Climate Change, Texas Water, Agriculture and the Environment: An Economic Investigation

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Theme

Theme

Climate Change + **Emissions** + **Water** = **Texas Risk**

Plan of presentation

Sources of Risk

Manifestation

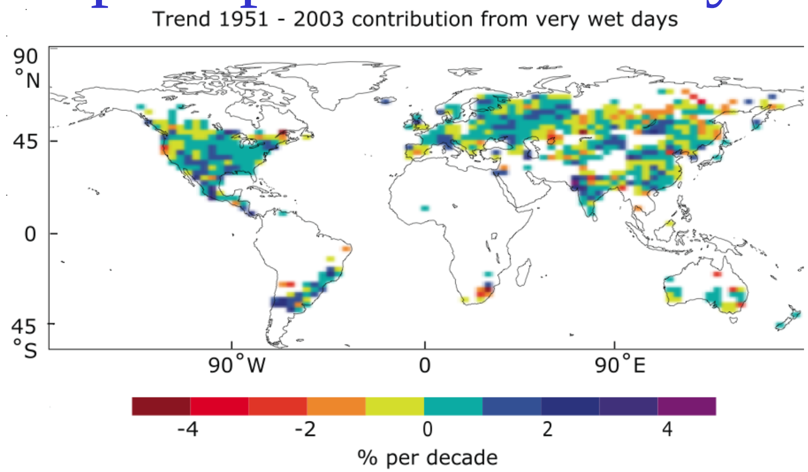
What is Water in this presentation

1) Ground
    1) Stock
    2) Recharge
2) Surface/Precipitation
3) Soil moisture
4) Sea level

Will mention all but sea level

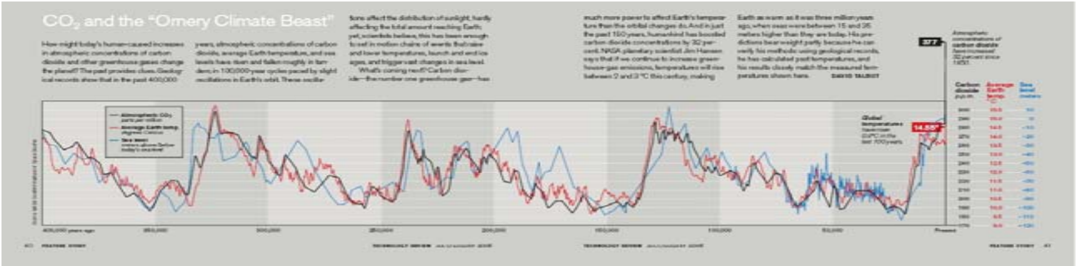
Sources of Risk -- As observed and projected and probably covered by others

1) Hotter climate
2) Altered precipitation amount
3) Altered precipitation intensity

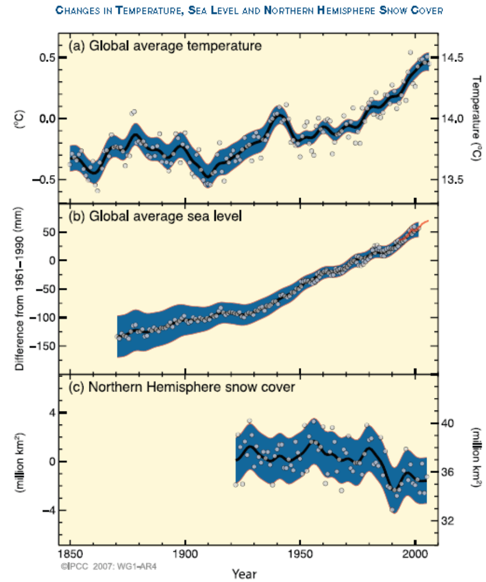


http://ipcc-wg1.ucar.edu/wg1/Figures/AR4WG1_Ch03-Figs_2007-10-23.ppt#296,40,Figure 3.39

4) Higher sea levels



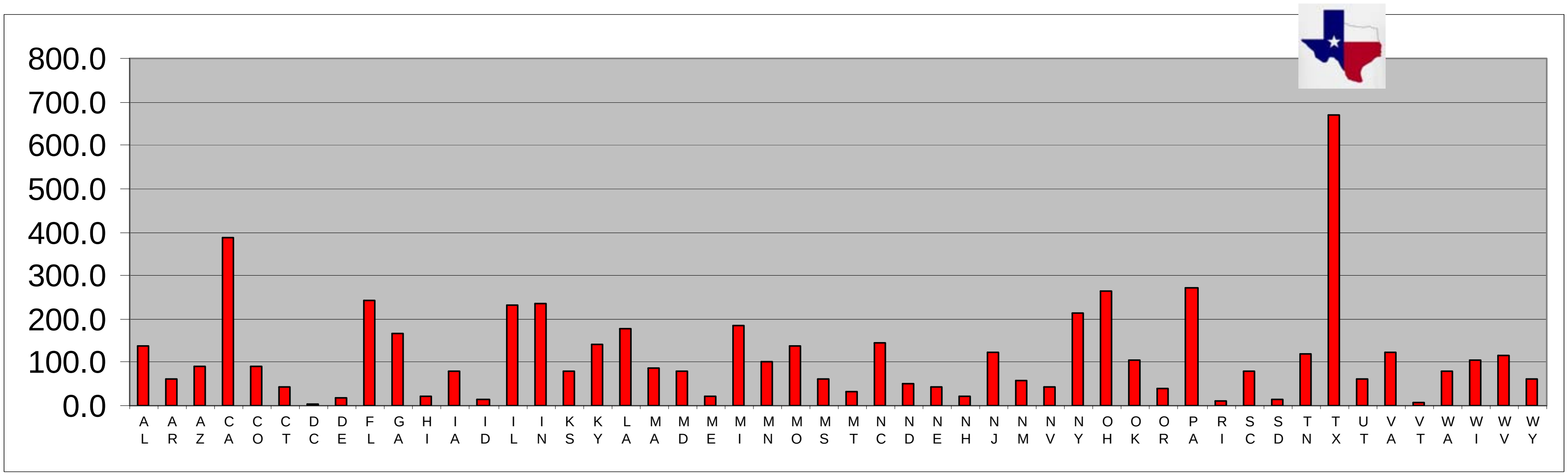
http://www.technologyreview.com/articlefiles/climatechart.pdf



Source : Intergovernmental Panel on Climate Change. IPCC Fourth Assessment Report WGI http://ipcc-

Sources of Risk - as observed and projected
As perhaps covered by others

5) Pests like hotter conditions
6) Soil moisture loss is a non linear function of temperature
7) GHG and climate change link
8) Texas is largest GHG emitter



Manifestations of Risk

1) Greater plant water needs
2) Greater city water demands
3) Less fresh surface water
4) More water in infrequent events
5) More pests
6) Less grass
7) Suitability for cattle
8) Northward crop migrations
9) Diminished water quality
10) Inundated facilities
11) GHG Emissions
12) Higher priced energy

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

Agricultural Sector Water Relevant Findings

I have done number of studies on climate change and water issues. I will discuss 4

1. Core national assessment
2. Regional Edwards Aquifer Study
3. EL Nino extreme events frequency change
4. Texas Assessment for book by North et al

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.

McCarl, B.A., Climate Change and Texas Agriculture, update of book in Impact of Global Warming on Texas, edited by Gerald R. North and others, forthcoming, 2008.

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

Texas Agricultural Sector Findings

	Base	Canadian	Hadley
Producer Net Income (million $)	4757	4707	4253
Index Numbers			
Production			
AllFarmProd	100.00	90.78	96.54
AllCrops	100.00	90.70	96.46
AllLivestock	100.00	90.15	96.00
Price			
AllFarmProd	100.00	101.61	93.12
AllCrops	100.00	92.85	91.10
AllLivestock	100.00	107.13	94.56
Calves in feedlots	8095	7000	7471
Total Broilers	596066	488384	542917
Acres cropped	1267426	985952	984254
Irrigation water use	5831	5885	5500

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

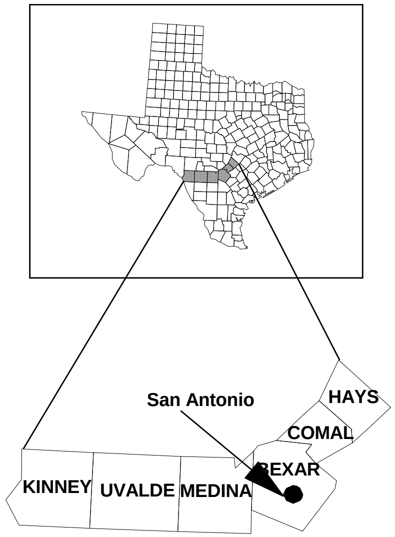
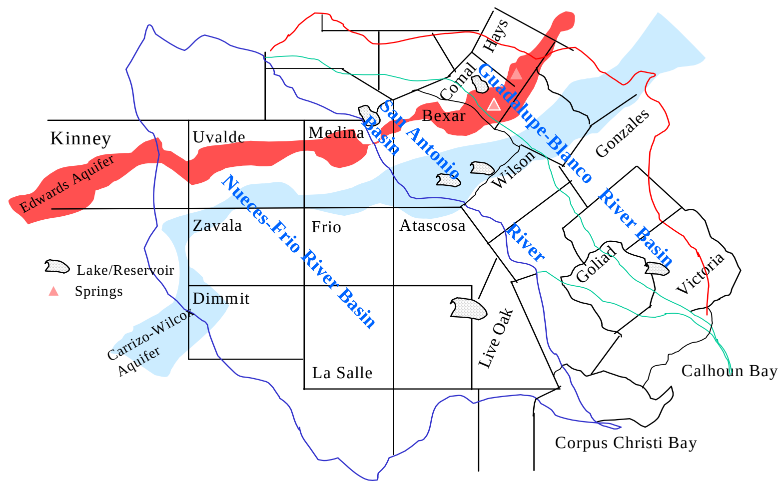


Figure Study Area By Texas Counties



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 (^0F)	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

Forecast is 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 form 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

			Climate Scenario			
			HAD2030	HAD2090	CCC2030	CCC2090
Variable	Units	Base	----------- % 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

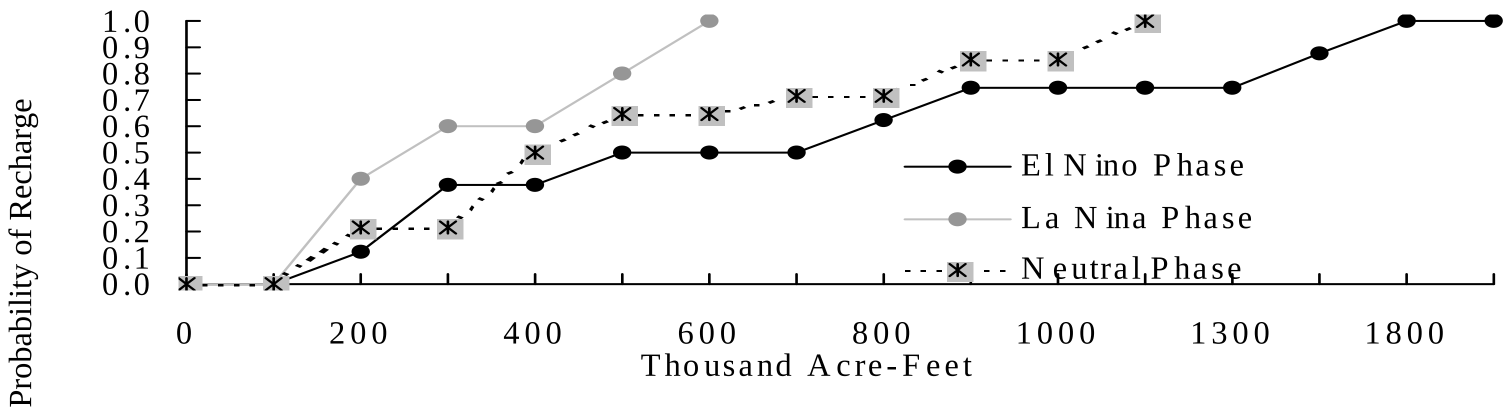
Basic premise – Timmermann et al suggest climatic change will alter ENSO frequency. This would have agricultural economic influences. EL Nino and La Nina increase in probability, Nuetral decreases. Strength increases

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

	From Today	To under IPPC - 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).

Inevitability of Adaptation

Characteristics of stabilization scenarios

Stabilization level (ppm CO_2-eq)	Global mean temp. increase at equilibrium (°C)	Year CO2 needs to peak	Year CO2 emissions back at 2000 level	Reduction in 2050 CO2 emissions compared to 2000
445 – 490	2.0 – 2.4	2000 - 2015	2000- 2030	-85 to -50
490 – 535	2.4 – 2.8	2000 - 2020	2000- 2040	-60 to -30
535 – 590	2.8 – 3.2	2010 - 2030	2020- 2060	-30 to +5
590 – 710	3.2 – 4.0	2020 - 2060	2050- 2100	+10 to +60
710 – 855	4.0 – 4.9	2050 - 2080		+25 to +85
855 – 1130	4.9 – 6.1	2060 - 2090		+90 to +140

- Mitigation efforts over the next two to three decades will have a large impact on opportunities to achieve lower stabilization levels

***IPCC WGIII Table SPM.5**: Characteristics of post-TAR stabilization scenarios WG3 [Table TS 2, 3.10], SPM p.23*

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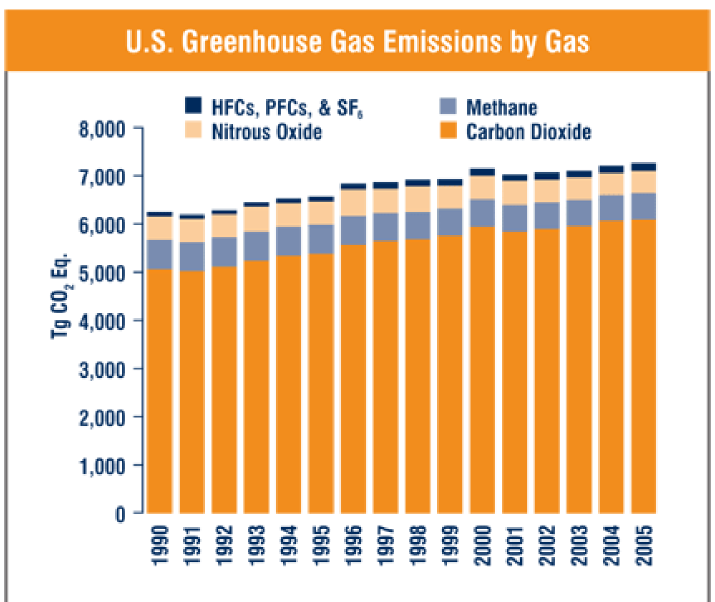

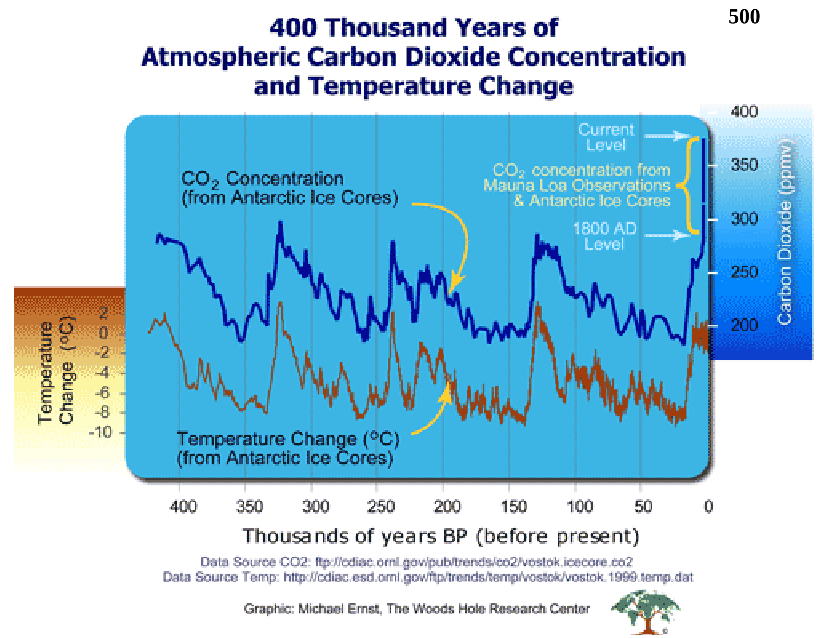

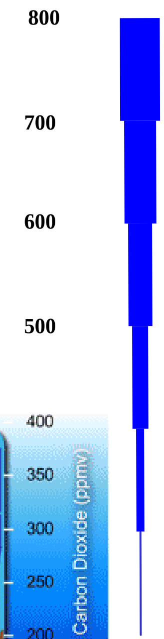

Concluding Thoughts

Texas is at risk

- **Losses gains from climate change**
- **Water**
- **La Nina sensitivity**
- **Agriculture in future less profitable than today?**
- **Mitigation**
- **Sea level**

Will we consider this in water and agricultural planning?

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