Extending Economic Life of Ogallala Aquifer with Water Conservation Policy Alternatives in the Texas Panhandle

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Ogallala Aquifer
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Presentation Layout

- **Agriculture and Texas Panhandle**
- **Regional Economic Impact and Water**
- **Research Objectives and Policy Assumptions**
- **Results and Discussion**
- **Concluding Remarks**

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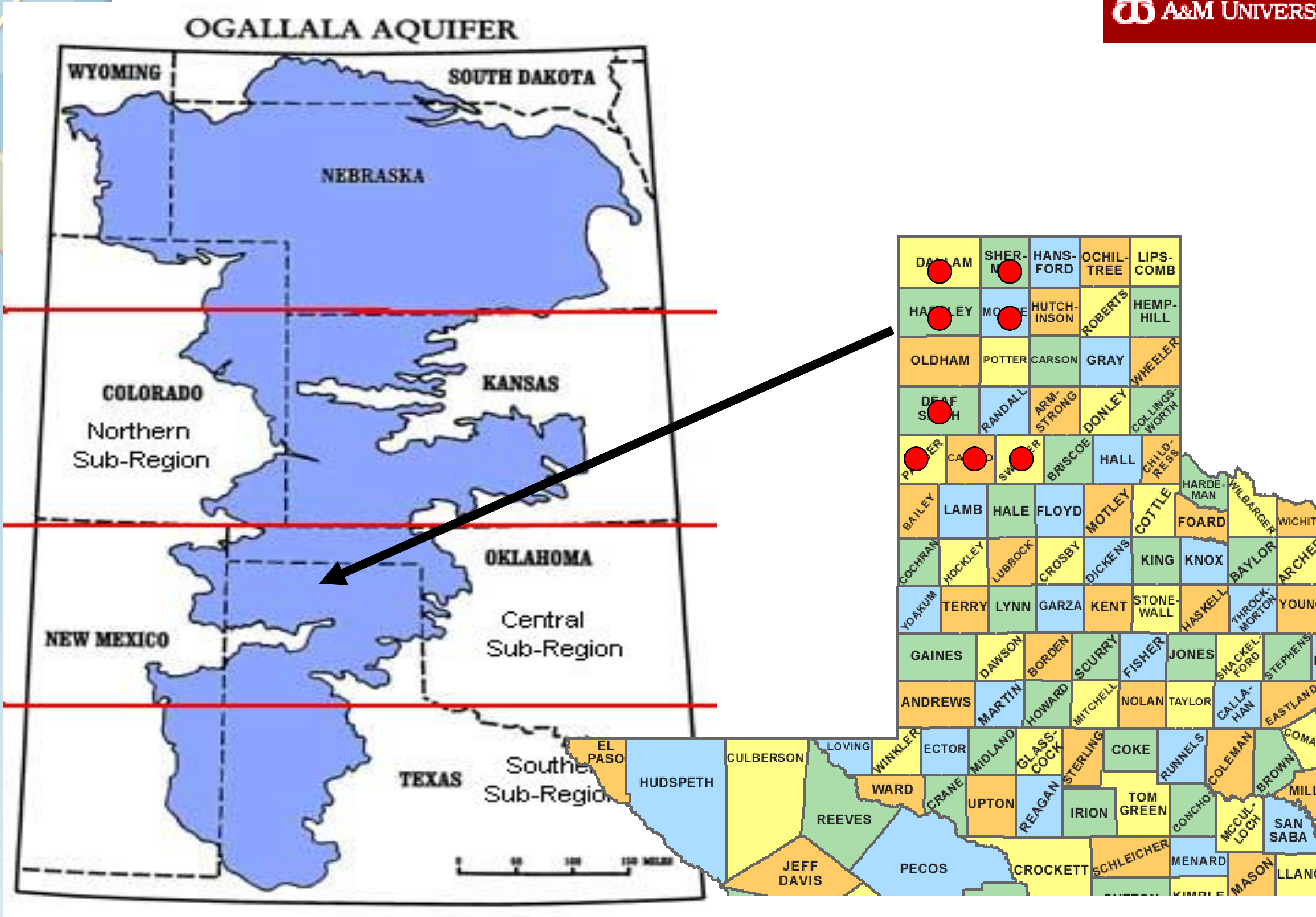

Agriculture-Texas Panhandle

- 14 million acres of Agricultural land
- > 5 million acres in crops
- 40 percent of cropland in irrigated production
- Major Crops -Corn, Cotton, Grain Sorghum, and Wheat
- Cattle Feeding Capital of the World

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Crop Production

Crop	Four County Area		Texas Panhandle (26 Counties)		Study Area Comparison with Texas Panhandle	
	Acres Harvested (1,000 ac.)	Production (1,000 bu)	Acres Harvested (1,000 ac.)	Production (1,000 bu)		
Wheat	**399.5**	**19,277**	**1,753.3**	**77,571.0**	**23%**	**25%**
Irrigated	190.1	12,046	474.4	28,572.0	40%	42%
Nonirrigated	209.4	7,231	1,278.9	48,999.0	16%	15%
Sorghum	**73.9**	**5,799**	**397.9**	**26,301.0**	**19%**	**22%**
Irrigated	49	4,901	169.2	15,682.0	29%	31%
Nonirrigated	24.9	898	228.7	10,619.0	11%	8%
Corn	**390.8**	**83,543**	**736.9**	**154,889.0**	**53%**	**54%**
Upland Cotton	24.8	58	350.6	700.3	7%	8%
Irrigated	21.1	54	193.0	503.3	11%	11%
Nonirrigated	3.7	4	157.6	197.0	2%	2%

Livestock Production

Fed Cattle Heads	4.90 million
Dairy Cows	0.10 million
Swine	1.07 million

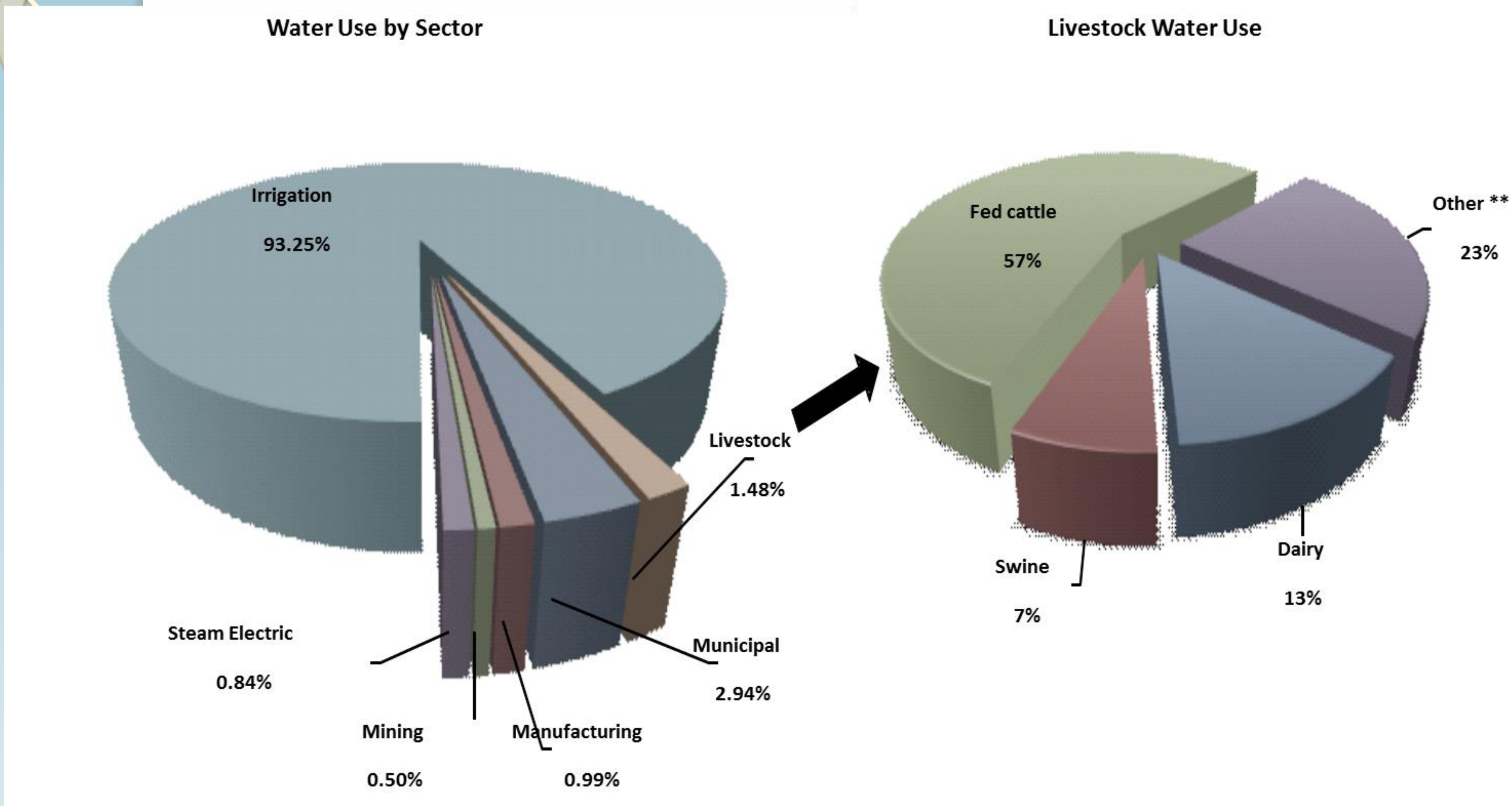
Feed Demand	470 million bushels
Feed Supply	180 million bushels
Feed Imported	290 million bushels

- Water Imported in the form of feed grains
  - **6 million acre-feet (1 acre-feet = 325,856 gallons)**

Regional Economic Impact

- > 25 % of all cash receipts for crops and livestock in Texas
- $5.8 billion in value of agriculture
- $6.9 billion regional economic impact
- $9.5 billion state economic impact
- 53,264 jobs with $1.1 billion in payroll

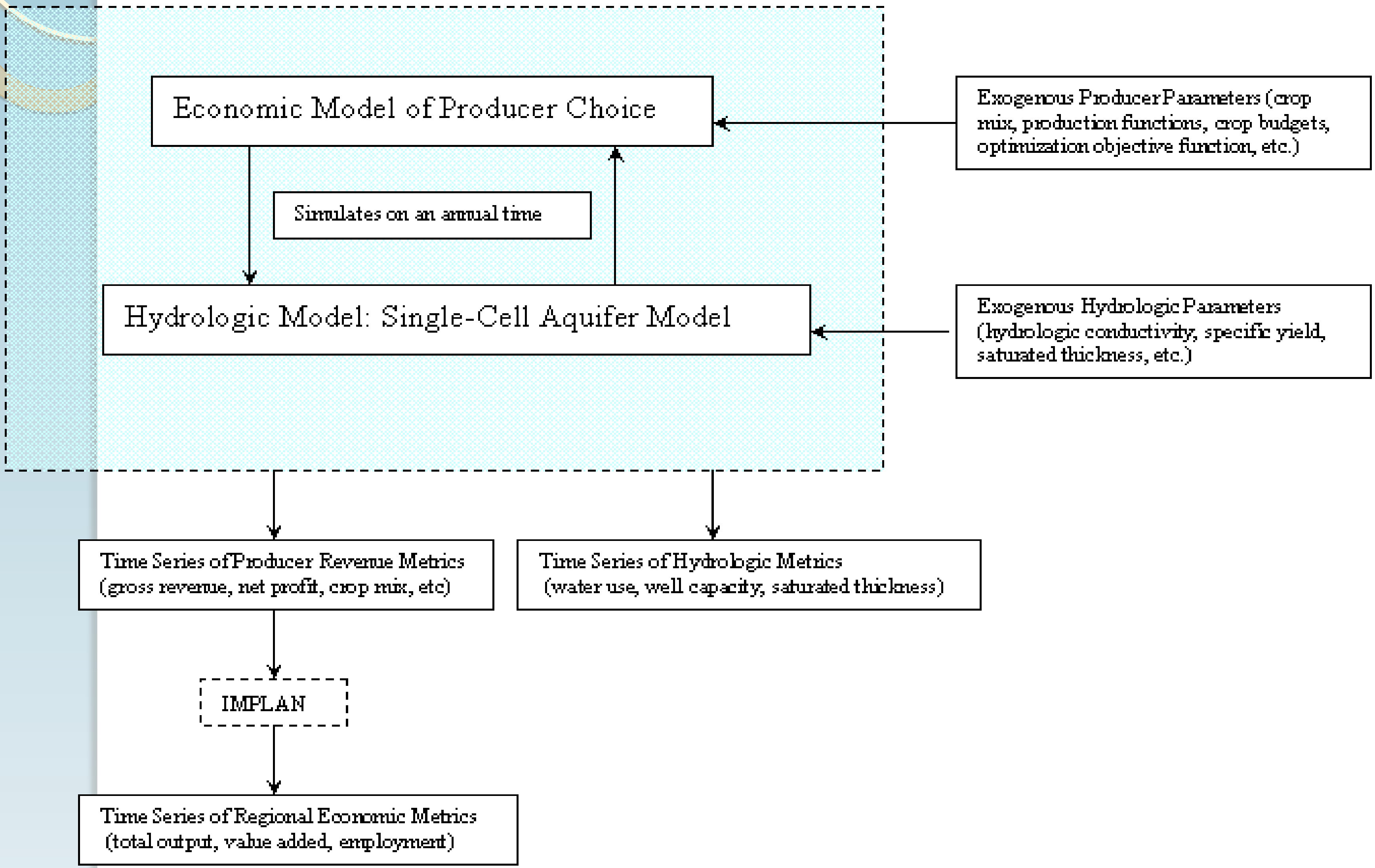
Water Use by Sector



Objectives of Policy Development

- To extend the life of the aquifer to maintain the economic viability for future generations.
- To assess the potential impacts in the region from implementing alternative water conservation strategies.
- Five policies compared to the baseline
- Economic dynamic optimization models developed to estimate changes in the aquifer, irrigated acreage and net farm income
- Socioeconomic models utilized to evaluate impacts on the regional economy

How Do We Model?
(Economic Dynamic Optimization Models)



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How Do We Model?

(Economic Dynamic Optimization Models)

Economic Model

Time	Saturated Thickness	Well Capacity	Alfalfa Acres	Irrigated Corn Acres	Soybeans Acres	Revenue	Total Water-Use	Change ST
1	89.8	587.4	1237	18558	4949	$5,279,829	26723.6	1.2
2	88.6	575.4						

Hydrological Model

Conceptual Framework

Objective function

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

$$NR_t = \Sigma_i \Sigma_k \Omega_{ikt} \{ P_i Y_{ikt} [WA_{ikt}, (WP_{ikt})] - C_{ik} (WP_{ikt}, X_t, ST_t)\}$$

Constraints

- $ST_{t+1} = ST_t - [(\Sigma i \, \Sigma_k \Omega_{ikt} * WP_{ikt}) - ARR] PIA/SY,$
- $X_{t+1} = X_t + [(\Sigma_i \Sigma_k \Omega_{ikt} * WP_{ikt}) - ARR] PIA/ SY,$
- $GPC_t = (ST_t/IST)^2 * (4.42*WY/AW), WT_t = \Sigma_i \Sigma_k \Omega_{ikt} * WP_{ikt}, WT_t \leq GPC_t$
- $(PC_{ikt} = \{[EF(X_t + 2.31*PSI)EP]/EFF\}*WP_{ikt},$
- $(C_{ikt} = VPC_{ik} + PC_{ikt} + HC_{ikt} + MC_k + DP_k + LC_k$
- $\Sigma_i \Sigma_k \Omega_{ikt} \leq 1$ for all t, $\Omega_{ikt} \geq (0.9) \Omega_{ik(t-1)}$, and $\Omega_{ikt} \geq 0$

Policy Assumptions

- **Baseline**: assumes no water conserving policy is implemented
- **Biotechnology**: assumes increased yields of 0.5% annually coupled with a 1% annual water use restriction
- **Irrigation Technology**: irrigation efficiency increases
- **Water Use Restriction:** assumes a 1% annual water use restriction
- **Temporary Conversion**: assumes 10% of irrigated acreage are temporarily converted to dryland
- **Permanent Conversion (A)**: assumes 10% of irrigated acreage are permanently converted to dryland. During the enrollment period dryland production is not allowed
- **Permanent Conversion (B)**: assumes 10% of irrigated acreage are permanently converted to dryland. During the enrollment period dryland production is allowed

Results: Change in Average Saturated Thickness for the Region

Policy Scenario:	Year 10	Year 20	Year 30	Year 40	Year 50	Year 60
Baseline	132.85	111.42	92.77	79.35	69.45	61.84
Biotechnology-	136.65	121.04	107.26	95.31	85.20	76.93
Change from Baseline	*2.86%*	*8.63%*	*15.62%*	*20.11%*	*22.67%*	*24.39%*
Irrigation Technology-	136.00	117.90	99.85	84.52	73.34	64.87
Change from Baseline	*2.37%*	*5.81%*	*7.63%*	*6.51%*	*5.59%*	*4.90%*
Water Use Restriction-	136.65	121.04	107.26	95.31	85.20	76.93
Change from Baseline	*2.86%*	*8.63%*	*15.62%*	*20.11%*	*22.67%*	*24.39%*
Temporary Conversion-	135.99	117.90	99.84	84.51	73.34	64.87
Change from Baseline	*2.37%*	*5.81%*	*7.63%*	*6.51%*	*5.59%*	*4.90%*
Permanent Conversion-	135.99	117.90	99.91	84.56	73.37	64.90
Change from Baseline	*2.37%*	*5.81%*	*7.70%*	*6.57%*	*5.64%*	*4.94%*

Results: Change in Average Saturated Thickness in Each County

	Dallam		Hartley		Moore		Sherman	
Policy Scenario:	**Year 1**	**Year 60**	**Year 1**	**Year 60**	**Year 1**	**Year 60**	**Year 1**	**Year 60**
Baseline	128.0	49.2	153.0	73.2	162.0	55.8	182.0	70.6
Biotechnology	128.0	61.5	153.0	89.9	162.0	65.7	182.0	92.7
Change from Baseline		*24.9%*		*22.7%*		*17.6%*		*31.2%*
Irrigation Technology	128.0	52.2	153.0	76.5	162.0	57.6	182.0	74.6
Change from Baseline		*6.0%*		*4.5%*		*3.2%*		*5.6%*
Water Use Restriction	128.0	61.5	153.0	89.9	162.0	65.7	182.0	92.7
Change from Baseline		*24.9%*		*22.7%*		*17.6%*		*31.2%*
Temporary Conversion	128.0	52.2	153.0	76.5	162.0	57.6	182.0	74.6
Change from Baseline		*6.0%*		*4.5%*		*3.2%*		*5.6%*
Permanent Conversion	128.0	52.2	153.0	76.5	162.0	57.7	182.0	74.6
Change from Baseline		*6.0%*		*4.5%*		*3.4%*		*5.6%*

Results: Irrigated Acreage as a Percent of Total Cropland Acres in the Region

Policy Scenario:	Year 10	Year 20	Year 30	Year 40	Year 50	Year 60
Baseline	72.10%	72.10%	62.07%	45.15%	34.46%	27.25%
Biotechnology-	71.99%	71.20%	65.03%	57.57%	49.65%	40.86%
Change from Baseline	*-0.15%*	*-1.24%*	*4.77%*	*27.50%*	*44.07%*	*49.93%*
Irrigation Technology-	69.35%	69.35%	68.04%	50.59%	37.92%	29.59%
Change from Baseline	*-3.82%*	*-3.82%*	*9.62%*	*12.04%*	*10.05%*	*8.57%*
Water Use Restriction-	66.07%	58.40%	51.20%	44.00%	36.81%	29.62%
Change from Baseline	*-8.36%*	*-19.00%*	*-17.52%*	*-2.54%*	*6.82%*	*8.67%*
Temporary Conversion-	64.89%	69.80%	69.08%	51.31%	38.48%	30.02%
Change from Baseline	*-10.00%*	*-3.19%*	*11.28%*	*13.65%*	*11.65%*	*10.15%*
Permanent Conversion-	64.89%	64.89%	64.89%	51.37%	38.51%	30.04%
Change from Baseline	*-10.00%*	*-10.00%*	*4.53%*	*13.78%*	*11.75%*	*10.24%*

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Results: Average Net Present Value of Net Returns per Cropland Acre

Policy Scenario:	Dallam	Hartley	Moore	Sherman	Weighted Average
Baseline	$3,907.96	$4,109.79	$5,825.06	$4,483.07	$4,546.47
Biotechnology-	**$9,158.70**	**$9,630.70**	**$12,062.27**	**$9,356.41**	**$9,980.33**
Change from Baseline	*134.36%*	*134.34%*	*107.08%*	*108.71%*	*119.52%*
Irrigation Technology-	$3,491.58	$3,899.80	$5,643.84	$4,252.84	$4,281.63
Change from Baseline	*-10.65%*	*-5.11%*	*-3.11%*	*-5.14%*	*-5.83%*
Water Use Restriction-	$3,447.58	$3,563.20	$5,398.98	$3,844.06	$4,025.39
Change from Baseline	*-11.78%*	*-13.30%*	*-7.31%*	*-14.25%*	*-11.46%*
Temporary Conversion-	$3,709.18	$3,924.80	$5,656.85	$4,305.89	$4,363.69
Change from Baseline	*-5.09%*	*-4.50%*	*-2.89%*	*-3.95%*	*-4.02%*
Permanent Conversion-	$3,704.73	$3,921.66	$5,629.04	$4,285.24	$4,349.82
Change from Baseline	*-5.20%*	*-4.58%*	*-3.37%*	*-4.41%*	*-4.33%*

Results Economic Impact

	Direct	Indirect	Induced	Total
Irrigated Corn	-591,303,636	-325,966,773	-173,689,530	-1,090,959,939
Irrigated Cotton	-82,776,730	-55,526,796	-26,866,015	-165,169,542
Irrigated Sorghum	-18,217,650	-13,719,457	-4,017,557	-35,954,664
Irrigated Wheat	-177,382,041	-126,258,408	-39,349,900	-342,990,349
Total Irrigated	***-869,680,057***	***-521,471,434***	***-243,923,002***	***-1,635,074,493***
Dryland Cotton	30,066,233	22,063,384	8,804,445	60,934,063
Dryland Sorghum	104,414,310	71,043,288	34,013,797	209,471,394
Dryland Wheat	63,414,855	40,331,975	20,390,095	124,136,925
Total Dryland	***197,895,398***	***133,438,646***	***63,208,338***	***394,542,382***
Total	**-671,784,659**	**-388,032,788**	**-180,714,664**	**-1,240,532,111**

Summary

- Best policy alternatives in the region focus on reducing water use, not reducing irrigated acreage
- Policy with least cost to producers is biotechnology adoption, though yields may not be attainable for some time due to the timing of development and adoption
- Other policies pose a significant financial hardship for producers and input suppliers
- Producers may be compensated for their losses to encourage water conservation
- Rural communities dependent on agriculture will feel the economic impact

Thank you for your attention

Comments and Questions?