL PLANTS IN THE TEXAS HIGH PLAINS

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Executive Summary

The Ogallala Aquifer is the primary source of water for the Texas High Plains. Depletion of this basically nonrenewable aquifer over the years has resulted in policy makers either imposing or considering pumping restrictions to extend the usable life of the aquifer. The region has sustained significant growth in confined livestock operations (CLOs) in the last decade with the rapid development of the dairy and swine industries. The recent arrival of the ethanol industry to the area is fueling concerns as to whether future expansions of these industries should be curtailed to protect water supplies. This study examines the impact and implications that confined livestock operations and ethanol plants are having on water use in the Texas High Plains.

Currently, the 42 counties of the Texas High Plains produce 88% of the fed beef in the state, as well as, contain 48% of the dairy cows and 95% of the hog inventories. All three grain based ethanol plants in the state, which produce 240 million gallons of ethanol annually, are located in the area. In the 2011 water plan for the region, it is estimated that irrigated crop production accounted for more than 93% of all water used while direct water use by all livestock operations was less than 1.5%. It is projected in the plan that: fed beef inventories will moderately increase over the next 50 years; the dairy industry is forecasted to have an influx of cows over the next decade and moderate growth after that; while the presence of the swine industry is expected to decrease slightly. No projections were made concerning the grain based ethanol industry in the region.

Indirect water use from growing the crops required to support CLOs and ethanol plants can account for more than 95% of their total water use. However, the Texas High Plains has been grain deficit for decades which implies additional indirect water needs of expanding industries will be met through importation of feedgrains from other regions of the country. Therefore, actual water use of the fed cattle, swine, and ethanol industries is closely approximated by their direct water use. However, expansion of the dairy industry, which is dependent on regional water supplies for forage production, will result in a change in the irrigated crop mix to favor more forage production.

Considerable differences in the impact on the regional economy exist between these industries and irrigated crop production. A study comparing the employment and industry output of a Texas High Plains ethanol plant to irrigated crops that utilized the same amount of direct water found that the ethanol plant generated 169 jobs while irrigated crop production added 4 to 8 jobs depending on the crop. Similar impacts should be expected comparing CLOs to irrigated crop production.

Results suggest that because of potential water use restrictions and the grain deficit nature of the Texas High Plains, future expansion of CLOs or ethanol production will have little impact on regional water use. However, water use in localized areas in the region could potentially be impacted by the expansion of these industries. Depending on their regional water use, expansion of these industries may be a potential benefit to the region by offsetting the inevitable losses in employment and economic activity that occur as water availability declines in the region but any increases in water use will accelerate mining of the Ogallala.

Water use by Confined Livestock Operations and Ethanol Plants in the Texas High Plains

Introduction

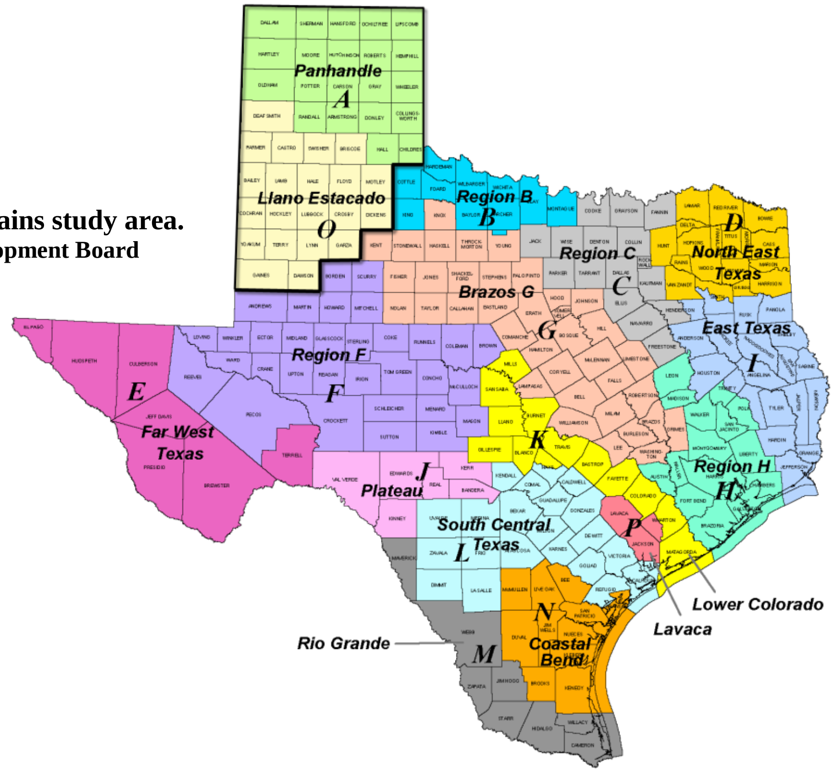
The Texas High Plains is home to one of the largest concentrations of confined livestock operations (CLOs) in the world. The excellent growing conditions, central location, sparse population, deep water tables and the certainty and consistency of environmental policies led to the development of the fed cattle industry starting in the 1960s. Subsequently, these same factors have and are attracting dairy and swine operations to the region resulting in a steady expansion of CLOs in the area. In addition, changes in U.S. policy that favor renewable energy to reduce dependence on fossil fuels has led to the development of ethanol production as a new industry on the High Plains. Ethanol plants have recently been opened in Hereford, Plainview, and Levelland.

The semiarid nature of the Texas High Plains has resulted in a dependence on one of the largest aquifers in the world, the Ogallala, to support the water needs of the region. While the Ogallala contributes the vast majority of the agricultural water needs of the region, other minor aquifer formations throughout the region include the Blaine, Rita Blanca, Dockum, and Edwards Trinity. Historically, water use in the Texas High Plains has exceeded the minimal recharge leading to increased depletion of the aquifer and creating concern among residents and local and state leaders about the future economic viability of the region and the appropriate use of its scarce water resource. This concern, coupled with the potential continued expansion of CLOs and the development of the ethanol industry in the region, has resulted in a questioning of how much water these operations are actually using in an effort to determine whether further expansion of these industries is to be encouraged. The objective of this study is to identify the impact that CLOs and ethanol production are having on the Ogallala Aquifer in the Texas High Plains, as well as, the potential impact of further expansion of these industries.

Study Region

The study area, which will be referred to as the Texas High Plains, includes the state water planning Regions A & O (Texas Water Development Board 2010), Figure 1. This 42 county area of the Texas High Plains predominately lies over the Ogallala Aquifer which serves as the primary water source for the region. The region consists of 7,585,303 acres of pastureland and 13,489,427 acres of cropland of which 4,620,542 acres are irrigated (Farm Service Agency 2008). Currently, the study region is home to one of the greatest concentrations of CLOs in the world. Approximately 88% of the states' fed beef, 95% of the swine, and 48% of the dairy cows are located in the region (National Agricultural Statistics Service 2008).

Figure 1. **Texas High Plains study area.**
Source: Texas Water Development Board



Methodology

Several primary sources of data were used to compile, project, and estimate the impacts of confined livestock operations, irrigated crops, and ethanol plants on the Texas High Plains. National Agricultural Statistical Service (NASS), U.S. Agricultural Census, and Texas Regional Water Plans comprised the majority of the data utilized in this report. The following three sections provide the methodology and sources used to estimate water requirements for primary crops, CLOs, and ethanol production within the Texas High Plains.

Irrigated Crops

Historical irrigated crop acres were compiled from two primary sources, NASS and the U.S. Agricultural Census. The U.S. Agricultural Census provided total irrigated acreage estimates for all crops including minor crops (Census of Agriculture 1934-2007) while NASS data was used for irrigated corn, cotton, sorghum, and wheat acres (National Agricultural Statistics Service 1973-2008). Water requirements were obtained for corn, cotton, sorghum, and wheat (Freese and Nichols Inc. 2010, Marek 2010). These estimates were based on evapotranspiration models developed by Texas AgriLife scientists in Amarillo which incorporate agronomic, climatic, and regional soil profile factors to estimate the amount of typical irrigation required by crop. Estimates are provided at county level increments which vary throughout the region. These values were then multiplied by the observed acreage by crop from NASS to approximate the irrigation water requirements by crop and county.

Confined Livestock Operations

Historical fed beef inventories were gathered from 1970 to 2009 using marketed head numbers provided by Southwestern Public Service (SPS) surveys and NASS data (National Agricultural Statistics Service 1977-1979 and 2000-2009, Southwestern Public Service Company (SPS) 1971-1977 and 1981-2000). The SPS surveys provided county level data of marketed fed beef for the Texas High Plains. Since marketed fed beef numbers overlap inventory, these numbers were converted to annual inventory using an average turnover ratio estimated by taking the ratio of marketed head to cattle on feed or inventory for the years 1975 to 1994 provided by NASS (National Agricultural Statistics Service 1975-1994). This turnover ratio was estimated to be 2.35, meaning that 2.35 head of cattle were marketed per head of inventory.

Direct water requirements for fed beef were assumed to be 12.5 gallons per day correlating with the requirements provided in the regional water planning reports (Freese and Nichols Inc. 2010, Llano Estacado Regional Water Planning Group 2010). Indirect water requirements or the water required for feedstock was estimated using daily ration requirements provided by a personal communication with Ted McCollum (2010) Beef Cattle Specialist from the Texas AgriLife Extension Service. Within the total daily ration it was assumed that 90% was corn based with the remaining 10% being sorghum based. Future water use was calculated based on projected inventories from 2010-2060 from the regional water planning reports (Freese and Nichols Inc. 2010, Llano Estacado Regional Water Planning Group 2010) using the same direct and indirect water requirements.

Dairy cow inventory was estimated using a combination of NASS milk cow numbers and the Milk Market Administrator production estimates for 1993-2009 (Milk Market Administrator 1993-2009, National Agricultural Statistics Service 1993-2009). Direct water requirements of 55 gallons per day per cow were obtained from the regional water planning reports (Freese and Nichols Inc. 2010, Llano Estacado Regional Water Planning Group 2010). Indirect water requirements and the corresponding feedstock requirement of 91.5 lbs per day per cow in the Texas High Plains were obtained from Bilby et al. (2010). It was assumed that one acre of irrigated silage under 20 acre-inches of irrigation would produce 24 tons of silage per year thus supporting 1.44 cows which allowed the indirect water requirements to be estimated. Supplemental data for the analysis was obtained from a survey conducted by Jordan and Lager (2010) of dairy operations in the Texas High Plains. Projected inventories from 2010-2060 were obtained from regional water planning reports (Freese and Nichols Inc. 2010, Llano Estacado Regional Water Planning Group 2010).

Swine inventories were obtained from NASS for the years 1974-2008. Direct water requirements per head were obtained from the regional water planning reports (Freese and Nichols Inc. 2010, Llano Estacado Regional Water Planning Group 2010). Indirect water requirements and feedstock needs were estimated from data provided by a personal communication with Jodi Sterle (2010), Texas AgriLife Extension Service Swine Specialist. Ration requirements of 4.08 lbs per head per day were assumed to be composed of 80% sorghum and 20% soybeans. Projected inventories from 2010 to 2060 were obtained from the regional water planning reports (Freese and Nichols Inc. 2010, Llano Estacado Regional Water Planning Group 2010).

Ethanol

The nameplate capacity of ethanol plants in the region were obtained from the Renewable Fuels Association (Renewable Fuels Association 2010a). The direct water requirement of 2.7 gallons of water per gallon of ethanol was acquired from actual usage data at the Levelland ethanol plant (Guerrero 2010) and a conservative estimate of 3.3 gallons of water per gallon of ethanol was assumed for the Hereford and Plainview ethanol plants. Indirect water requirements were estimated for the Levelland plant using one hundred percent sorghum feedstock for the plant. This plant produces an average of 2.67 gallons of ethanol from a bushel of sorghum (Guerrero 2010). Regional production numbers of irrigated and dryland sorghum were used to determine the indirect water requirements of the plant (National Agricultural Statistics Service 1973-2008). The indirect water use for the Hereford and Plainview plants were estimated by assuming a mix of corn and sorghum use of 80 and 20 percent, respectively. The Levelland estimate of 2.67 gallons of ethanol per bushel of sorghum was assumed for these plants and an estimate of 2.8 gallons of ethanol produced for each bushel of corn was used (Texas AgriLife Extension Service 2010).

Background and History

Irrigation in the Texas High Plains first started in the mid 1930s and steadily increased until the mid 1940s when a rapid expansion occurred due to discovering additional water supplies and improved drilling technology, Figure 2. Irrigated acreage in the region peaked in the mid 1970s at almost six million acres. Depletion of the aquifer combined with low commodity prices led to a steady decline in irrigated acreage from the mid 1970s until 1990 when irrigated acreage fell below four million in the region. The slowing of the rate of decline in the 1980s and 1990s coincided with the adoption of more efficient sprinkler irrigation systems. From 1990 to 2000, irrigated acreage increased to more than 4.5 million acres. This increase can be attributed in part to U.S. farm policy adopting a market oriented approach which has led to increased commodity prices and profitability. In addition, improvements in application efficiency through increased adoption of low energy precision application and subsurface drip irrigation have decreased the marginal cost of water applied to crops. Currently, approximately two-thirds of the irrigated acres are located in the Region O and one-third in Region A water planning areas. Since 2000, irrigated acreage has decreased to approximately 3.3 million acres due to water availability and increased pumping costs. It has been estimated that the value of irrigated crop production to the Texas Panhandle regional economy (26 counties) is approximately $1.6 billion in economic activity and 16,650 jobs (Guerrero et al. 2010).

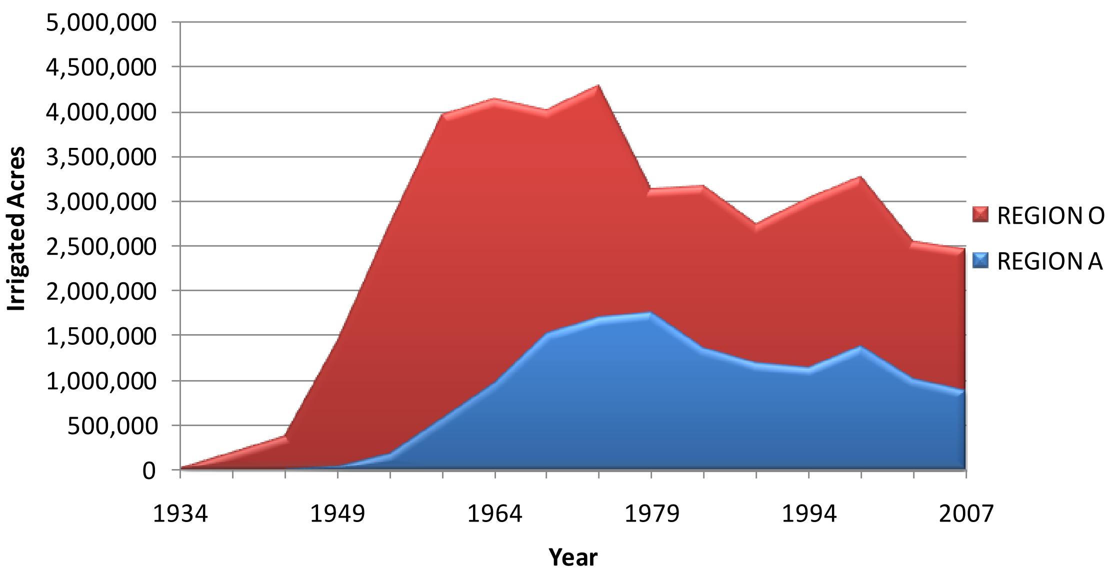


Figure 2. Texas High Plains irrigated crop acres by water planning region, 1934-2007.
Source: U.S. Census of Agriculture

The first confined livestock operation did not come to the region until 20 to 30 years after the development of irrigation. There is no doubt they have had an impact on irrigated crop production. The demand for feedgrains created by the CLOs has resulted in price premiums for corn and to a lesser extent, cotton (with cottonseed as a protein supplement). Typically, area corn producers receive a 20 to 50 cent premium per bushel over Midwest producers because of this demand adding to the feasibility of corn production in the region. While fed cattle operations do not use wheat as a feed source, the existence of these operations has stimulated wheat acreage through increased returns due to the value of winter grazing of stocker cattle prior to entering feedlots.

Crop production has always played a major role in the Texas High Plains. More than 25 crops are commercially produced in the area with corn, cotton, sorghum and wheat being the primary irrigated crops. This region produces nearly one third of the U.S. cotton and is a leader within the state in terms of sorghum production. Through the advent of irrigation, production has increased on the semiarid landscape allowing for large areas of cropland to be irrigated from the Ogallala Aquifer. As seen in Figure 3, cotton, corn, sorghum and wheat acres comprise the majority of the irrigated cropland farmed in the Texas High Plains. Cotton has always been a leader in region, particularly within Region O which produces 97% of the irrigated cotton on the Texas High Plains. Region A is typically suited for more grain intensive operations producing 64% of the region's corn and 60% of the wheat. Over time irrigated acres have decreased, primarily driven by decreasing water availability and increasing pumping costs.

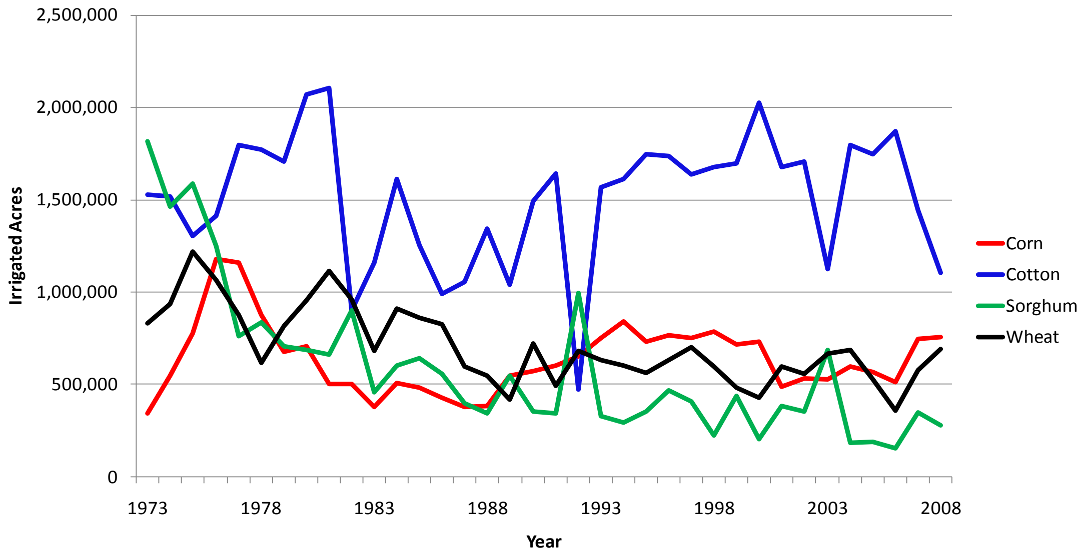


Figure 3. Texas High Plains corn, cotton, sorghum, and wheat irrigated acres, 1973-2008.
Source: National Agricultural Statistics Service

Fed Beef

The fed cattle industry has grown to become an important part of Texas High Plains agriculture due to climatic factors, land availability, and proximity to feedstock. Numbers of fed cattle inventory within the region doubled between 1970 and 2000 to over 2.6 million head resulting in more than five million head marketed annually as seen in Figure 4. However, no growth has occurred in the fed cattle industry over the last decade and a slight decrease has resulted in recent years primarily due to economic conditions. Feedyards within the region are typically located on the northern and western areas of the Texas High Plains.

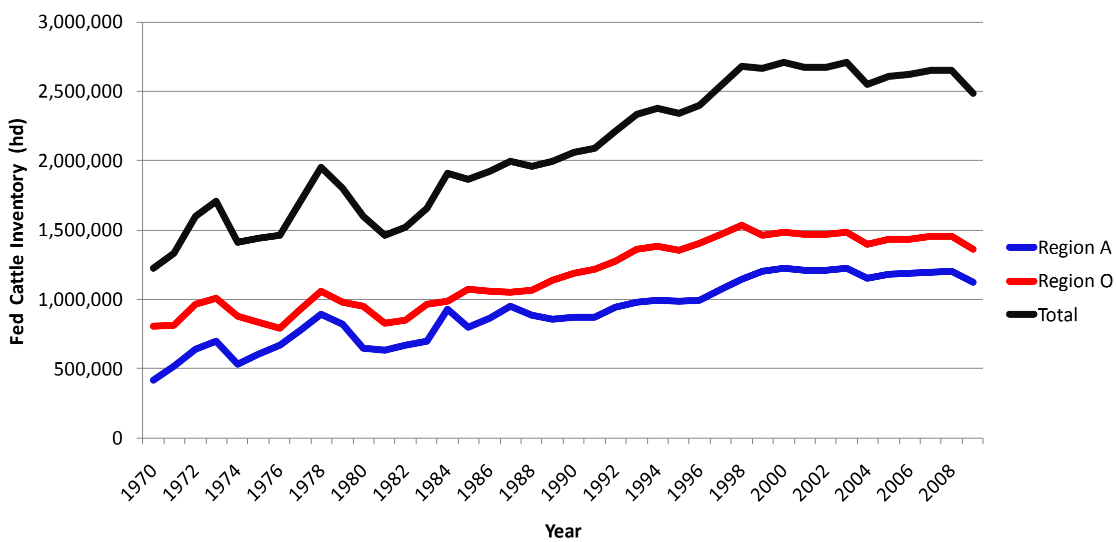


Figure 4. Texas High Plains fed cattle inventory by water planning region, 1970-2008.
Source: Southwestern Public Service Company and National Agricultural Statistics Service

Dairy

The dairy industry has grown substantially in recent years. Population growth, economic, and environmental pressures have forced dairy owners from across the U.S. to find alternative production areas for their operations. The Texas High Plains is well suited for this industry, providing irrigated land for silage production and relatively less expensive land prices than many other dairy producing regions. The trend in the region's dairy cow inventory is illustrated in Figure 5. The growth in the region's dairy industry coincides with the building of the Southwest Cheese plant in Clovis, NM and the subsequent addition of the Hilmar cheese plant in Dalhart. The number of dairy cows increased 1750 % from 1993 to its peak in 2008. Inventories have declined since 2007 as the recession has taken a toll on milk prices and dairy profitability.

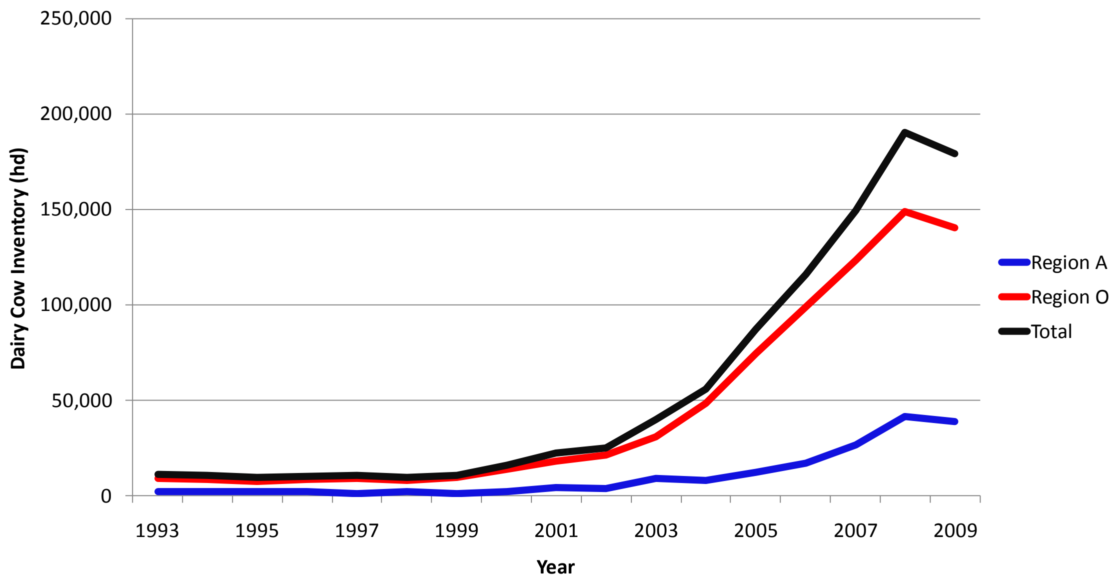


Figure 5. Texas High Plains dairy cow inventory by water planning region, 1993-2009.
Source: National Agricultural Statistics Service

Swine

Much like the dairy, the swine industry is relatively new to the region. Similar pressures such as land availability, environmental factors, central location and a relatively sparse population have allowed the swine industry to grow in the Texas High Plains. The trend in the region's swine inventory is illustrated in Figure 6. In 1992, 10% of the state's hogs were grown in the region. In 1993, inventories grew to 20% and in 1994, the area's portion of the state's total doubled again to 40%. By 2009, the Texas High Plains hog numbers topped a million head and the area's total exceeded 95% of the state's hog inventory. Nearly all the hogs are found in Region A (99%), and are primarily located in the northern tier of counties of the Panhandle; Dallam, Sherman, Hansford, Ochiltree, and Lipscomb.

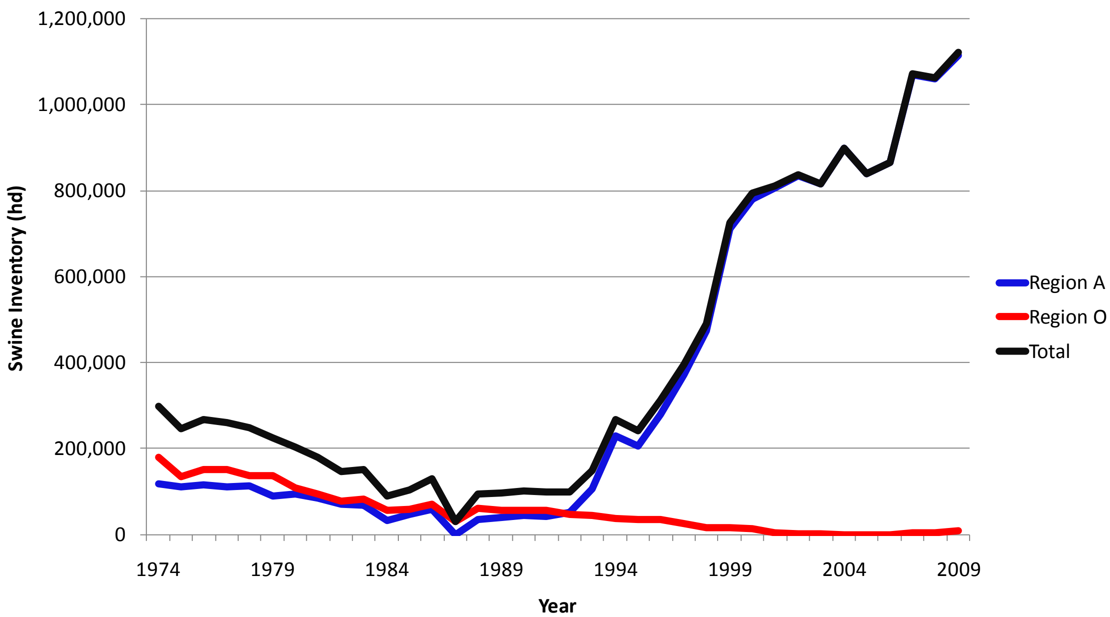


Figure 6. Texas High Plains swine inventory by water planning region, 1974-2009.
Source: National Agricultural Statistics Service

Ethanol

The ethanol industry saw smaller facilities in the 1970s that subsequently closed. The emergence of large plants is fairly new to the Texas High Plains with substantial growth in the last five years. Construction of ethanol plants began in 2006. There are currently three ethanol plants operating in the region. White Energy has two ethanol plants located in Hereford and Plainview which both have the capacity to produce 100 million gallons of ethanol per year. These two plants began construction in 2006 and started operating in 2008. The Plainview plant was idled in 2009 and resumed operation in 2010. The other plant operating in the region is the Hockley County ethanol plant located just outside of Levelland. This plant was constructed in 2007 and began operation in 2008. The Levelland plant produces approximately 40 million gallons of ethanol per year. The current capacity for ethanol production in the region totals 240 million gallons.

Crop Water use in the Texas High Plains

Significant time and effort has been spent by the Region A & O water planning groups to identify direct water use by sector in the Texas High Plains. These estimates were initially made in the 2001 planning effort, refined in the 2006 water plan and further refined for the ongoing 2011 water plan. In the 2001 planning effort, a desired goal of having 50% of the underground water, i.e., the Ogallala Aquifer, remaining in 50 years was identified. This 50/50 goal and very similar goals have continued to gain popularity in subsequent planning efforts and is now leading regional water districts to consider and/or implement policies to meet these goals including pumping restrictions.

In the 2011 plans for Regions A & O, it was estimated that 6,111,751 acre-feet of water was pumped for municipal, industrial, steam-electric power generation, mining, irrigation, and total livestock in 2010 throughout the region, Figure 7. Municipal water use accounted for 2.94% of the region's total water use, manufacturing 0.99%, steam electric 0.84%, mining 0.50% and the remaining almost 95% being attributed to agriculture. Agricultural industries in total, used an estimated 5,793,933 acre-feet with irrigated crop production accounting for 93.25% of total water use and direct water use from all types of livestock operations at 1.48%. Of the 1.48% livestock water usage, confined livestock operations accounted for 1.13% and other livestock operations utilized 0.35%.

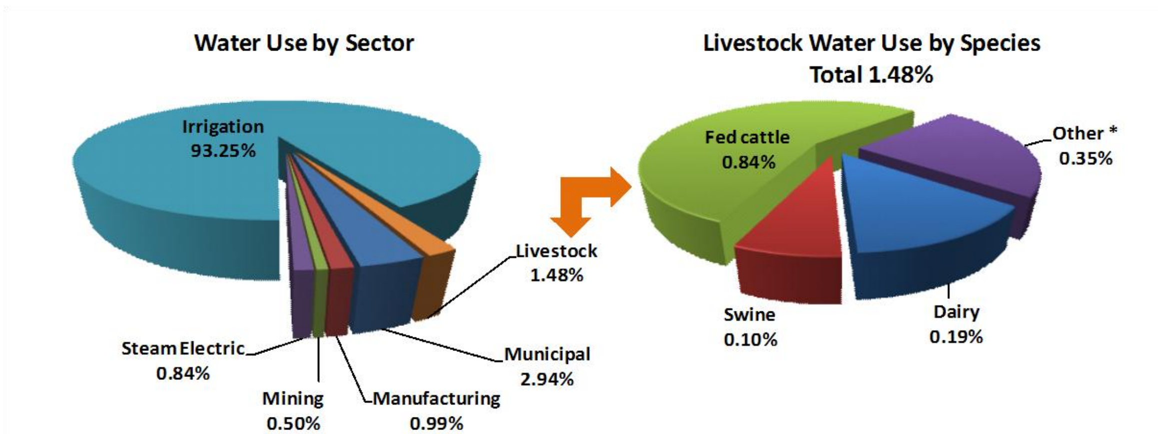


Figure 7. Texas High Plains water use by sector.
*** Other includes poultry, range beef, equine, sheep and goat, and summer and winter stocker water use estimates.**
Source: Region A & O 2011 Water Plans

The four primary irrigated crops grown in the region, corn, cotton, sorghum, and wheat, differ considerably in the amount of water used per acre. Corn currently is not a drought tolerant crop; therefore, it requires a significant amount of water for production and exhibits a very positive yield response to water applied. In the water plans, it is estimated that 16 to 25 acre-inches are applied to corn per acre, Table 1. Cotton, sorghum and wheat are relatively drought tolerant crops that can be grown under irrigated or dryland conditions throughout the region. Their production functions are not as responsive to irrigation as corn, typically resulting in less water being applied per acre. The estimated water applied per acre to irrigated cotton, sorghum and wheat in the study area was; 4 to 14, 7 to 14 and 3 to 19 acre-inches, respectively. Ranges in water applied are due to variations in water availability, weather, and soil types in the study region.

Table 1. Texas High Plains irrigated crop water use per acre by water planning region.

Crop	Region A	Region O
	acre-inches applied per acre	
Corn	16.7 - 24.3	21.5 - 24.8
Cotton	4.0 -11.9	9.4 - 14.2
Sorghum	6.9 - 13.2	10.4 - 14.4
Wheat	2.5 -11.9	3.2 - 18.5

Source: Region A 2011 Water Plan and Marek

Irrigated crop production accounted for 93.25% of total water use within the region or a total of 5,616,008 acre-feet. Irrigated corn, cotton, sorghum and wheat utilized a vast majority of the water applied to crops. Cotton and corn producers were the biggest users pumping in excess of 2,300,000 and 1,500,000 acre-feet annually, respectively while sorghum and wheat producers used 250,000 and 400,000 acre-feet, respectively, Figure 8. Interesting to note that sorghum used less water than the other three crops but still used considerably more water than any other non-agriculture sector (next largest sector was municipal at 177,040 acre-feet).

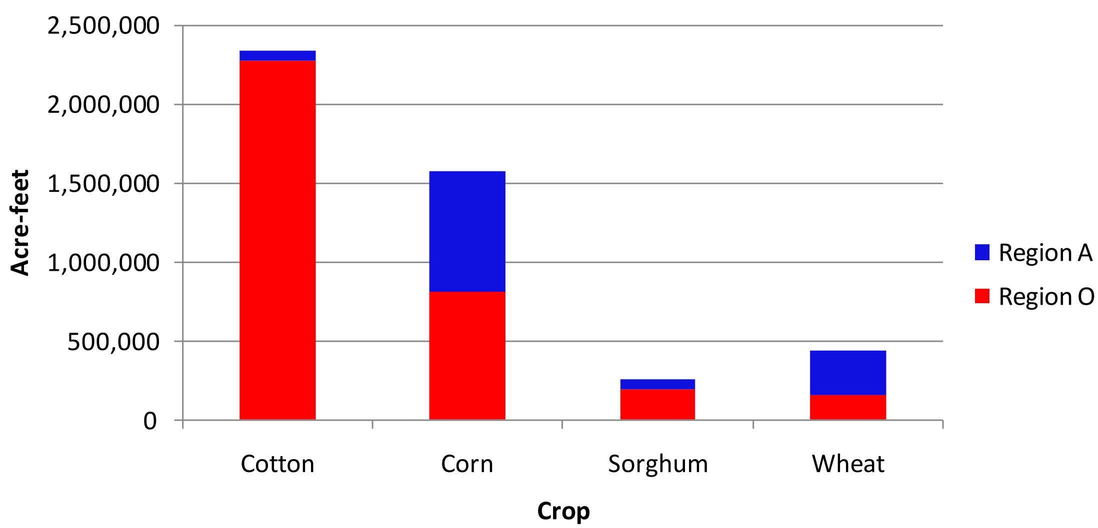


Figure 8. Texas High Plains 2010 projected irrigation water use by major crop and water planning region.

Region O accounts for approximately two-thirds of the water pumped in the Texas High Plains. In Region O, cotton used the highest percentage of water of the four major crops at 58.8% followed by corn at 23.9%, sorghum at 9.0%, and wheat at 8.3%. In Region A, a majority of the water was applied to corn (64.9%) followed by wheat (23.5%) while relatively little was utilized on cotton and sorghum reflecting the emphasis on cattle feeding.

Impact of Grain Deficit Production on Confined Livestock Operations and Ethanol Plants Effective Water Use

Whether the Texas High Plains is a grain deficit region is a critical factor in determining the actual water use from the aquifer by CLOs and ethanol plants within the area. Indirect water use of ethanol plants through feedstock and CLOs through feedgrain and forage requirements accounts for more than 95% of their total water use. Effective production of feedgrains and the demand for feedgrains by CLOs and ethanol plants is presented in Figure 9 for the 1973 – 2008 time period. It is clearly seen that the demand for feedgrains has long exceeded effective production of feedgrains in the region. Effective grain production accounts for leakages in the grain supply due to alternative uses such as chip manufacturing and sorghum exportation and is characterized as 80% of the corn and 20% of the sorghum produced within the region. It is assumed that the remaining corn and sorghum supply could be utilized by CLOs or ethanol plants.

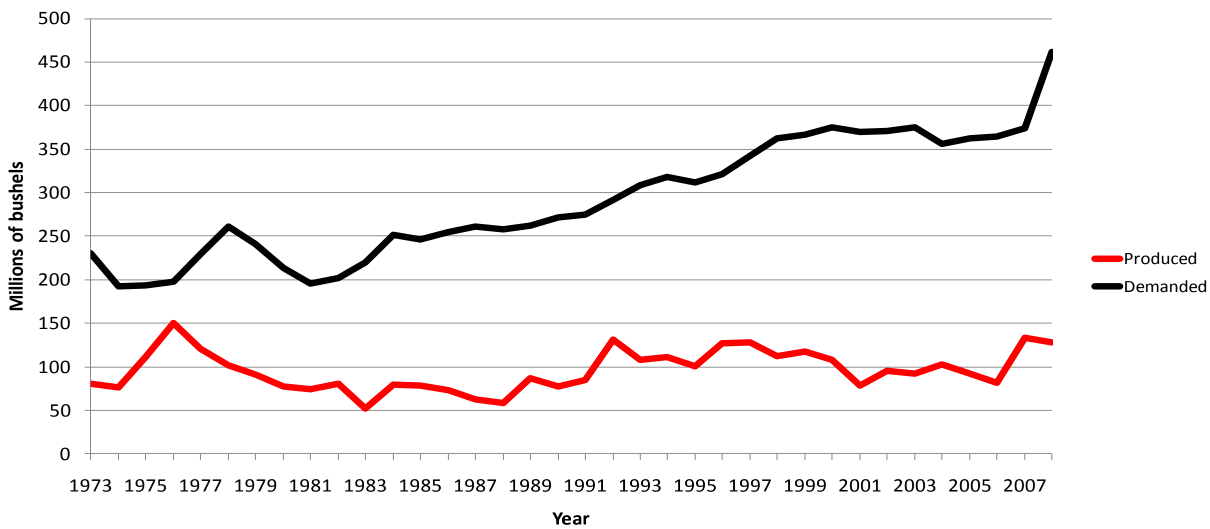


Figure 9. Texas High Plains estimated production of feedgrains and demand from confined livestock operations and ethanol, 1973-2008.

Demand for grain based inputs has exceeded regional grain supplies as early as 1973, thus causing the region to import large volumes of grain. Imported grain is defined as the difference between total grain demand which accounts for all grain ration requirements of CLOs and ethanol plants and the effective regional grain production. Historical feedgrain imports have more than doubled since 1973 from approximately 150 million bushels to 330 million bushels in 2008 as shown in Figure 10.

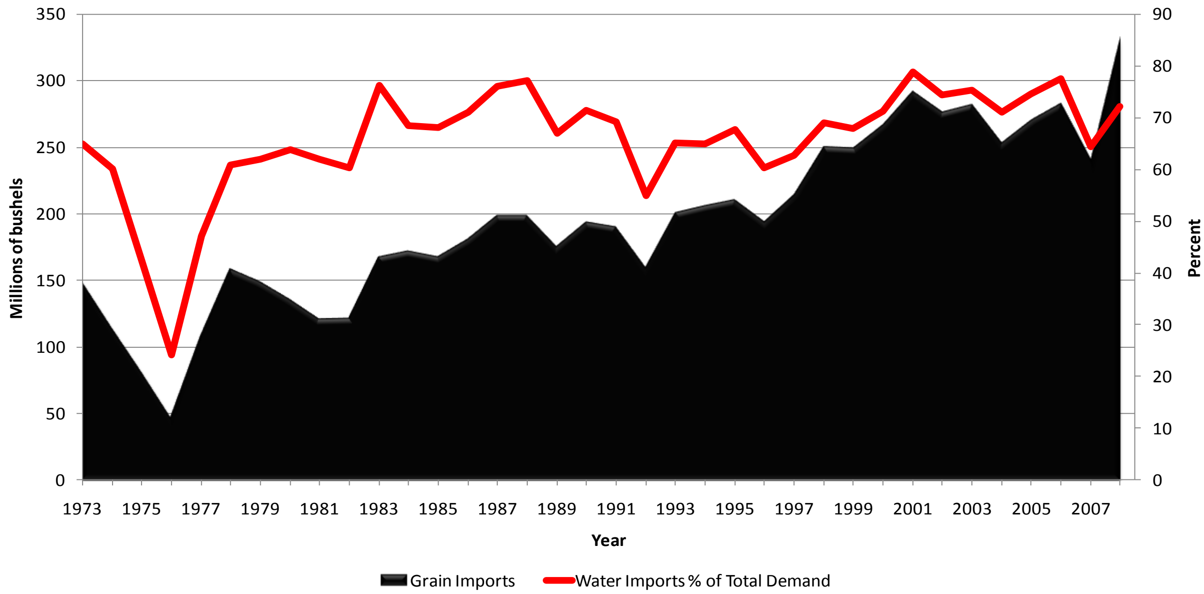


Figure 10. Texas High Plains estimated grain imports in volume and the percentage of water imported of total demand to support confined livestock operations and ethanol, 1973-2008.

While regional imports for grains have increased through time, the percentage of grain imported relative to the total demand has remained fairly constant at approximately 70%, Figure 10. This is due to continued increases in regional supply through production and technology advancements. Changes in both mechanical technology such as irrigation systems and crop genetics have improved the region's production efficiency and allowed the Texas High Plains to increase the amount grain produced per acre.

Operations that have started or expanded in the region have had to rely on imported feedstock to meet their needs (approximately 70%). This directly correlates to the amount of water that is being imported to the Texas High Plains resulting in approximately 70% of the indirect water needs of the region being imported. Most of this water is imported through corn shipped from the Midwest via railcars to feedyards and ethanol plants throughout the region. Therefore, the impact of any expansion or addition of fed cattle, swine, and ethanol industries on regional water use will be minimal and closely tied to their direct water use as much of the grain, and thus indirect water, are imported.

Water use by Confined Livestock Operations and Ethanol

Determining water use in confined livestock operations is significantly more complicated than in crop production. Water use for CLOs can be separated into direct and indirect categories. Direct use is the water required for drinking, dust control, washing, and other daily needs within the operation. In swine, the direct water use varied by county depending on the composition of farrow-to-finish operations and growing or finishing operations, Table 2. Direct water is considered to be completely derived from regional resources. Indirect use is the water required to produce feedstock for each operation. Indirect water required by CLOs is derived from feedstock and forage produced in the region and feedstock imported from outside the region. It is important to account for imported feedstock since water used in growing these inputs does not impact regional water supplies.

Table 2. Texas High Plains confined livestock operations water use and feedgrains/forage requirements per animal per day.

Livestock Group	Direct Water Use (gallons/day)	Feedgrains/forage use (lbs/day)
Fed Beef	12.5	20
Dairy	55	91.5
Swine	5 - 8.5	4.08

Source: Region A & O 2011 Water Plans, McCollum, Sterle, and Bilby

Fed Beef

The fed cattle industry is the largest consumer of water within the CLOs evaluated in this study. While the direct water consumption per head of 12.5 gallons per day is less than the dairy industry (55 gallons), the large quantity of cattle on feed makes the direct water consumption of fed cattle an average of nearly 37,000 acre-feet per year in recent periods. This is water pumped directly from the Ogallala Aquifer on site at feedyards throughout the region.

Indirect water consumption for fed cattle is based on the water required to produce the crops which are processed into the feeder rations. While there are many ingredients that go into the formulation of a ration, in this region, feedlot rations are typically composed of two primary components, corn and sorghum. Approximately 72% of the dry matter total ration is assumed to be corn while 10% is sorghum. Thus, the majority of the indirect water requirements are derived from corn production.

The water requirements for the fed cattle industry are presented in Figure 11. The total water includes the direct water and indirect water needed to supply all the grain demand of the industry. In recent years, the number has fluctuated between 3 and 4 million acre-feet annually. However, much of the indirect water demand is coming from grain stock which is imported to the region primarily from the Midwest. In a grain deficit region, the agricultural industry cannot meet the grain demands of the fed beef industry, thus imports to the region are essential. The regional water represents the estimated amount of direct water and indirect water that is acquired through feedstock production within the region.

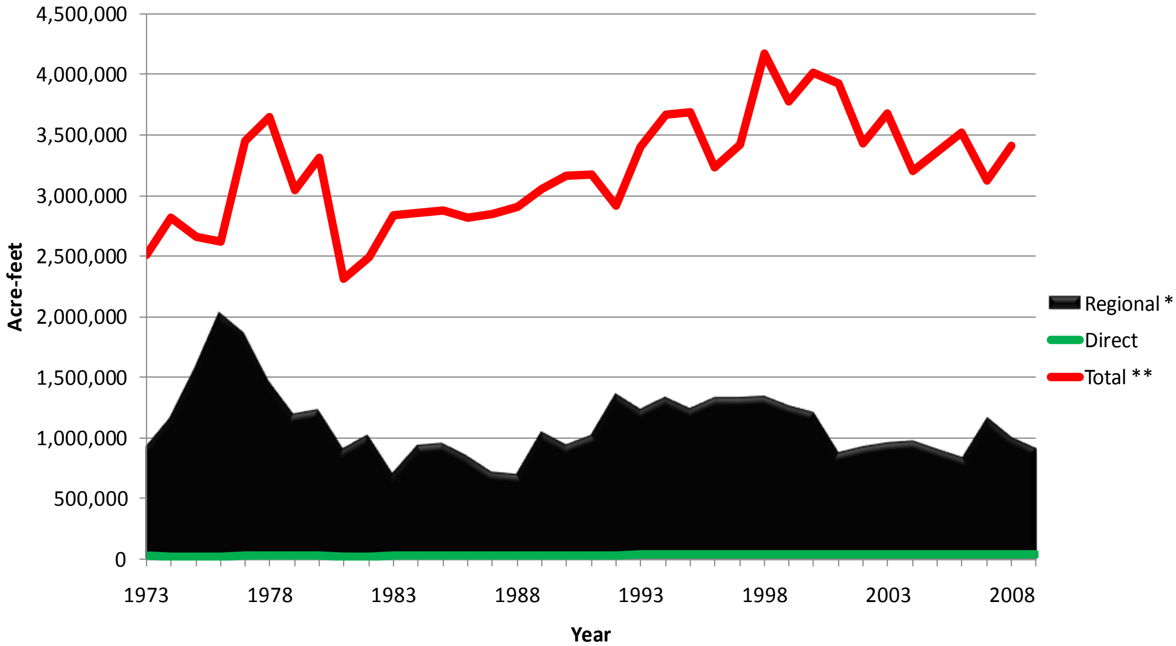


Figure 11. Texas High Plains estimated regional, direct, and total water use by fed cattle, 1973-2008.
* Regional includes direct and indirect water use from feedgrains produced in the region
** Total includes regional water use and water through imported feedgrains

Dairy

The rapid growth of the dairy industry has concerned leaders within the region about its impacts on the Ogallala Aquifer. The direct and indirect water demands of the dairy cattle in the region are presented in Figure 12. The direct water is the water required for drinking and facility maintenance on the dairy farm. It is important to note that the dairy industry typically recycles a portion of the water used on the dairy, as refuse and other waste is typically pumped to nearby center pivots for irrigation purposes, which was not accounted for in this study.

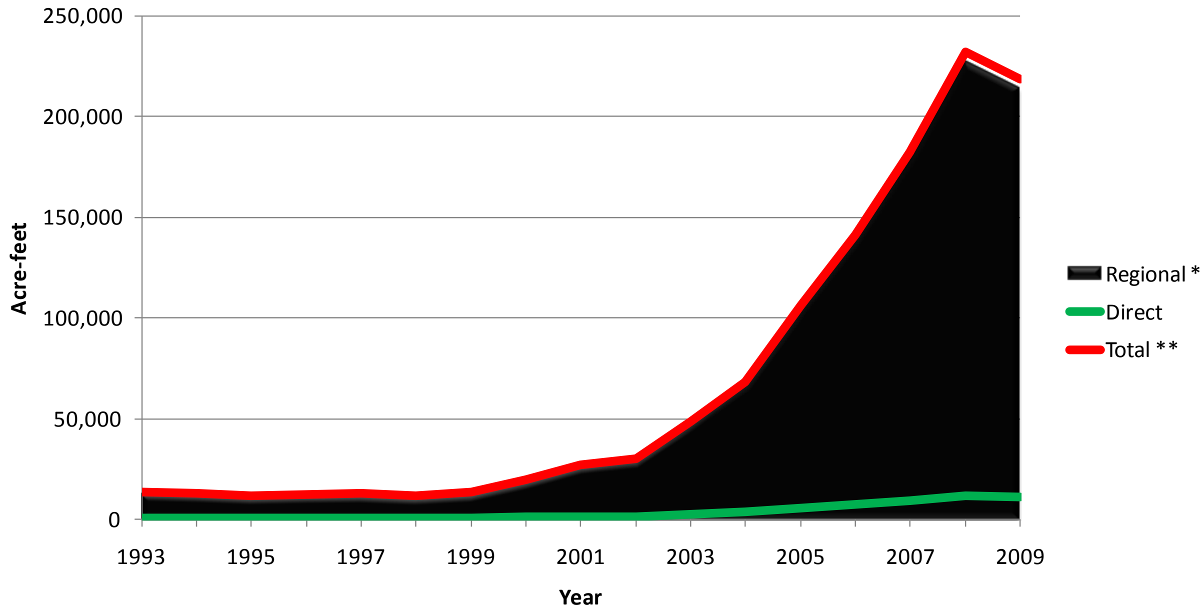


Figure 12. Texas High Plains estimated regional, direct, and total water use by dairy cows, 1993-2009.
* Regional includes direct and indirect water use from feedgrains produced in the region
** Total includes regional water use and water through imported feedgrains

With recent expansion in the region, dairy cows consumed a maximum of indirect water of approximately 225,000 acre-feet. This is the water required to produce corn and sorghum silage as well as alfalfa for the dairy cow's silage based diet. Since the primary feedstock for dairy cows is silage, which is typically not suitable for long distance shipping, it is assumed that all silage based feedstock for the dairy is grown within the region while one ton of alfalfa hay is imported from outside of the region. The regional water represents both direct water and indirect water obtained within the region.

Water usage of dairy operations through the practice of double cropping forage production has become a major concern. Results of a recently completed survey indicate that 25.2% of a dairies' crop acreage is double cropped (Jordan and Lager). Interestingly, effluent was applied to 39.1% of the double cropped acres. The increase in water use caused by double cropping may be relatively minor since the amount of water applied per acre to silage crops tends to be less than grain crops because of the shorter growing season and effluent is replacing some of the fresh water being applied on both summer and winter silage crops.

An example of the estimated water use comparing grain production versus double cropping silage on the same 100 acres is presented in Table 3. In the example, it is assumed that 10% less water is applied to the silage crops due to the shorter growing seasons and 25% of the acreage is double cropped (Jordan and Lager 2010). Therefore, corn grain, corn silage, sorghum grain, sorghum silage, and wheatlage were expected to use 19.1, 17.2, 9.7, 8.7, and 7.0 ac-in, respectively. Results of the analysis suggest that corn grain used slightly more water than the double cropped silage alternative (1910 ac-in versus 1895 ac-in). Conversely, the double cropped sorghum silage – wheatlage used

7.7% more water than sorghum for grain production. Estimated water use on the double cropping systems is slightly less due to the application of effluent from retention ponds not being considered in the analysis.

Table 3. Estimated water applied for irrigated grain production versus double cropped silage production.[a]

	Corn Grain	Double Cropped Corn Silage Wheatlage	Sorghum Grain	Double Cropped Sorghum Silage Wheatlage
A. Acres	100	100	100	100
B. AC-IN Applied/Acre[b]	19.1	17.2	9.7	8.7
C. AC-IN Applied (AxB)	*1910*	*1720*	*970*	*870*
D. Double Cropped Acres		25		25
E. AC-IN Applied/Acre[b]		7		7
F. AC-IN Applied (DxE)		*175*		*175*
G. Total AC-IN Applied (C+F)	**1910**	**1895**	**970**	**1045**

[a] Assumes a 10% water savings on silage crops and 25% of cropland is double cropped with wheatlage (Source: Jordan and Lager)
[b] Source: 2011 Region A Water Plan
Note: No economic analysis was performed on relative profitability of alternatives.

The alfalfa production associated with dairies is a concern because of high irrigation requirements. Alfalfa typically uses 25% more water than our highest water use crop (corn). An acre of alfalfa production will use approximately the same amount of water applied as three irrigated acres of cotton, sorghum or wheat. The change in alfalfa acreage from 2000 – 2008 is illustrated in Figure 13. Alfalfa acreage has increased more than 23,000 acres over the time period. The increase in alfalfa acreage relative to total irrigated acreage (3.5 million) is minor, however, given the alfalfa's water use, it warrants closely monitoring in the future.

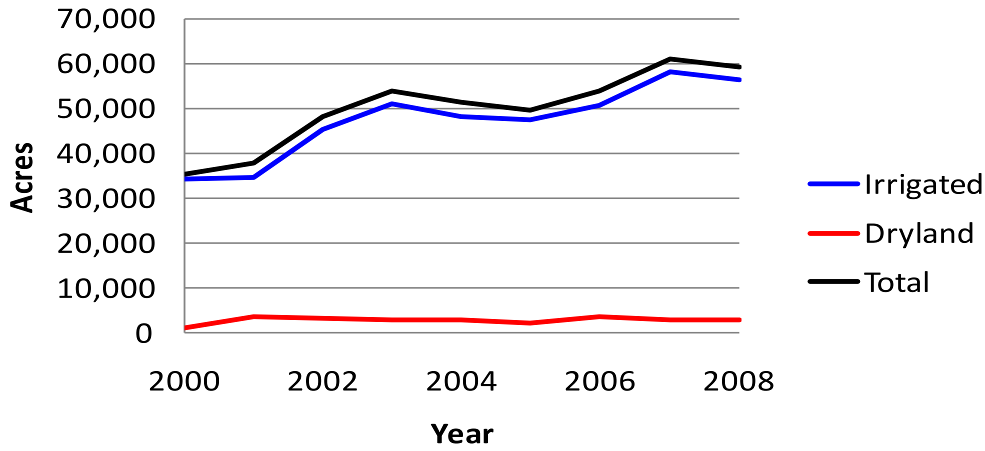


Figure 13. Texas High Plains alfalfa acres, 2000-2008.
Source: Farm Service Agency

Swine

The swine industry has grown tremendously in recent years along with the water use and feed requirements. The total, regional, and direct water is illustrated for the swine industry in Figure 14. Within the region, the direct water use for the swine industry averages about 6,000 acre-feet per year. The typical four pound ration for swine operations consists mainly of grain sorghum at 80% with the remaining 20% being composed of soybean meal. The total direct and indirect water demand from grain has averaged about 375,000 acre-feet in recent years. However, only approximately 120,000 acre-feet of this demand is supplied from within the region.

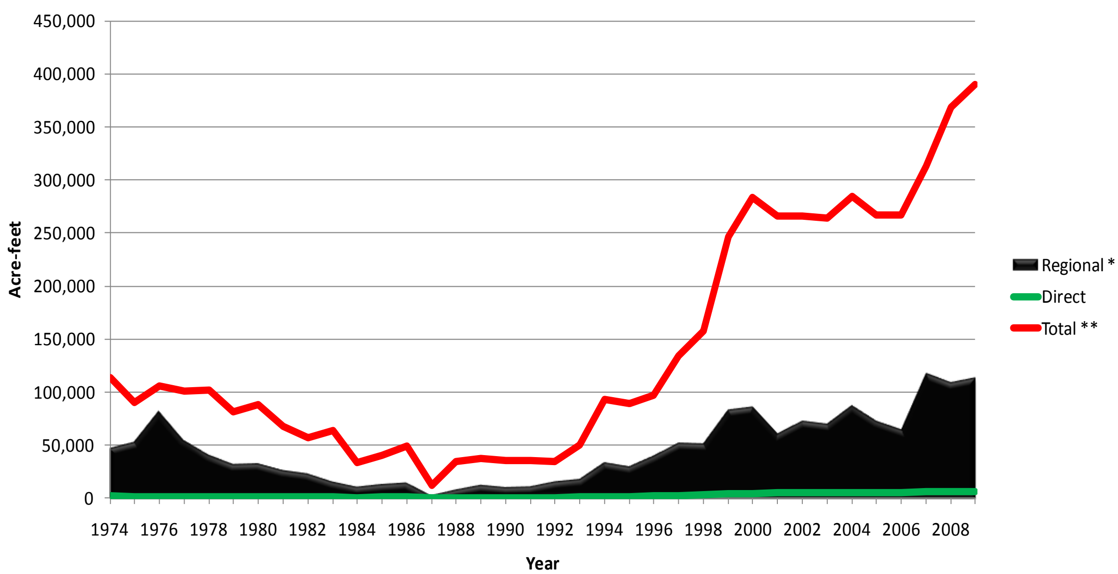


Figure 14. Texas High Plains estimated regional, direct, and total water use by swine, 1974-2009.
* Regional includes direct and indirect water use from feedgrains produced in the region
** Total includes regional water use and water through imported feedgrains

Ethanol

The direct and indirect water is illustrated for the ethanol industry in Figure 15. The ethanol industry consumes 2,375 acre-feet per year through direct water use within the region when all three plants are in operation. The ethanol industry also uses water indirectly through feedstock requirements. The Hereford and Plainview plants use a mix of corn and sorghum as grain inputs depending on the relative prices, whereas the Levelland plant uses only grain sorghum. The indirect water demand is approximately 885,000 acre-feet per year when all three plants are in operation which constitutes 99.7% of total water use. It is assumed that the Hereford and Plainview ethanol plants import the majority of feedstocks while the Levelland plant uses local resources. Approximately 140,000 of the total water demand is supplied within the region.

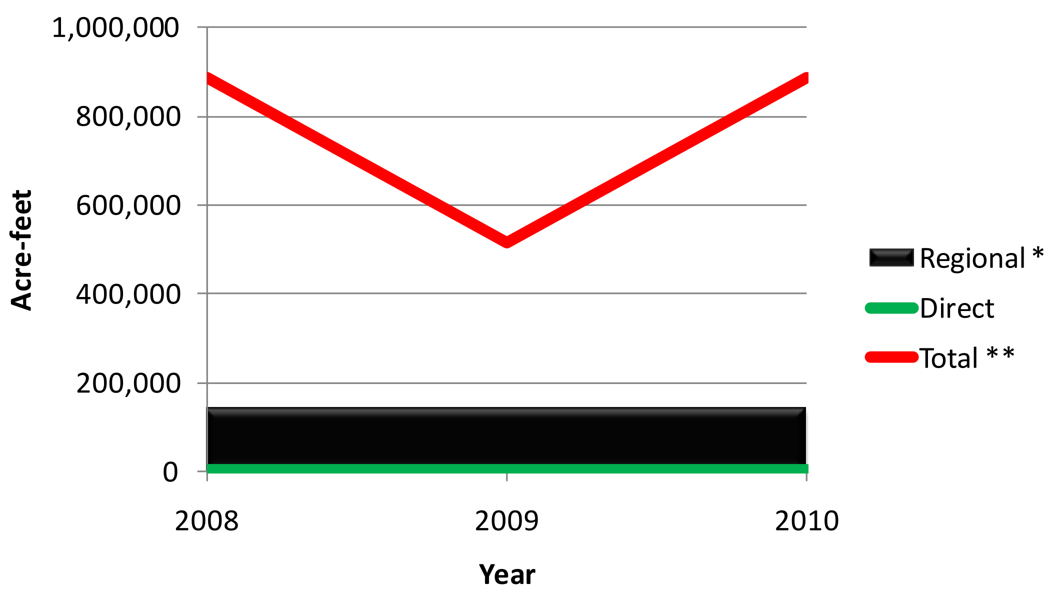


Figure 15. Texas High Plains estimated direct and indirect water use for ethanol, 2008-2010.
Assumes 2.7 gallons of water and 0.36 bushels of grain are required to produce a gallon of ethanol.
* Regional includes direct and indirect water use from feedgrains produced in the region
** Total includes regional water use and water through imported feedgrains

Future Growth Projections of Confined Livestock Operations

In the 2011 Region A and O water plans, the anticipated changes in CLO inventories have been projected through 2060. These projections were made in consultation with representatives of each industry to ensure getting the most realistic estimates. Impacts of increased water demand have been estimated using the same methodology as the historical values. In future water projections, no growth in feedgrain production is assumed resulting in the change in regional water use being equal to the direct water consumption plus any forage production required.

Fed Beef

The growth of the ethanol industry in the Midwest has caused a relative increase in cattle feeding in that area, allowing the decades of growth in fed beef inventories to stabilize in the Texas High Plains over the last few years. The most recent economic downturn has resulted in a slight decline in inventories in the Texas High Plains. However, assuming stabilization in grain based ethanol production and the economy, it is anticipated that selected counties will have moderate growth in fed cattle numbers over the 50 year horizon, Figure 16, resulting in a projected moderate increase in total, regional, and direct water use, Figure 17.

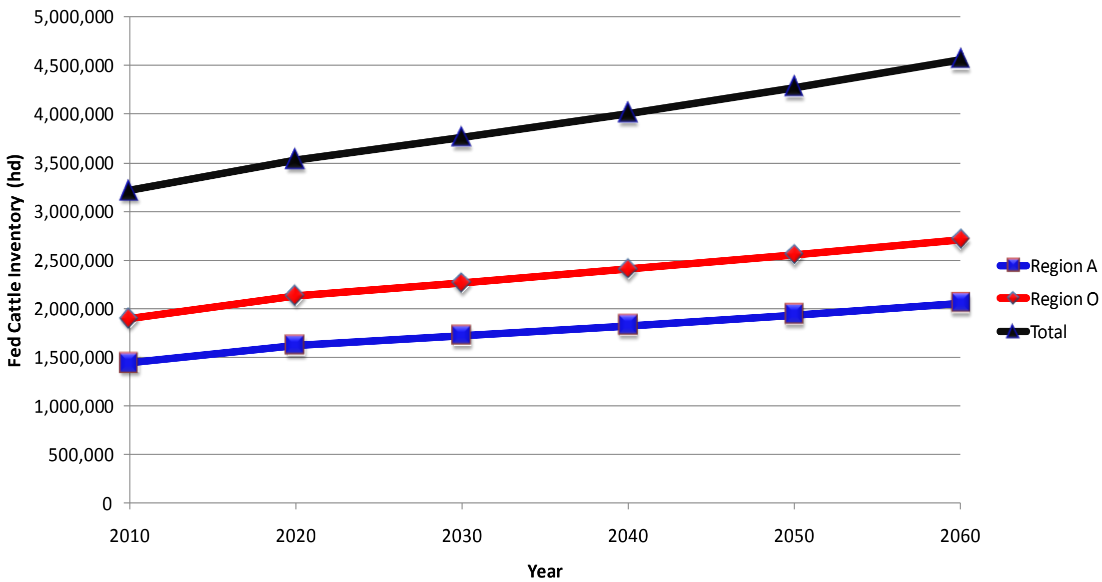


Figure 16. Texas High Plains projected fed cattle inventory, 2010-2060.
Source: Region A & O 2011 Water Plans

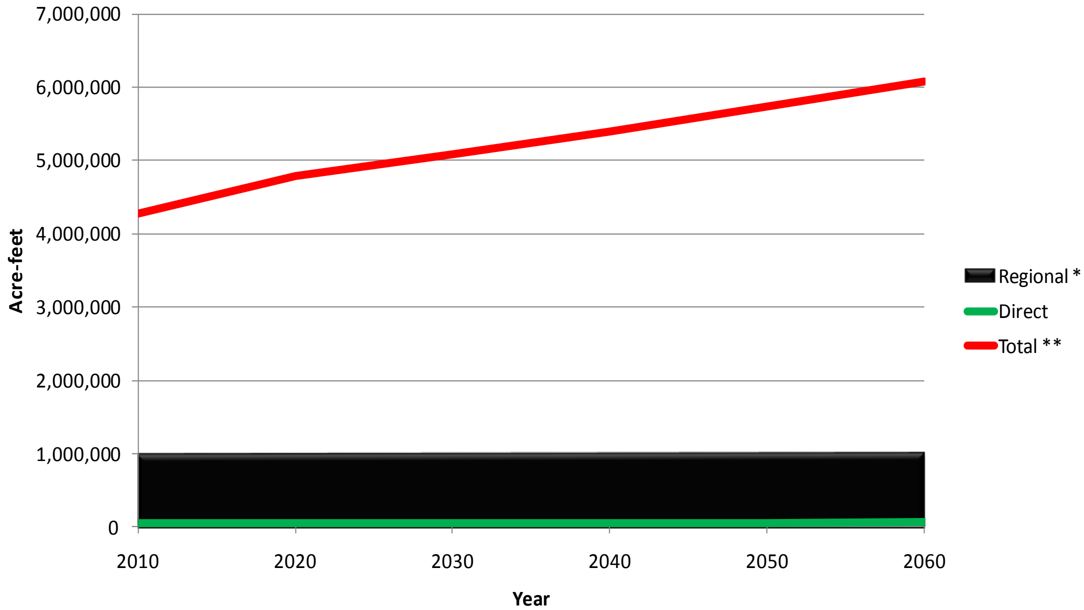


Figure 17. Texas High Plains projected regional, direct, and total water use by fed cattle, 2010-2060.
* Regional includes direct and indirect water use from feedgrains produced in the region
** Total includes regional water use and water through imported feedgrains

<u>Dairy</u>

The expansion of the dairy industry in the Texas High Plains is continuing and is reflected in the projections made by both A & O water planning groups in the 2011 plan, Figure 18. The expansion and planned expansions of the Southwest Cheese plant in Clovis, NM and Hilmar Cheese in Dalhart are going to require substantial increases in milk production to meet processing requirements. For example, Hilmar Cheese Plant's planned expansion (Phase 2) which should occur within the next five years will require an additional 80,000 cows. Therefore, dairy cows are projected to increase in the region by more than 100,000 over the next decade before exhibiting a much slower growth over the remaining time horizon. This results in a doubling of inventory by 2060 and projections of an increase in water use for dairies in the region, Figure 19.

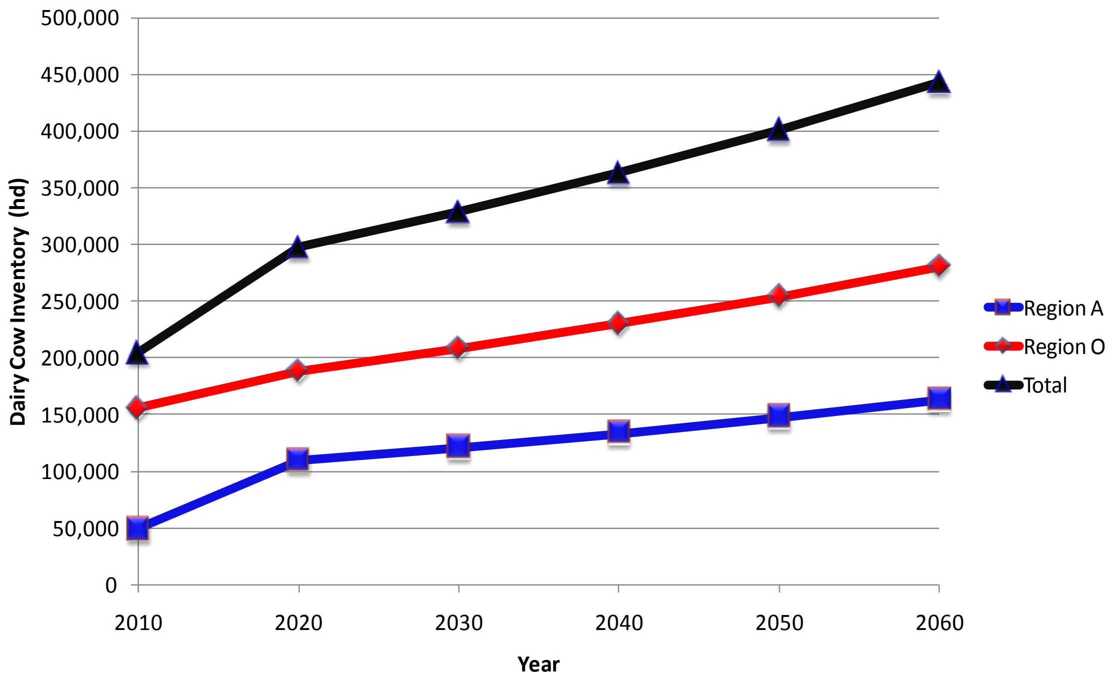


Figure 18. Texas High Plains projected dairy cow inventory, 2010-2060.
Source: Region A & O 2011 Water Plans

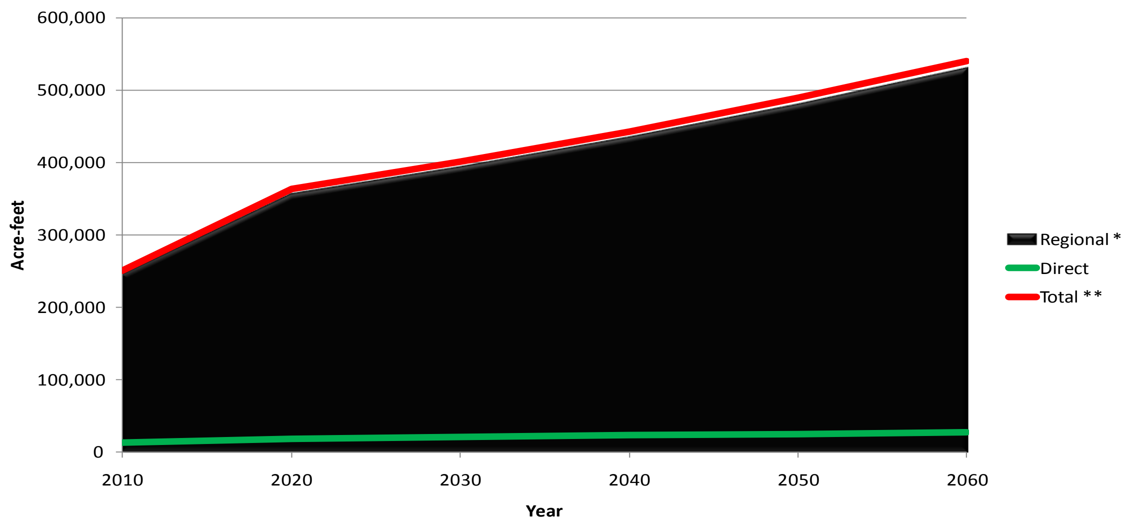


Figure 19. Texas High Plains projected regional, direct, and total water use by dairy cows, 2010-2060.
* Regional includes direct and indirect water use from feedgrains produced in the region
** Total includes regional water use and water through imported feedgrains

Swine

In the 2006 Region A water plan, a dramatic increase in hog inventories was projected based on the speculation of another packing plant being built within the region. However, plans to build that packing plant have been dropped, and it is no longer a consideration. Representatives of the four major swine operations consulted in the 2011 planning effort have indicated that they expect no future growth in the industry, Figure 20. In fact, one operation indicated that they plan to decrease inventories somewhat in the future and this is reflected in projections. It should be noted that hog projections may actually be overestimated. Since the projections were made, Premium Standard Farms (PSF) in Dallam County has closed its operation, thereby significantly reducing hog inventories in the region. There has been no indication whether PSF or another company will reopen the facilities. Taking these factors into consideration, water use by the swine industry is projected to decrease in the near term and then remain steady throughout the planning horizon, Figure 21.

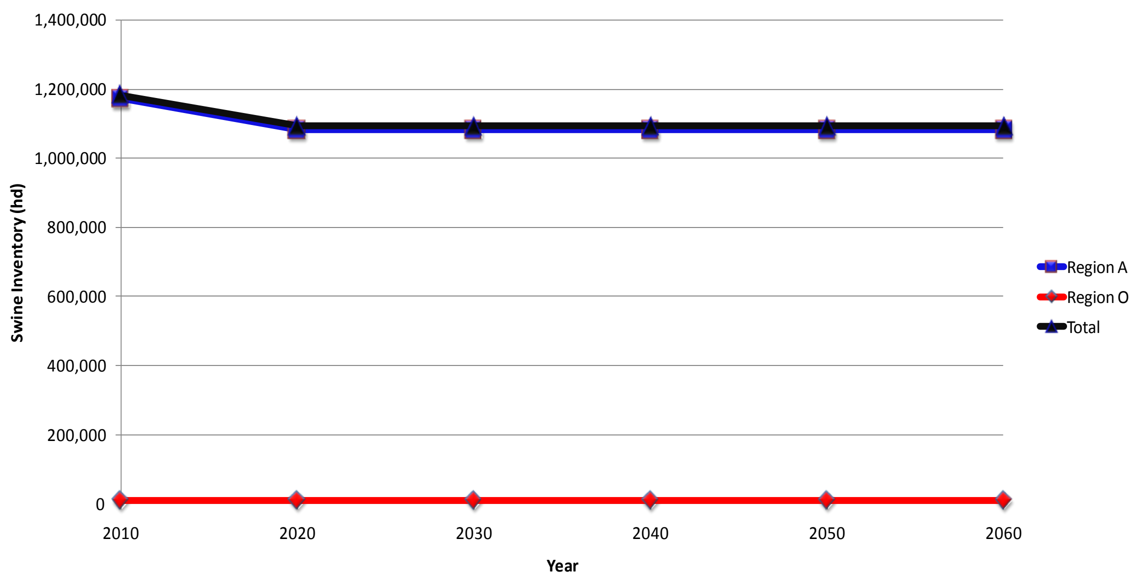


Figure 20. Texas High Plains projected swine inventory, 2010-2060.
Source: Region A & O 2011 Water Plans

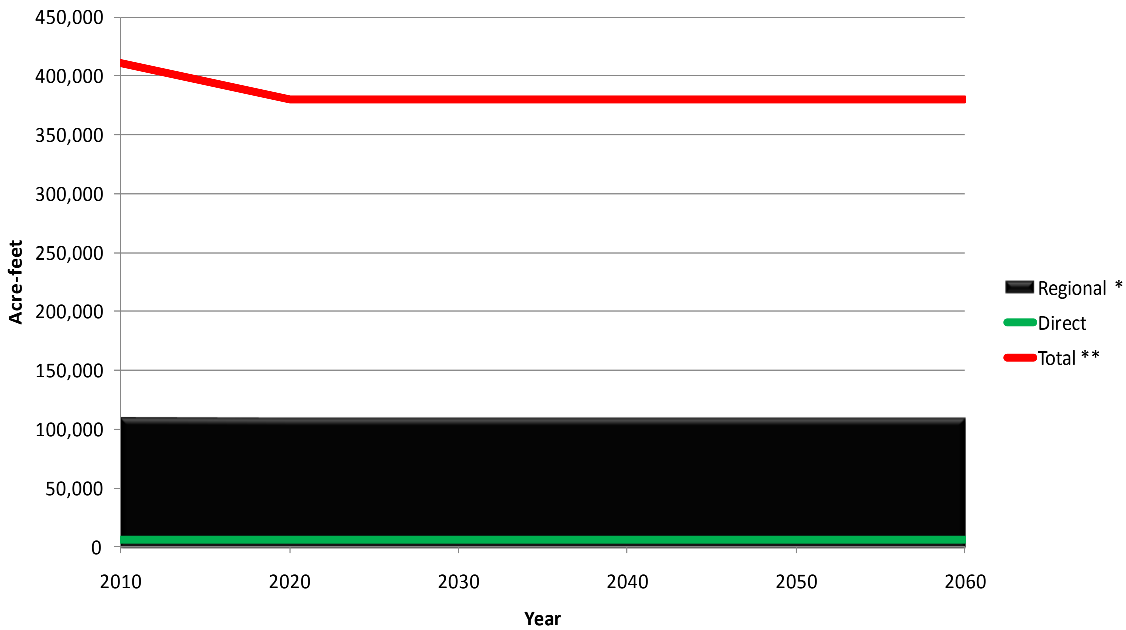


Figure 21. Texas High Plains projected regional, direct, and total water use by swine, 2010-2060.
* Regional includes direct and indirect water use from feedgrains produced in the region
** Total includes regional water use and water through imported feedgrains

Ethanol

The expansion of the ethanol industry in the United States has slowed. In 2009 the industry produced 10.75 billion gallons of ethanol. The 2010 Renewable Fuels Standard (RFS) requires 12.95 billion gallons of renewable fuel comprised of 12 billion gallons of conventional biofuel and 0.95 billion gallons of advanced biofuel. The RFS for conventional biofuel reaches a maximum in 2015 at 15 billion gallons (Renewable Fuels Association 2010b). However, the current blending rate of ethanol in gasoline is only 10% resulting in a maximum market potential of 12.5 to 13.5 billion gallons (Renewable Fuels Association 2010c), hindering further expansion and creating a "blending wall" for future ethanol production to reach levels set by the RFS. It is anticipated that the EPA will raise the blending rates which would result in further but limited expansion of grain based ethanol production subject to the 15 billion gallon cap in the RFS which it is rapidly approaching.

The Texas High Plains is an ideal location for ethanol production due to proximity to feedlots and dairies which utilize distillers grains. Thus, this region could experience growth in ethanol production in the future. One plant in the region is not in operation at the present time. The Panda ethanol plant in Hereford has the capacity to produce 115 million gallons which could be a substantial addition to the current ethanol industry in the region. While it is likely that this plant will be in operation in the near future, no further grain based ethanol plants are expected to be built in the region. Any ethanol plants that are built in the future will most likely be cellulosic in nature.

Production and Employment Comparisons between Agricultural Water User Groups

The presence of the fed beef industry along with the expansion of dairies and the establishment of an ethanol industry in the Texas High Plains has directly created jobs and increased economic activity in the region. The economic impacts of these industries, however, go well beyond the boundaries of the operation. The materials and labor required for the construction of dairies and ethanol plants along with the inputs necessary for day-to-day operation for CLOs and ethanol generate additional economic impacts in other areas of the economy tied directly and indirectly to inputs for these industries. These “ripple effects” are felt in many other sectors of the economy and are referred to as direct, indirect, and induced socioeconomic impacts. For example, a feedyard purchases feed trucks (direct effect). In turn, the truck dealer may need a higher inventory of trucks to keep on hand (indirect effect). Further, the employees of both the feedyard and truck dealer will spend their money at local businesses such as the grocery store (induced effect). The presence of CLOs and the ethanol industry increases regional economic activity.

While the presence and growth of CLOs and ethanol have generated beneficial socioeconomic impacts, stakeholders are concerned about the amount of scarce water resources these industries are using. It is necessary to evaluate the effectiveness of these industries in their use of scarce water resources in terms of socioeconomic impacts relative to current irrigated crop production in order to address this concern. The Levelland Hockley County Ethanol plant was selected to compare the socioeconomic impacts resulting from the operation of the plant and the socioeconomic impacts from irrigated crop production in the region requiring the same amount of water (Guerrero 2010).

The Levelland Hockley County Ethanol plant uses an estimated 2.7 gallons of direct water for every gallon of ethanol produced or approximately 108 million gallons of water per year with the plant running at capacity. One of the unique aspects of this plant is that recycled city waste water from the city of Levelland is used in the production process. The reverse osmosis water is used in the boilers to provide steam to the plant and in the cooling tower. Reverse osmosis water accounts for 90% of water used in the production process while groundwater accounts for the remaining 10%. In addition to using reverse osmosis water, 63% of the total water requirement was reused in the production process.

Production comparisons were made for agricultural enterprises using the equivalent direct water use as a 40 million gallon ethanol plant (similar to the Levelland plant) and a 100 million gallon ethanol plant, Table 4. Water use estimates were obtained by enterprise (Freese and Nichols Inc. 2010) to determine the amount of production (number of head or acreage) that would require the same amount of water as the direct water use of the ethanol plant. The estimated production from alternative agricultural enterprises that would use an equivalent amount of direct water from the aquifer (108 million gallons) as the Levelland ethanol production was determined to be 5,380 head of dairy cows, 23,671 head of fed cattle, 59,178 head of hogs, 208 acres of corn, 569 acres of cotton, 412 acres of sorghum, or 508 acres of wheat. A 100 million gallon ethanol plant uses approximately 270 million gallons of water annually assuming the same ratio as the Levelland ethanol plant. Production under alternative agricultural enterprises using 270 million gallons of water is approximately 13,450 head of dairy cows, 59,178 head of fed cattle, 147,945 head of swine, 520 acres of corn, 1,423 acres of cotton, 1,029 acres of sorghum, or 1,270 acres of wheat.

Table 4. Comparative production units of supported agricultural enterprises at 108 and 270 million gallons of water pumped annually.

		Equivalent Water Requirement	
Enterprise	Production Unit	108 mil. gallons	270 mil. gallons
Ethanol	mil. gals	40	100
Dairy	head	5,380	13,450
Fed Cattle	head	23,671	59,178
Finishing Hogs	head	59,178	147,945
Irrigated Corn	acres	208	520
Irrigated Cotton	acres	569	1,423
Irrigated Sorghum	acres	412	1,029
Irrigated Wheat	acres	508	1,270

Source: Water use estimates based on the Region A 2011 Water Plan.

The socioeconomic impacts for the Levelland Hockley County ethanol plant and crop acreages were estimated using the IMPLAN model. IMPLAN is an economic input-output model that is used to understand the linkages between industries in an economy. It is often used to capture the impact of an activity or shock to an economy (Minnesota IMPLAN Group 2004). Regional employment was the socioeconomic measure used to compare impacts of ethanol production and crop production. The impacts from ethanol production are significantly higher than the impacts from any of the irrigated crop production acreages evaluated requiring equivalent water. Ethanol production in the Southern High Plains of Texas created a total of 169 jobs for the region. On the other hand, irrigated corn production has total employment impact of only eight jobs, irrigated cotton production six, and irrigated sorghum or wheat produced a total of four jobs.

It is important to note that the IMPLAN model captures only economic linkages from the farm-gate backward and thus, any forward linkages to local gins, elevators, or processing sectors tied to irrigated crop production are not captured. Thus, the actual employment on a regional basis for irrigated crops is likely underestimated. This is due to the fact that most ethanol is exported out of the region, whereas irrigated crops remain local and are processed further in the area. In addition, the study only analyzes direct water use for ethanol production. If the regional water use of ethanol plants were considered, it would dampen the relative magnitude of impacts compared to irrigated crop production.

Confined livestock operations are expected to have a similar degree of difference in socioeconomic impacts when compared to irrigated crop production. Studies are currently in progress which will estimate the magnitude of socioeconomic impacts from the fed beef, dairy, and swine industries in the Texas High Plains region. However, there have been studies from other parts from the United States that have determined the socioeconomic impacts of fed beef, dairies, and swine in those particular areas. A study by Mayen and McNamara (2007) concluded that the four largest livestock industries in Indiana, including pork, poultry, dairy, and beef, create a state economic impact of $6 billion and more than 35,000 jobs. Another study (DiPietre and Watson 1994) estimated that the economic impact of Premium Standard Farms on the state of Missouri was almost $655 million and 2,739 jobs. The economic impact of the dairy industry was evaluated for the state of New Mexico by Cabrera et al. (2008) which concluded a total impact of $1.98 billion and 14,313 jobs. It is important to note that the magnitude of impacts from these studies depends upon the study area chosen and the source of data. Thus, no judgment can be drawn from these studies to attempt an estimate of the economic value of these industries to the state of Texas.

Summary and Conclusions

This study examines the impact fed beef, dairy and swine CLOs and ethanol plants are having on water use in the Texas High Plains in order to determine whether further expansion of these industries should be encouraged. The study region was defined as the 42 counties of the Texas High Plains that overlie the Ogallala Aquifer and are in the state water planning regions A & O. The semiarid nature of the Texas High Plains has resulted in a dependence on the Ogallala Aquifer to support the water needs of the region. Historically, water use in the Texas High Plains has exceeded recharge leading to depletion of the aquifer and creating concern among residents of the future economic viability of the region and the appropriate use of the its scarce resource, water. Water districts in the Texas High Plains have or are considering implementing policies which include pumping restrictions to preserve some water supplies for future generations.

The development of irrigation within the region preceded the arrival of the fed beef industry by approximately 30 years. By the time any significant numbers of fed beef were produced in the region (mid 1960s), irrigated acreage had already exceeded five million acres, or approximately a million and a half acres more than is currently irrigated. Cotton, corn, sorghum and wheat are the primary irrigated crops grown in the region utilizing a vast majority of the water pumped on irrigated crops.

The fed beef industry was the first of the confined livestock operations to come to the Texas High Plains with significant numbers being recorded by the mid 1960's. This industry was attracted by the excellent growing conditions, central location, sparse population, deep water tables, and the certainty and consistency of environmental policies. The fed beef numbers have continued to grow in the area over the years until leveling off during the last decade. Dairy and swine CLOs, which were virtually nonexistent in the region 10 to 15 years ago, have come to the area and expanded rapidly.

Currently, 88% of the fed beef produced in the state, as well as, 48% of the dairy and 95% of the hog inventories are located in the region.

The grain based ethanol industry is the latest of the industries analyzed to come to the Texas High Plains. The first plant began production in 2008. Subsequently, two more plants have opened. Currently, a total of 240 million gallons of ethanol are produced in these three plants.

In the 2011 Region A & O water plans, it is estimated that irrigated crop production accounted for more than 93% of all water used in the region on an annual basis with irrigated cotton and corn using a vast majority. Direct water use by all livestock operations was less than 1.5%. However, indirect water use of CLOs and ethanol plants must be included in the calculation of total water use. Indirect water use includes the water utilized in growing the feedstock required to sustain these operations. Analysis performed in this study suggests that more than 95% of total water use by these operations is indirect.

Also, in the 2011 water plans for the region, growth projections for CLOs were forecasted over the next 50 years in consultation with scientists and industry representatives. The fed beef industry is expected to resume moderate growth. The dairy industry is forecasted to have an influx of cows during the next decade due to the expansion of cheese processing plants in the area and moderate growth after that while the presence of the swine industry is expected to decrease slightly. No projections were made concerning grain based ethanol industry in the region, however, it is anticipated that one more 115 million gallon plant will open with no further additions given current energy policies.

The amount of indirect water use that should actually be attributed to CLOs and ethanol plants is dependent upon the regional feedgrain production relative to total demand by these operations. An analysis performed in this study indicates that the Texas High Plains has been grain deficit since at least the early 1970s. This suggests that the indirect water requirements of expansions or additions to these industries are being met through the importation of feedstuffs from other parts of the country. Therefore, the actual water use of any further additions to fed cattle, swine, and ethanol industries can be approximated by their direct water use. However, expansion of the dairy industry, which is dependent on regional water supplies for forage production, will result in a change in the irrigated crop mix to favor more forage production.

The relative impact on employment and economic activity can be an important consideration in determining whether these industries should be encouraged to move/expand in the region. In results of a recently completed study on the impacts of ethanol production in the Texas High Plains, the impacts on employment and industry output of an ethanol plant utilizing an equivalent amount of water as our primary irrigated crops were compared. The ethanol plant generated 169 jobs while comparable irrigated crop production added 4 to 8 jobs depending on the crop. The total industry output was five to ten times greater from the ethanol plant relative to irrigated crop production.

However, this analysis did not include any economic benefits from forward linkages tied to irrigated crop production such as local gins, elevators, or other processing sectors. In addition, the study only analyzes direct water use for ethanol production. If the regional water use of ethanol plants were considered, it would dampen the relative magnitude of impacts compared to irrigated crop production. Currently, similar studies are underway to identify the impacts of the various CLOs in the region. A literature review suggests that the employment and industry output relationship between CLOs and irrigated crops will be similar.

In conclusion, results of this study suggest that the impact on water use in the Texas High Plains from future expansion of confined livestock production and/or ethanol production in the region will be minimal. However, water use in localized areas throughout the region could potentially be impacted by the expansion of these industries. Restrictions in pumping that have been or will be put in place to ensure water availability for future generations will result in the water required from any expansion in these industries to come from the irrigated crop sector. Even these transfers will be relatively small since the region is grain deficit, thus, the water required for expansion is equivalent to the direct water use of the operations which is currently estimated to be 1.13% of total water use in the region. Expansions, especially in the dairy industry, will result in a change in irrigated crop composition in the region with some traditionally grown crops being replaced with forage production. Additional confined livestock production and/or ethanol production may actually be a potential strategy to pursue to offset inevitable losses in employment and economic activity that occur as water availability declines over time in the region.

Study Limitations and the Need for Further Research

The objective of this study was to analyze the impact that confined livestock operations and ethanol plants are having on water use in the Texas High Plains. No attempt was made to identify the effects on a local community. Impacts on localized water availability as well as economic activity are magnified from their presence in a community and warrant further study. More research is needed to refine irrigated water use associated with crops and double cropping systems to improve the accuracy of results provided in this study. Also, detailed studies need to be performed to identify the benefits that these industries have on the local and regional economies. Finally, the effect of changes in farm programs and potential water policies should be analyzed to better understand their impact on these operations and water use within the region.

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