POLICY ALTERNATIVES FOR THE SOUTHERN OGALLALA AQUIFER

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Abstract: Due to declining water levels in the Ogallala Aquifer, policy alternatives for extending the life of the aquifer for irrigation and other purposes are evaluated. The study concludes that blanket water conservation policies for the region are likely to be inefficient because of economic and hydrologic differences in the region.

Key Words: Ogallala Aquifer, water conservation policies, non-linear dynamic optimization.

Introduction

Since the late 1800's, irrigated agriculture has played a vital role in the development and growth of the Great Plains Region of the United States. The primary source of water for irrigation in this region is the Ogallala Aquifer, which encompasses 174,000 square miles and underlies parts of eight states: Texas, New Mexico, Oklahoma, Colorado, Kansas, Nebraska, South Dakota, and Wyoming (Alley, Riley and Franke, 1999). In the Great Plains Region, the water pumped from the Ogallala Aquifer accounts for approximately 65% of the total water used for irrigation in the U.S. annually (High Plains Water District #1, 2004). The Southern portion of the Ogallala Aquifer is considered exhaustible due to the relatively low level of recharge when compared to the quantities of water pumped annually for agricultural production of cotton, corn, grain sorghum, wheat, and peanuts.

The Great Plains region produces approximately 45% of the national production of wheat, 25% of the national production of corn, over 88% of the national production of grain sorghum, and 32% of the national production of cotton (NASS, 1999). Another important agricultural activity in the Great Plains is the cattle feeding industry, composed of feedlots and beef packing plants, where over 15 million head of cattle are produced annually (Dennehy, 2002).

Average precipitation in the Southern portion of the Great Plains ranges from 15 to 20 inches per year; however, a minute amount of precipitation contributes to the recharge of the aquifer due to the high evapotranspiration. Ninety percent of the recharge in the aquifer is percolated through the soil through small playa lakes that dot the landscape from Texas to Nebraska (Alley, Riley and Franke, 1999). Sources vary on the exact amount of recharge in the

Southern portion of the Ogallala Aquifer, but many agree on a range from half an inch to several inches per year per surface acre (High Plains Water District #1, 2004).

Water conservation policies may effectively extend the economic life of the Ogallala Aquifer in the Southern High Plains of Texas and Eastern New Mexico and maintain the viability of a regional economy dependent on agriculture. This study evaluates water conservation policies which limit drawdown of the aquifer over a sixty year planning horizon. Because the majority of the study area is in Texas, the water conservation policy alternatives find their basis in and are most applicable to the Texas counties of the study area. The basic goal of the policy alternatives evaluated here is allowing agricultural irrigation and water for other uses to be available further into the future than would result under current water extraction practices.

The policy alternatives considered in this study include: 1) compensating producers for decreasing water usage to 0% drawdown relative to the total amount that would have otherwise been used over sixty years through a water conservation reserve program, 2) limiting water usage to limit drawdown to 50% of the total amount of water that would be used in the absence of a policy over sixty years, and 3) limiting water usage to limit drawdown to 75% of the total amount of water that would be used without a policy over sixty years. The first alternative considered is somewhat similar to the Federal Conservation Reserve Program (CRP) enacted for the purpose of soil conservation, but with a goal of water conservation. The second and third alternatives are directly linked to Senate Bills 1 and 2 passed by the Texas Legislature in 1997 and 2001, respectively. Senate Bills 1 and 2 gave Underground Water Conservation Districts (UWCD) the right to regulate water usage in the State of Texas.

Comparisons of policy alternatives considered were conducted to evaluate the costs and benefits to producers and society. Specifically, the baseline solution, the solution which provides the optimal amount of water to use in the absence of a water use constraint, was compared to the 0% drawdown (CRP) alternative as well as the 50% and 75% drawdown policies. These comparisons illustrate the marginal effects of water usage under the different alternatives.

Study Area

As the decline of the aquifer becomes a timely topic in state legislatures across the Great Plains, it is important to sub-divide the aquifer into regions where more specialized and accurate information can be analyzed. This study focuses primarily on the Southern Sub-Region of the Great Plains which includes the Southern portion of the Texas Panhandle and Eastern Plains of New Mexico. This region, lying on the 100th meridian, is the second largest water use area, behind Nebraska, of the Ogallala Aquifer, accounting for approximately 12% of annual extraction (National Research Council, 1996). Specifically, the counties analyzed were: Andrews, Bailey, Borden, Cochran, Crosby, Dawson, Dickens, Floyd, Gaines, Garza, Glasscock, Hale, Hockley, Howard, Lamb, Lubbock, Lynn, Martin, Midland, Motley, Terry, and Yoakum in Texas, and Lea and Roosevelt counties in New Mexico.

Objectives

The primary objective of this study was to analyze and evaluate the impacts of selected water conservation policy alternatives on the Ogallala Aquifer underlying the Southern High Plains of Texas and Eastern New Mexico for the purpose of identifying alternatives which could effectively achieve conservation of the aquifer and keep the heavily agriculturally dependent economy viable. The specific objectives were to:

1. Determine the characteristics of water conservation policy alternatives which could extend the economic life of the aquifer, and

2. Evaluate the economic life of the aquifer across the region under different water conservation scenarios over a sixty year planning horizon.

Model Specification

The framework of the optimization model used in this study was originally developed by Feng (1992) and was later expanded and modified by Terrell (1998), Johnson (2003), and Das (2004). The objective of the this study's county level optimization models is to maximize the net present value of net returns to land, management, groundwater, and irrigation systems over a sixty year planning horizon for a given county as a whole.

The objective function is defined as:

(1) $$\text{Max NPV} = \sum_{t=1}^{60} NR_t (1 + r)^{-t}.$$

Where: NPV is the net present value of net returns; r is the discount rate; and NR_t is net revenue at time t. NR_t is defined as:

(2) $$NR_t = \sum_i \sum_k \Theta_{ikt} \{ P_i Y_{ikt} [WA_{ikt}, (WP_{ikt})] - C_{ik} (WP_{ikt}, X_t, ST_t)\}.$$

Where: i represents crops grown; k represents irrigation technologies used; Θ_{ikt} is the percentage of crop i produced using irrigation technology k in time t, P_i is the output price of crop i, WA_{ikt} and WP_{ikt} are per acre irrigation water applied and water pumped per acre respectively. $Y_{ikt}[\cdot]$ is the per acre yield production function, C_{ikt} represents the costs per acre, X_t is pump lift at time t, ST_t represents the saturated thickness of the aquifer at time t.

The constraints of the model are:

(3) $$ST_{t+1} = ST_t - [(\sum_i \sum_k \Theta_{ikt} * WP_{ikt}) - R]A/s,$$

(4) $$X_{t+1} = X_t + [(\sum_i \sum_k \Theta_{ikt} * WP_{ikt}) - R] A/s,$$

(5) $$GPC_t = (ST_t/IST)^2 * (4.42*WY/AW),$$

(6) $WT_t = \sum_i \sum_k \Theta_{ikt} * WP_{ikt}$,

(7) $WT_t \leq GPC_t$

(8) $PC_{ikt} = \{[EF(X_t + 2.31*PSI)EP]/EFF\}*WP_{ikt}$,

(9) $C_{ikt} = VC_{ik} + PC_{ikt} + HC_{ikt} + MC_k + DP_k + LC_k$

(10) $\sum_i \sum_k \Theta_{ikt} \leq 1$ for all t,

(11) $\Theta_{ikt} \geq (2/3)\, \Theta_{ikt-1}$,

(12) $\Theta_{ikt} \geq 0$.

Equations (3) and (4) represent the two equations of motion included in the model which update the two state variables, saturated thickness and pumping lift, ST_t and X_t respectively. Where R is the annual recharge rate in feet, A is the percentage of irrigated acres expressed as the initial number of irrigated acres in the county divided by the area of the county overlying the aquifer, and s is the specific yield of the aquifer.

Constraints (5), (6) and (7) are the water application and water pumping capacity constraints respectively. In equation (5), GPC represents gross pumping capacity, IST represents the initial saturated thickness of the aquifer and WY represents the average initial well yield for the county. Equation (6) represents the total amount of water pumped per acre, WT_t, as the sum of water pumped on each crop. Constraint (7) requires WT_t to be less than or equal to GPC.

Equations (8) and (9) represent the cost functions in the model. In Equation (8), PC_{cit} represents the cost of pumping, EF represents the energy use factor for electricity, EP is the price of energy, EFF represents pump efficiency, and 2.31 feet is the height of a column of water that will exert a pressure of 1 pound per square inch. Equation (9) expresses the cost of production, C_{ikt} in terms of VC_{ik}, the variable cost of production per acre, HC_{ikt}, the harvest cost per acre,

MC_k, the irrigation system maintenance cost per acre, DP_k, the per acre depreciation of the irrigation system per year, and LC_k, the cost of labor per acre for the irrigation system.

Equation (10) limits the proportional sum of all acres of crops i produced by irrigation systems k for time period t to be less than or equal to 1. Equation (11) is a constraint placed in the model to limit the annual shift to 33% change from the previous year's acreage. Equation (12) is a non-negativity constraint to assure all decision variables in the model take on positive values.

Data Collection

Specific data was compiled for each county within the study region for both Texas and New Mexico. The county specific data included a five year average of planted acreage of cotton, corn, grain sorghum, wheat and peanuts; and total acreage under conventional furrow, low application spray application (LEPA) and dryland. Operating costs associated with the most commonly used crop production practices was also collected for specific crops, including fertilizer, herbicide, seed, insecticide, fuel, irrigation technology maintenance, irrigation, labor, and harvesting costs. Finally, other relevant data, including the area of each county overlying the aquifer, average recharge, total crop acres per irrigation well, average saturated thickness of the aquifer, initial well yield, and average pump lift was collected.

Hydrologic Data: The amount of annual recharge in the Southern Ogallala is not known, and most estimates are considered controversial at best. For the purposes of this study, a recharge estimate by Stovall (2001) using Texas Water Development Board data was used. Stovall separated recharge into two categories, primary and secondary. Primary recharge values were available for each square mile in the study area. However, there were fewer values for secondary recharge. Therefore, the recharge value used was average primary recharge by county plus a weighted secondary county recharge value to account for the differences in data availability between the two recharge estimates. There were no values of secondary recharge for Andrews, Midland, and Glasscock Counties. Therefore, Martin County secondary values were used for Midland and Andrews Counties and Howard County values for Glasscock County. Additionally, recharge values were unavailable for Lea and Roosevelt Counties in NM. For this reason Gaines County, TX values were used for Lea County and Bailey County, TX values were used for Roosevelt County.

Saturated thickness and pump lift by county were calculated from the TWDB groundwater database reports for the most recent year's data. Saturated thickness was calculated by subtracting the depth to water from the depth of the well. Pump lift was calculated as the depth from the surface to the water level. An estimated specific yield of 0.15 was used for the entire study area and the initial well yield by county was estimated using the Analytical Study of the Ogallala Aquifer in various counties (Texas Water Development Board, 1976). Initial acres served per well was calculated from the TWDB Survey of Irrigation (2000) as the number of acres irrigated with groundwater divided by the number of wells in the county.

Acreages: General county acreages including area of the county were obtained from the 2000 U.S. Estimating county acreages by crop was a two step process: 1) dryland and irrigated county planted acres by crop were obtained from the Farm Service Agency (FSA) for 1999-2003, 2) FSA planted acres were converted to harvested acres using the ratio of planted to harvested acres for the same crops and systems for 1999-2003 from the National Agricultural Statistics Service (NASS).

In order to allocate irrigated acres between furrow and LEPA, the TWDB Survey of Irrigation (2000) was used to obtain the total acres irrigated by groundwater and by LEPA for each county in the study region. Assuming only two systems, furrow and LEPA, allowed the subtraction of acres irrigated with sprinkler (LEPA) from total groundwater irrigated acres to obtain the percent of acres under furrow and LEPA for each county. Finally, the percent irrigated by each system was multiplied by the number of irrigated acres of each crop in a county to estimate county acreages by crop and system with the exception of peanuts and corn due to the fact that no dryland corn and only LEPA peanuts are grown.

Production Functions: The crop simulation software CROPMAN, was used to estimate county production function parameters by crop and system. The most prevalent soil types along with the weather data from the closest weather stations were used for each county. CROPMAN data files for New Mexico counties were unavailable; therefore Gaines County and Bailey County productions functions were used for Lea and Roosevelt Counties, respectively. Yields were obtained from CROPMAN for LEPA (95% efficiency) and furrow (60% efficiency) for varying water application rates. Regressions for each crop and system were then estimated in Microsoft Excel where Y was calculated as the CROPMAN yield minus the actual NASS 1999-2003 average dryland yield, X was water application rate, and X^2 was water application rate squared. The regressions were estimated using restricted least squares processes while setting the intercept to zero. The dryland yield was then added back as the intercept to the equation.

Commodity Prices: Prices for wheat, corn, and sorghum were collected from the Agricultural Marketing Service (AMS). The prices used were 1999-2003 AMS quotes for South of Line from Plainview to Muleshoe. Due to the fact that the price of cotton for the same five year period was below the marketing loan price, a price equal to the loan price plus coupled government payments ($0.57/lb) was used in place of the AMS price. Additionally, AMS does not include peanut prices and therefore the 1999-2003 NASS peanut price was used.

Costs of Production: 2005 Texas Crop and Livestock Budgets produced by the Texas A&M Cooperative Extension Service for Districts 1&2 were the primary sources for costs of production. Costs are both crop and irrigation system specific. Electricity is the primary power source for this study area; therefore budgets were converted from natural gas to electricity when needed. The electricity price used was the South Plains Electric Coop 1998-2002 average price of .06442 $/kwh. Additionally, several sprinkler budgets were converted to furrow budgets when needed.

Results

Optimal levels of saturated thickness, annual net revenue per acre, pump lift, water applied per cropland acre, cost of pumping, and net present value of net returns per acre (NPV) by county were derived using the non-linear dynamic optimization model for the baseline scenario and the three water conservation policy alternatives for nineteen of the twenty-four counties in the study area. Results for the remaining five counties where saturated thickness showed and increase in saturated thickness over the planning horizon are not included.

Results for Gaines County

The results for the baseline model and three policy alternatives will be discussed and analyzed in this section for Gaines County. Gaines County was selected as the representative county because the entire county overlies the aquifer, it has a diverse crop mix, crop acreages in both irrigated and dryland, and it is in close proximity to the center of the study area. Gaines County contains 465,701 acres of cropland with the predominant soil type being Brownfield fine sandy loam. The initial percentages of cropland by crop and system are: 42% LEPA irrigated cotton, 16% LEPA irrigated peanuts, 4% LEPA irrigated wheat, 27% dryland cotton, 8.5% dryland sorghum, and 2% dryland wheat.

In the baseline scenario, in the absence of a water use constraint, the results for Gaines County showed that saturated thickness fell from 65ft. to 14ft. by the end of the sixty year planning horizon. Nominal net revenue increased initially from approximately $89.00 per acre to $117.00 per acre before falling to $46.00 at the end of the planning horizon and the NPV for the baseline scenario was $2,824.99 per acre.

Comparison of Policy Alternatives for Gaines County

In this section, comparisons pertaining to specific policy alternative results are relatively compared to the baseline.

0% Drawdown Policy to the Baseline: the constraint forcing all irrigated acres into dryland acres in the 0% drawdown policy caused significant differences in saturated thickness in year sixty compared to the baseline. Saturated thickness in the 0% drawdown case is 77 ft. above the baseline level. The model also showed major differences in the net revenue per acre. The 0% scenario nominal net revenue per acre was $96.00 lower than the baseline in year two. The gap between nominal net revenue per acre did narrow slightly between the two scenarios in later time periods, but yearly baseline net revenue remained well above the 0% drawdown policy net revenue over the entire planning horizon. In the 0% drawdown scenario, the NPV per acre was 546.18, or 81% less than the baseline. Therefore, $2,278.81, the difference between the baseline and 0% drawdown levels of NPV, would be the approximate per acre compensation that would have to be provided to Gaines County producers in year one for them to be no worse off by discontinuing water usage for sixty years.

50% Drawdown Policy to the Baseline: saturated thickness in the 50% drawdown scenario was 25.5 ft. above the baseline saturated thickness at the end of the planning horizon. Nominal net revenue per acre was interestingly not significantly affected by the 50% restriction remaining about $3.00 per acre below the baseline through year sixty. NPV per acre for the 50% policy was $2,293.65, or 19% below the baseline level.

75% Drawdown Policy to the Baseline: saturated thickness in the 75% drawdown scenario concluded 13 ft. above the baseline level whereas net revenue per acre remained similar to the baseline until year thirty-three. After year thirty-three, nominal net revenue per acre remained approximately $4.00 below the baseline level through year sixty. NPV per acre was determined to be $2,602.91, or 8% below the baseline NPV.

Regional Results

As discussed previously, in the baseline scenarios five counties in the region (Borden, Dickens, Howard, Martin, and Motley) showed an increase in the saturated thickness over the planning horizon in addition to comparatively low net revenue per acre and water applied per cropland acre. These counties lie relatively close to the eastern edge of the Ogallala Aquifer and currently have low saturated thickness levels and insignificant amounts of irrigation compared to other counties in the study area.

Apart from the five low saturated thickness counties mentioned above, results of the baseline scenario and policy alternatives showed generally consistent trends across the region in irrigation practices and cropping patterns. In the baseline scenario and the three policy alternatives, furrow irrigation quickly moved into LEPA irrigation systems in all counties. The optimal crops for the region became LEPA irrigated cotton, LEPA irrigated peanuts for counties that had peanuts in year one, and dryland sorghum. Counties with LEPA irrigated peanuts often had higher NPV levels due to the profitability of the crop; however, counties without historical peanut production were not allowed to add the crop in later time periods. Corn, wheat, irrigated sorghum, and dryland cotton went out of production in all counties in all scenarios evaluated. A regional evaluation of the four policy alternatives is discussed below:

- 0% Drawdown Policy: this policy again forced all irrigated acres to dryland acres for years two through sixty. In all counties, 100% of acres transitioned into dryland sorghum; therefore, the agricultural viability of a county under this scenario depended primarily on the profitability of dryland sorghum production. Often counties that did not have a comparatively high NPV in the baseline scenario did have high NPV in this scenario. For example, Cochran County's baseline NPV was $3,927.71 whereas Midland County's was $2,674.39. In the 0% drawdown policy, Cochran County's NPV dropped to $834.58 compared to Midland County's at $1,048.85. Therefore, Cochran County had a relatively high NPV in the baseline scenario whereas Midland County had a relatively high NPV in the 0% drawdown policy. This was due to the fact that Midland County had a higher level of profitability for dryland sorghum than Cochran County.
- 50% Drawdown Policy: the results for this policy were fairly consistent across the region. All counties transitioned to LEPA irrigated cotton, LEPA irrigated peanuts (where applicable), and dryland sorghum. Most counties were able to continue their existing level of irrigation through about year thirty. When the 50% saturated thickness drawdown level was approaching, irrigated acres decreased and dryland sorghum acres increased. Four counties (Dawson, Glasscock, Lynn, and Roosevelt) were able to continue a relatively constant level of irrigation throughout the planning horizon. The effects on NPV and annual net revenue per acre were similar to the Gaines County case discussed above for the entire region: nominal net revenue was lower than in the baseline scenario level, but not substantially.

- 75% Drawdown Policy: the regional results for this policy were quite similar to the 50% drawdown policy discussed above; the difference being that irrigation practices were continued closer to year forty-five for most counties. County NPV levels in this scenario were often within $100.00 of the baseline NPV implying there was little cost to the policy; however, there was very little water conserved as well because the drawdown constraint was not very restrictive.

Though the overall regional trends are similar in irrigation practices and cropping patterns, the results of the policies also show that the impacts of the policies differ greatly across the region. Another factor examined that demonstrates the major differences across the region is the cost of each policy. Table 1 depicts the implicit cost of water conservation per acre foot of saturated thickness on a cropland acre basis for the 0% drawdown Policy, the 50% drawdown policy, and the 75% drawdown policy.

The cost of conserving an additional foot of saturated thickness under these policies is a direct result of total saturated thickness depletion and NPV for each scenario. Andrews, Howard, and Roosevelt Counties for example showed either no or a minute amount of aquifer depletion in the baseline; therefore, the cost of conserving an additional foot of saturated thickness is relatively high in those counties. The cost of conserving an additional foot of saturated thickness in Howard County is $2,281.00 because in the baseline scenario, the saturated thickness increases approximately the same level it does in the 0% policy: the year sixty saturated thickness is only 0.9 ft. higher than in the baseline scenario which in turn causes the higher cost. Alternatively, Hale and Lubbock Counties are high water use counties and show significant levels of depletion in the baseline scenario. Therefore, the cost of conserving an additional acre foot of saturated thickness in these counties is much lower.

Another interesting characteristic shown in Table 1 is the differences in the costs of conservation between policies. The cost of the 0% drawdown policy is notably higher than both the 50% and the 75% policies for all counties in the study area. Conversely, the gap in the costs of conserving an additional acre foot of saturated thickness between the 50% and the 75% policy are often in close proximity to one another. Gaines County for example shows that the cost of conserving an additional acre foot of saturated thickness is only $3.77 more under the 50% policy than under the 75% policy. Overall, the results of the study indicate that policy impacts vary greatly across the region. How a policy alternative impacts a county depends on the hydrologic characteristics of the county, the level of current irrigation, and the profitability of the optimal crops grown.

Policy Implications

0% Drawdown Policy: this policy conserved massive amounts of water in the Ogallala Aquifer; but it also significantly decreased NPV and is likely to be quite detrimental to economic activity across the region. The decrease in economic activity would be similar to the effects expected in the case of total aquifer exhaustion, which is what water conservation policies are attempting to circumvent. As stated previously, five counties showed an increase in saturated thickness throughout the planning horizon in the baseline scenario. Many other counties did exhibit aquifer drawdown in the baseline scenario, but not to the extent that a policy this restrictive on water use would be required across the region. This policy would likely be best used in only those counties, or areas of counties, with extensive annual aquifer drawdown, and should be implemented only on a portion of total cropland acres within a county.

50% Drawdown Policy and 75% Drawdown Policy: these two water conservation policies exhibited similar trends. Compared to the 0% water conservation policy discussed above, neither of these two policies will likely be necessary across the study region. Both the 50% drawdown and the 75% drawdown policies caused decreases of NPV as compared to the baseline solution, and both conserved water in the aquifer relative to the baseline. The 75% policy had a slightly higher NPV than the 50% policy whereas the 50% drawdown policy conserved 25% more water than did the 75% policy.

These two policies were the most restricting on high water use counties. Hale County, the highest water use county in the study area, showed a NPV 16% lower than the baseline for the 50% policy while the 75% policy NPV was 7% lower than the baseline. However, the 50% policy conserved an additional 16 ft. more saturated thickness than did the 75% policy. Alternatively, Midland County is a low water use county. The NPV for the 50% policy in this scenario was 7% less than the baseline whereas the 75% policy NPV was 2% below the baseline. However, in this case, the 50% policy conserved 4 ft. of saturated thickness relative to the baseline and the 75% policy conserved 3 ft. of saturated thickness relative to the baseline. Therefore, these water conservation policy alternatives are likely not to be necessary for Midland County.

Conclusions

The results from this study indicate that because of the significant differences in hydrologic characteristics and current irrigation levels across the study area, blanket water conservation policies for the region as a whole are likely to be inefficient. Under the baseline scenario, there are many counties in the study area that do not deplete saturated thickness to a level that warrants a conservation policy. As shown in the results section, the cost of conserving an additional acre foot of water in low water use counties is extremely high. Legislative time and tax money would be more efficiently spent enacting policies to conserve water in those counties that significantly utilize the aquifer underlying the county. After analyzing the water use practices and aquifer levels in each county, this study concludes that for this region, water conservation policies should focus on counties that deplete the aquifer to less than 30 ft. of saturated thickness in the baseline scenario; where the implicit cost of conserving a foot of saturated thickness is relatively low. These are the most heavily irrigated counties in the study region, and society as a whole would most likely benefit from the focus of water conservation being in these high water use counties.

The nine counties in the study region in which a depletion of saturated thickness to less than 30 ft. in the baseline scenario are: Cochran, Floyd, Gaines, Hale, Hockley, Lamb, Lubbock, Terry, and Yoakum. By focusing water conservation on these nine heavily irrigated counties, policy makers can conserve water for future irrigation where it is likely to be most vital to the regional economy.

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Table 1. Water Conservation Cost

Implicit Cost in Dollars of Water Conservation Per Foot of Saturated Thickness By Policy On a Cropland Acre Basis

County	0%	50% Total	75%
Andrews	800.98	435.07	340.28
Bailey	21.38	10.12	7.11
Borden	341.89	N/A	N/A
Cochran	54.82	27.75	20.99
Crosby	25.43	11.90	8.24
Dawson	79.88	20.60	10.56
Dickens	70.03	N/A	N/A
Floyd	49.96	34.68	28.62
Gaines	29.56	20.81	17.04
Garza	119.78	55.00	37.11
Glasscock	43.41	8.91	4.29
Hale	38.60	33.81	29.56
Hockley	58.70	41.27	35.30
Howard	2281.00	N/A	N/A
Lamb	20.11	14.34	11.92
Lea	427.32	226.68	164.24
Lubbock	21.04	16.36	14.31
Lynn	82.68	29.43	14.30
Martin	473.23	N/A	N/A
Midland	112.42	47.32	27.87
Motley	80.17	N/A	N/A
Roosevelt	343.90	110.89	63.37
Terry	83.98	59.58	48.78
Yoakum	58.35	34.70	27.65