

Potential Impacts of Global Warming on Texas Agriculture Water Related Issues

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Presented at Environmental Defense Conference

Global Warming and Texas Water

Austin, TX

Friday, May 12th, 2006

Presentation Plan

Musings based on the 20 years of climate work covering

AG-Water sector interaction

Main water section findings on irrigation

Info from recent assessments

US National

Edwards Aquifer

Climate change

El Nino Southern Oscillation

Water Issues in Climate change and Agriculture Assessments

- 1) Climate change influence on yields and water use
- 2) Climate change influence on irrig water availability
 - Groundwater sources
 - Surface water sources
- 3) Net agricultural water availability due to changes in
 - a) Nonagricultural demands for water use
 - b) In stream demands for stream ecology, waste dilution, freshwater inflows etc.
- 4) Changes in irrigated acres and water use

Water Sector Irrigation Relevant USNA Findings

Climate change will likely **exacerbate competition** for water supplies

More precipitation will fall as rain. **Snowpack will develop later and melt earlier** with runoff shifted from spring/summer to winter/spring.

May be able to **store** water in reservoirs to dampen the effects of changes in flow regimes, but this comes with **environmental costs**.

Regionally **groundwater levels may fall**, reducing seasonal streamflows.

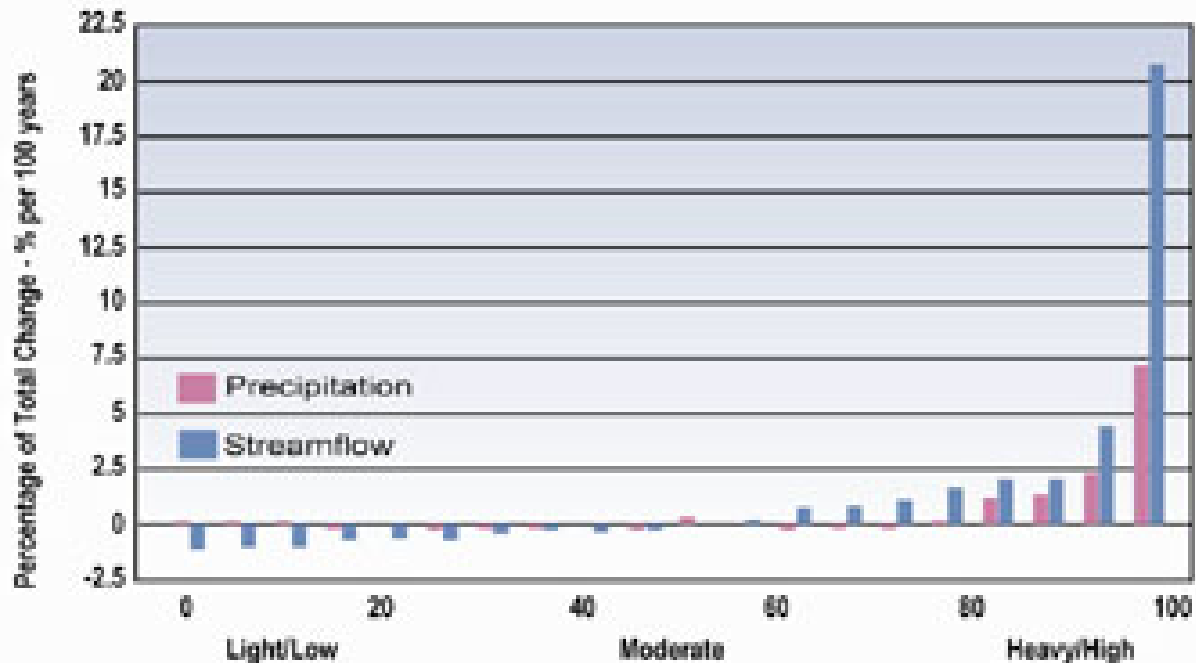
Pumping groundwater faster than recharge is a major concern, especially in parts of the country that have no other supplies.

Gleick, P.H and the U.S. National Assessment Water Team: [The Potential Consequences of Climate Variability and Change for the Water Resources of the United States](http://www.usgcrp.gov/usgcrp/Library/nationalassessment/14water.pdf) <http://www.usgcrp.gov/usgcrp/Library/nationalassessment/14water.pdf>

Water Sector Irrigation Relevant USNA Findings

Precipitation in the US has increased by 5-10% during the 20th century with much of this increase attributed to heavy and very heavy precipitation events. During this period, the relative increase in runoff has been even greater

Observed Changes In Streamflow and Precipitation (1939-99)



Agricultural Sector Water Relevant Findings

I have done number of studies on climate change and water issues. I will discuss 3

1. Core national assessment
2. Regional Edwards Aquifer Study
3. EL Nino extreme events frequency change

Reilly, J.M., and Agricultural Assessment team, Changing Climate and Changing Agriculture: Report of the Agricultural Sector Assessment Team, US National Assessment, prepared as part of USGCRP National Assessment of Climate Variability, Cambridge University Press, 2002.

Reilly, J.M., F. Tubiello, B.A. McCarl, D.G. Abler, R. Darwin, K. Fuglie, S.E. Hollinger, R.C. Izaurralde, S. Jagtap, J.W. Jones, L.O. Mearns, D.S. Ojima, E.A. Paul, K. Paustian, S.J. Riha, N. Rosenberg, and C. Rosenzweig, "U.S. Agriculture and Climate Change: New Results," Climatic Change, 57, 43-69, 2003.

McCarl, B.A., and J.M. Reilly, "US Agriculture in the climate change squeeze: Part 1: Sectoral Sensitivity and Vulnerability," Draft report TAMU, 2006.

Agricultural Sector Irrigation Investigation

Surface Water percent changes from Water Sector

	Hadley	Canad	CSIRO	REGCM
Corn Belt	59.09	-14.22	22.43	22.43
Great Plains	56.51	-7.19	24.66	24.66
Lake States	69.90	-18.48	25.71	25.71
Northeast	31.78	-9.81	10.99	10.99
Rocky Mount	65.02	-9.69	27.66	27.66
Pac Sthwest	149.99	35.90	92.95	92.95
Pac Northwst	14.61	3.63	9.12	9.12
South Cent	24.62	-50.87	-13.13	-13.13
Southeast	25.84	-63.60	-18.88	-18.88
South West	18.00	-18.51	-0.26	-0.26

Agricultural Sector Relevant Findings

Table 2 National crop sensitivity over all crops
(average yield change, percent)

	-- GCM behind Climate Scenario --			
	Hadley	Canadian	CSIRO	REGCM
Corn Belt	24.02	18.23	6.05	6.58
Great Plains	25.29	17.28	3.67	4.82
Lake States	43.75	53.03	9.34	11.84
Northeast	9.48	-2.07	2.13	4.45
Rocky Mountains	27.74	19.37	18.27	15.04
Pacific Southwest	17.76	21.44	15.58	15.05
Pacific Northwest	65.42	17.01	17.22	18.30
South Central	13.25	-6.06	-0.71	-0.79
Southeast	10.00	-3.16	3.84	2.40
South West	21.66	14.69	3.38	2.60
National	25.14	16.51	6.02	6.46

Red signifies results below mean

Agricultural Sector Irrigation Relevant Findings

**Table 7 Annual welfare changes for agriculture
(million of dollars)**

	Climate scenario name			
	Canad	Hadley	REGCM	CSIRO
	--	Change from	the base	--
U S	4499	5632	345	177
Rest World	1764	2498	147	127
Total	6263	8130	492	304

Agriculture gains

Agricultural Sector Irrigation Relevant Findings

Table 8 Annual consumer and producer welfare changes for 2030 climate, with adaption (million of dollars)

		GCM scenario name			
		Canadian	Hadley	REGCM	CSIRO
United States					
Consumers	Change	3005	9894	1347	1043
Producers	Change	1494	-4262	-1002	-866
	Percent	4.68%	-13.34%	-3.14%	-2.71%
Total	Change	4499	5632	345	177
Rest of the World					
Consumers	Change	2527	4761	398	143
Producers	Change	-763	-2264	-251	-15
Total	Change	1764	2498	147	127

Gain goes to Consumers

Agricultural Sector Irrigation Relevant Findings

- **Consistent losses in the Corn Belt, South Central and Southeast**
- **Mixed but largely negative results in the Southwest**
- **Positive results in the Pacific Northwest**
- **Mixed but mostly positive results in the Great Plains, Northeast, Pacific Southwest**
- **Mixed results in the Lake States, and the Rocky Mountains.**

A Study of the Effects of Climatic Change on the Texas Edwards Aquifer Region

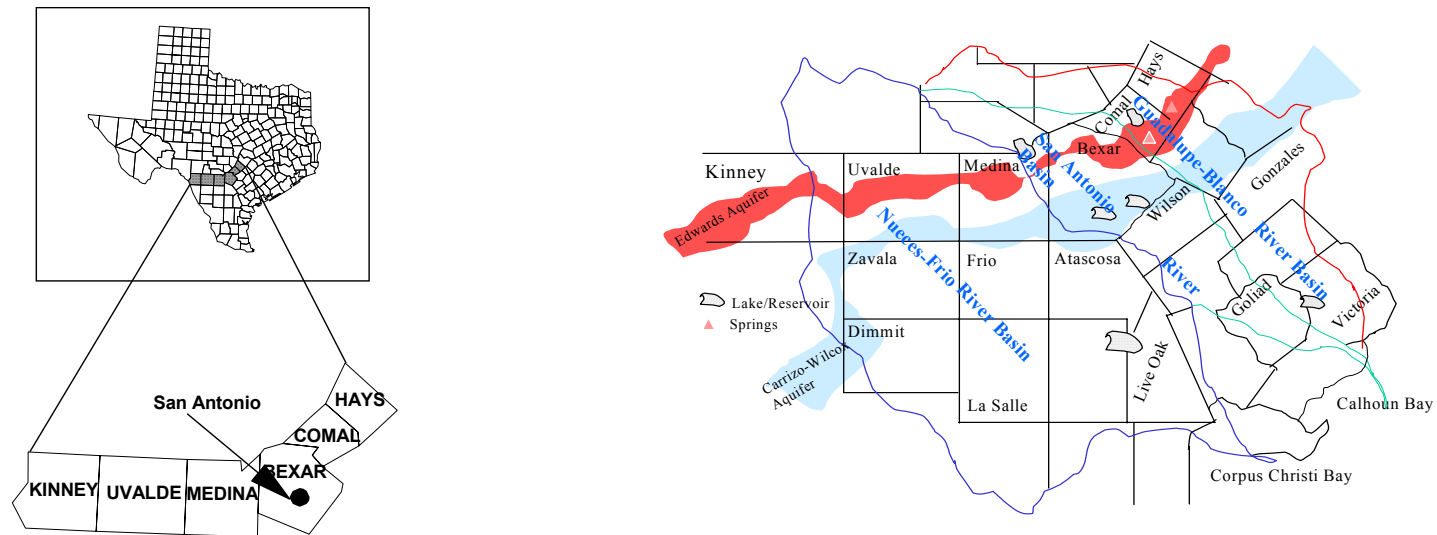


Figure Study Area By Texas Counties

Chen, C.C., D. Gillig, and B.A. McCarl, "Effects of Climatic Change on a Water Dependent Regional Economy: A Study of the Texas Edwards Aquifer," Climatic Change, 49, 397-409, 2001.

Effects on Regional Climate from GCMs

Use data for 2030 and 2090

Canadian Climate Center Model (CCC)

Hadley Climate Center Model (HAD)

Average changes for the 10 year periods

Climate Change Scenario	Temperature (°F)	Precipitation (Inches)
HAD 2030	3.20	-4.10
HAD 2090	9.01	-0.78
CCC 2030	5.41	-14.36
CCC 2090	14.61	-4.56

Effects on Water based on GCMs

Results for EA Recharge Prediction

(% change from the BASE)	Hadley		Canadian	
Recharge in Drought Years	-20.59	-	-29.65	
Recharge in Normal Years	-19.68	-	-28.99	-
Recharge in Wet Years	-23.64	-	-34.42	-

Municipal Demand

Forecasted that climate change will increase municipal water demand by 1.5% (HAD) to 3.5% (CCC).

Climate Change Implications

Strongest effects fall on springflow and the Ag sector

Shifts in the sectoral water use share from Ag to M&I

Welfare loss

Decrease in M&I surplus

Farm income falls 16-30% under the 2030 scenario and 30-45% under the 2090 scenario.

Value of water use permits increases by 5-24%.

Decrease in Comal springflows by 10-16% under the 2030 scenarios and by 20-24% under the 2090 scenarios

endangered species

Table 2. EA Regional Results under Alternative Climate Change Scenarios

Variable	Units	Base	Climate Scenario			
			HAD2030	HAD2090	CCC2030	CCC2090
			----- % change from Base Scenario -----			
Ag Water Use	1000 af	150.05	-0.89	-2.4	-1.35	-4.15
M&I Water Use	1000 af	249.72	0.63	1.54	0.9	2.59
Total Water Use	1000 af	399.77	0.06	0.06	0.06	0.06
Net AG Income	1000 \$	11391	-15.85	-30.34	-29.41	-44.97
Net M&I Surplus	1000 \$	337657	-0.2	-0.58	-0.36	-0.92
Authority Surplus	1000 \$	6644	3.76	12.73	7.07	21.6
Net Total Welfare	1000 \$	355692	-0.64	-1.3	-1.16	-1.93
Comal Flow	1000 af	379.5	-9.95	-20.15	-16.62	-24.15
San Marcos Flow	1000 af	92.8	-5.07	-10.09	-8.3	-12.06

Maintaining Environmental Services

Pumping level to keep springflows at the BASE

⇒ decreases 35,000 to 50,000 af under the 2030 scenarios

⇒ decreases 55,000 to 80,000 af under the 2090 scenarios

Agricultural and M&I water use reduction

Substantial economic costs: **an additional cost of \$0.5 to \$2 million per year**

Increase in EA authority surplus or rents to water right holders

» Regional environmental preservation becomes more costly

Other U.S. related water studies and findings

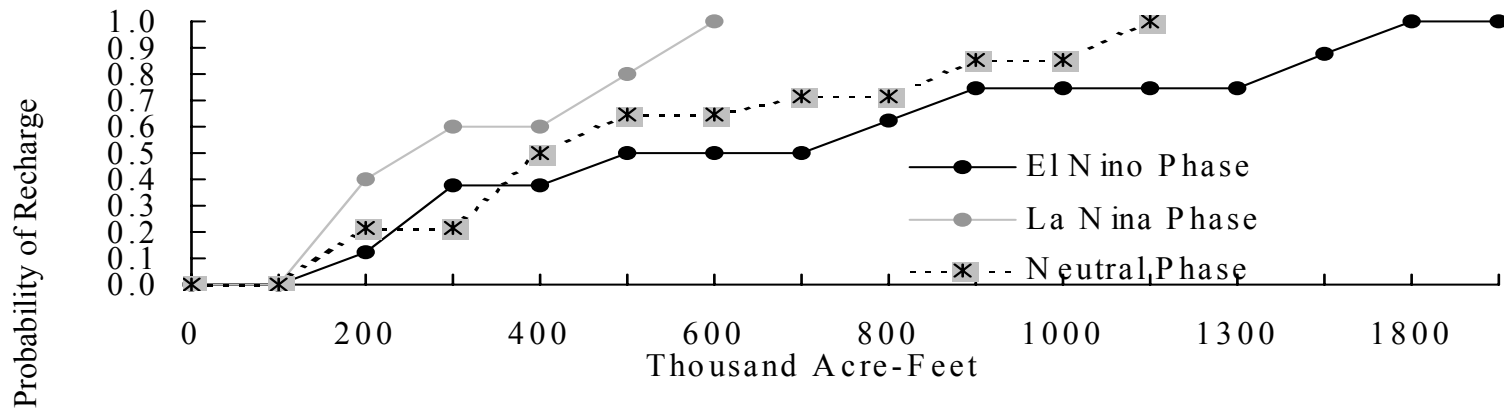
Basic premise – Timmermann et al suggest climatic change will alter ENSO frequency. This would have agricultural economic influences. EL Nino and La Nina increase in probability, Neutral decreases. Strength increases

According to Timmermann et al, the probability of ENSO event occurrence will shift

	From Today	To under IPCC - IS92a
El Nino	0.238	0.351
La Nina	0.250	0.310
Neutral	0.512	0.351

with stronger events
Chen, C.C., B.A. McCarl & R.M. Adams, Economic implications of potential climate change induced ENSO frequency and strength shifts, *Clim. Change*, **49**, 147-159 (2001).

Other U.S. related water studies and findings



Edwards is vulnerable note much less recharge under La Nina

Other U.S. related water studies and findings

USNA Extreme Event

Timmerman et al's increased frequency of ENSO caused an average annual loss of \$323 million

When both frequency and strength shifted the loss increased to a \$1.008 billion.

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Chen, C.C., B.A. McCarl & R.M. Adams, Economic implications of potential climate change induced ENSO frequency and strength shifts, *Clim. Change*, **49**, 147-159 (2001).

Concluding Thoughts

Texas is vulnerable

Less gains from climate change

Water

La Nina sensitivity

Agriculture in future less profitable than today?

Other things I did not show

Less land use

Northeast shift

For more info see web site

<http://agecon2.tamu.edu/people/faculty/mccarl-bruce/papers.htm>