Climate Change Effects on the Southern High Plains

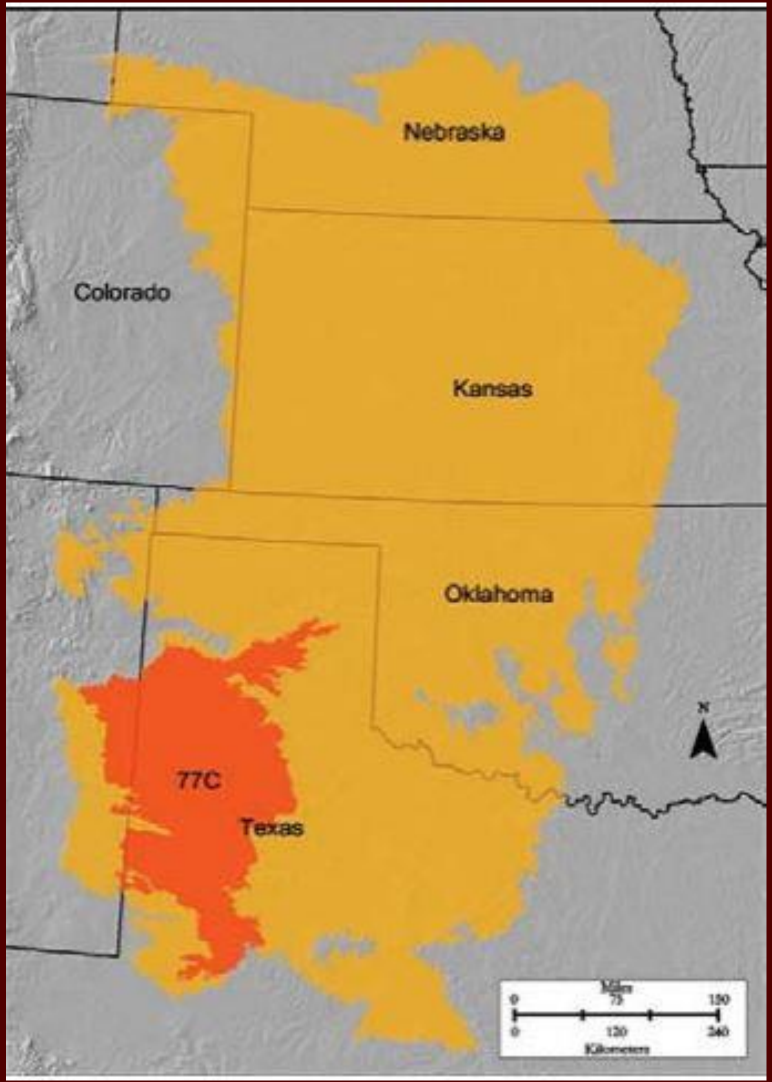
Christopher J. Cobos

AGEC 677

February 28th, 2023

TEXAS A&M AGRILIFE

The Southern High Plains

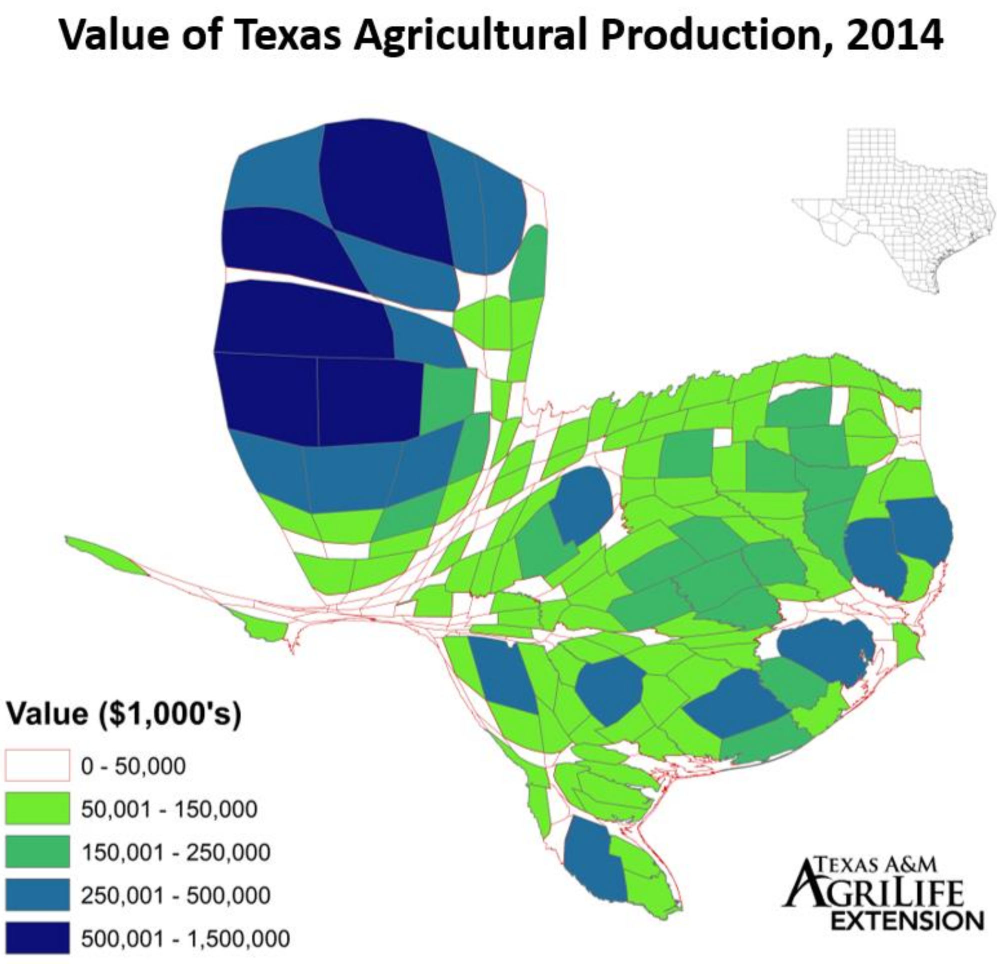


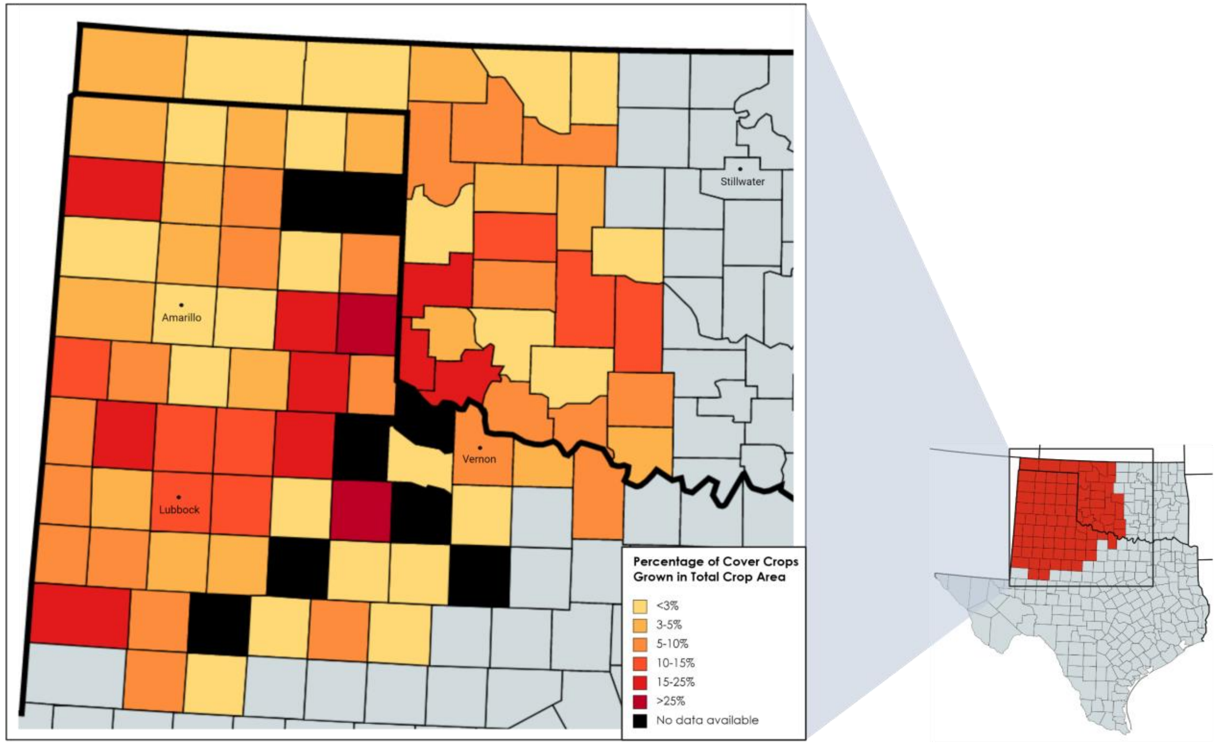
"Each new generation tends to forget – until it confronts the sobering reality – *that dryness has always been the normal condition in the western half of the state. Wet years have been the exceptions*…Traditionally it has taken a strong-willed individualistic breed to live west of [the 98th meridian], especially when hat living is tied closely to the soil, as is the case with the rancher and the farmer."

-Elmer Kelton

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296.

Agricultural Production





Conservation management:

- Cover cropping – 7.5%
- Reduced tillage – 54.4%

Values from 2017 Census of Agriculture

Regenerative agriculture (#RegenAg)

Sustainable agricultural intensification and enhancement using regenerative agricultural practices

USDA Award Number: 2021-68012-35897

Our project goal is to intensify agricultural production in an environmentally sustainable manner that enhances the agronomic, economic, and community resiliency in the Southern Great Plains.

Collaborators -

Texas Water Resources Institute *make every drop count* · Texas A&M AgriLife Research · Texas A&M AgriLife Extension · ATM · OSU · T · WT · Soil Health Institute · Kansas State University

Climate-smart agriculture in Texas

Climate-smart cotton - $30 million

Climate-smart cotton through a sustainable and innovative supply chain approach

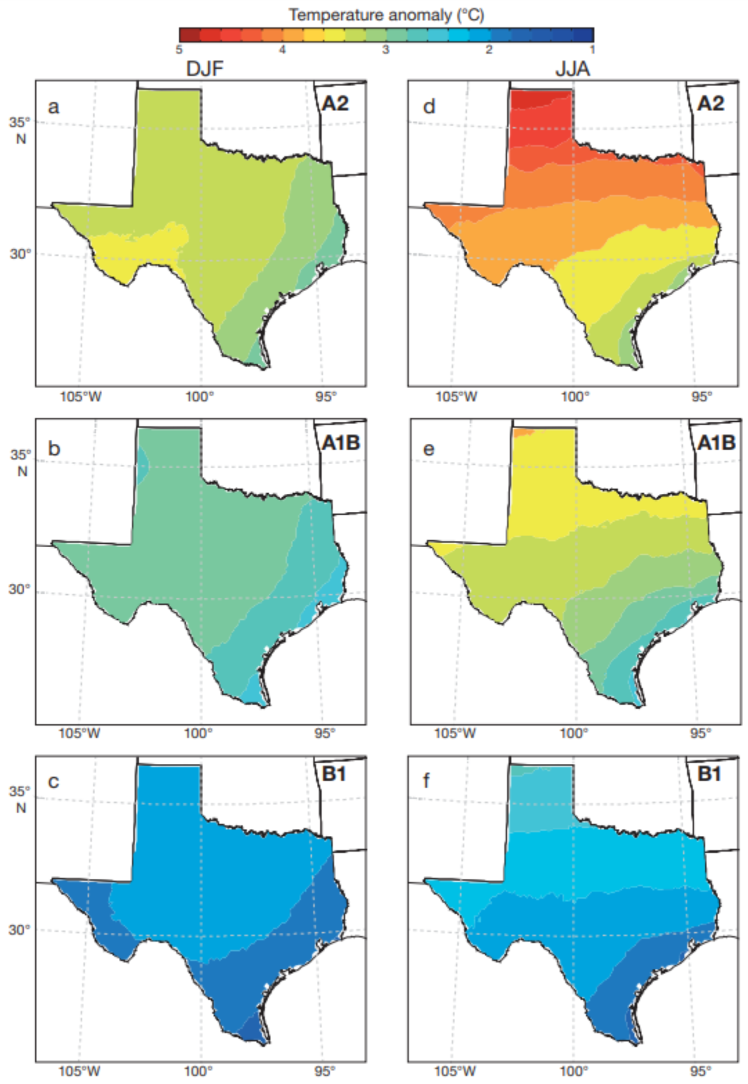
Collaborators: Katie Lewis, Emi Kimura, Will Keeling, Josh McGinty, and the University of Arkansas Department of Agriculture

Climate-smart sorghum - $65 million

Conservation of natural and sustainable environmental resources with verified engagement (CONSERVE)

Collaborators: Katie Lewis, Jourdan Bell, Paul DeLaune, Kansas State University, and Oklahoma State University

Projected Effects



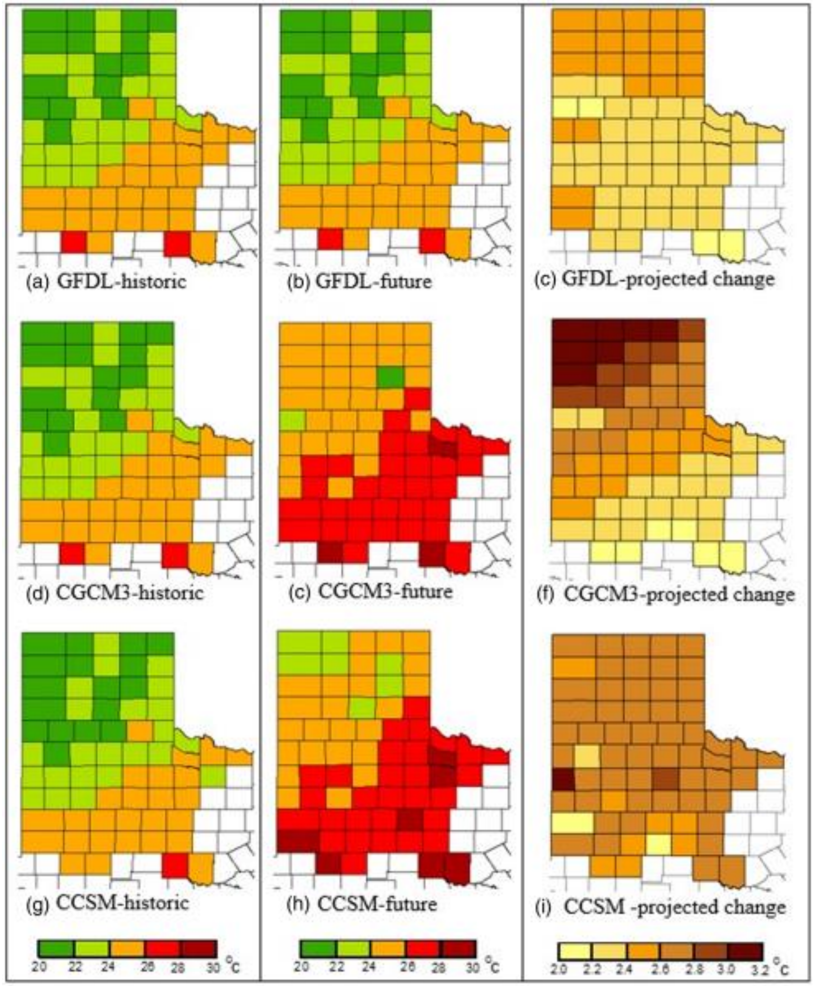
Projected (a–c) winter (DJF: Dec-Jan-Feb) and (d–f) summer (JJA: Jun-Jul-Aug) surface air temperature changes (°C) between 2070–2099 and 1971–2000 under the 3 emissions scenarios over Texas

- WCRP CMIP3 projections used for 3 IPCC SRES emissions scenarios
- Increased surface air temperature by 2100; **4.8°C for A2, 3.6°C for A1B, and 2.2°C for B1**
- Precipitation and surface air temperatures are negatively correlated
- Regional variability

Nakicenovic, Nebojsa, Joseph Alcamo, Gerald Davis, B. de Vries, Joergen Fenhann, Stuart Gaffin, Kenneth Gregory et al. "Special report on emissions scenarios." (2000).

Jiang, X., and Z.L. Yang. 2012. Projected changes of temperature and precipitation in Texas from downscaled global climate models. Clim Res. 53:229-244.

Projected Effects

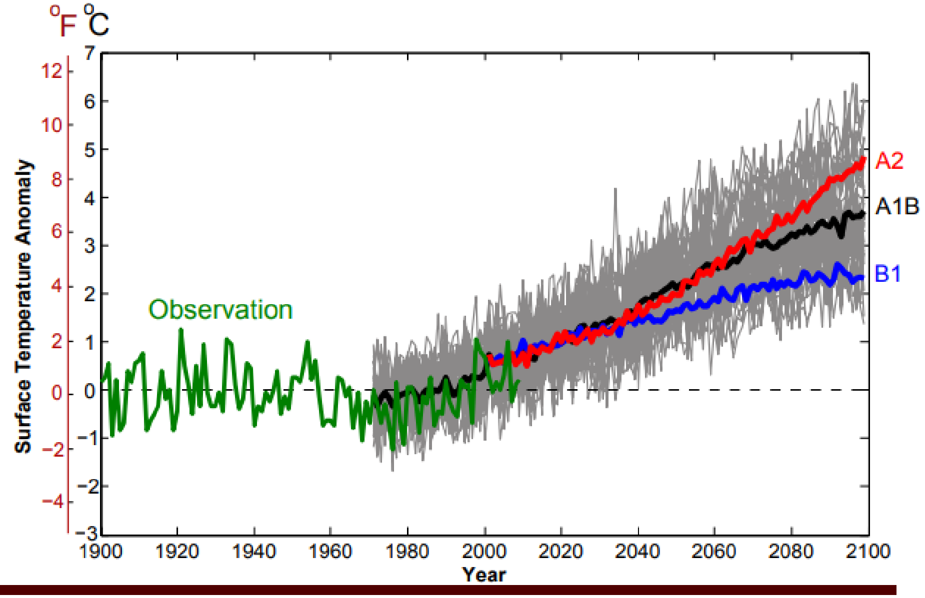


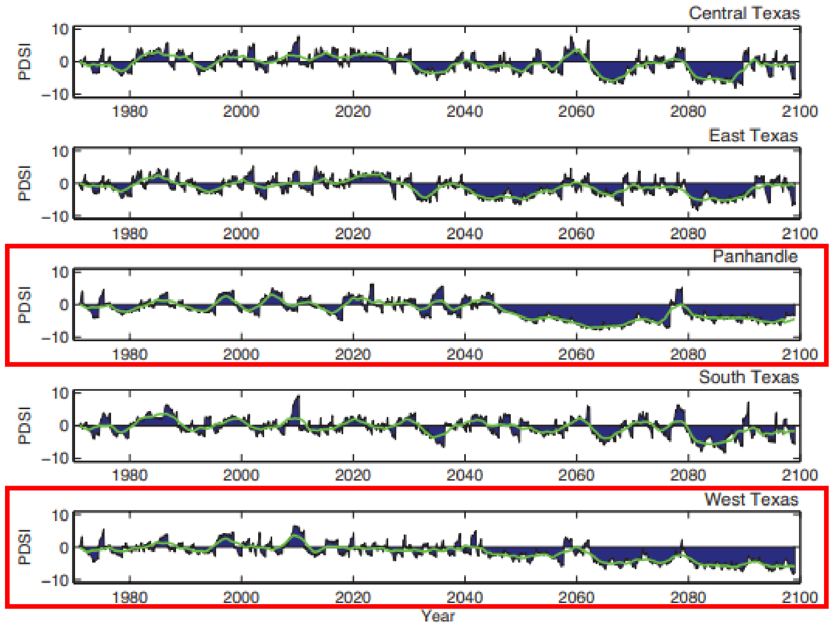
Spatial variability in maximum temperature (TMAX) in the Texas Plains region under historic (1971–2000; left panel) and future (2041–2070; middle panel) climate scenarios and projected change in TMAX (future-historic; right panel) as predicted by three regional climate models: Regional Climate Model Version3–Geophysical Fluid Dynamics Laboratory (RCM3-GFDL), RCM3-CGCM3 (Regional Climate Model Version3–Third Generation Coupled Global Climate Model), and Canadian Regional Climate Model–Community Climate System Model (CRCM-CCSM). a GFDL-historic. b GFDL-future. c GFDL-projected change. d CGCM3-historic. e CGCM3- future. f CGCM3-projected change. g CCSM-historic. h CCSM-future. i CCSMprojected change

- Three regional climate models used under A2 (high emissions) scenario
- Maximum air temperature projected to increase **2.0-3.2°C** by 2070
- Predicted decline in precipitation for the region within a range of 30 to 127 mm
- Increase in intensity of extreme precipitation events

Modala, N. R., Ale, S., Goldberg, D. W., Olivares, M., Munster, C. L., Rajan, N., & Feagin, R. A. (2017). Climate change projections for the Texas high plains and rolling plains. *Theoretical and Applied Climatology*, *129*, 263-280.

Projected Effects





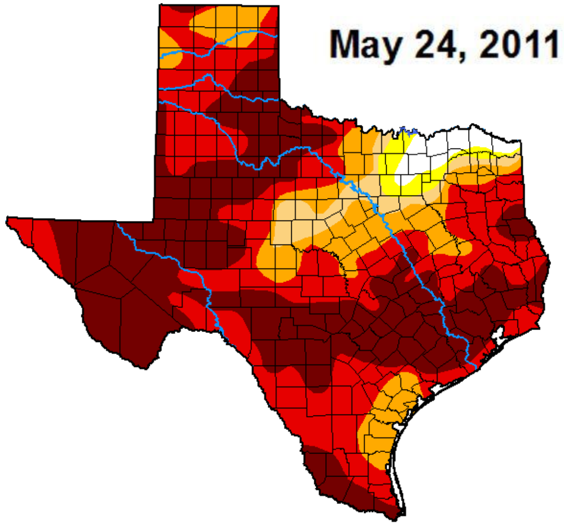
Texas is highly susceptible to global climate change effects

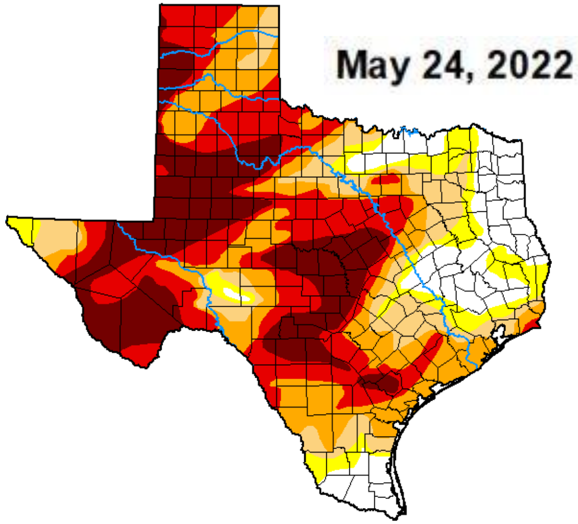
Shift to more arid environments

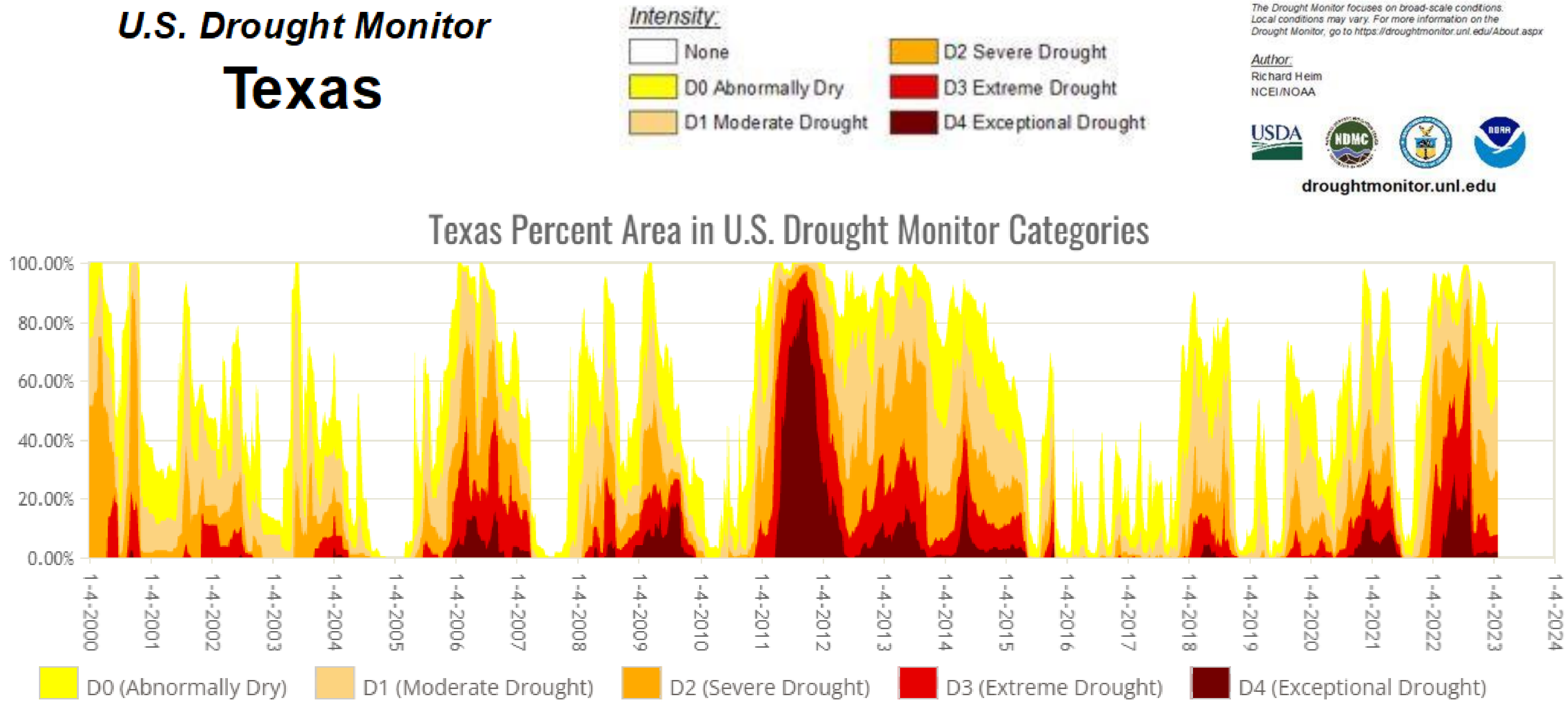
The magnitude, timing, and regional distribution of these changes are uncertain

Banner, J. L., Jackson, C. S., Yang, Z. L., Hayhoe, K., Woodhouse, C., Gulden, L., ... & Castell, R. (2010). Climate change impacts on Texas water: A white paper assessment of the past, present and future and recommendations for action. *Texas Water Journal*, *1*(1), 1-19.

Drought Across the SHP



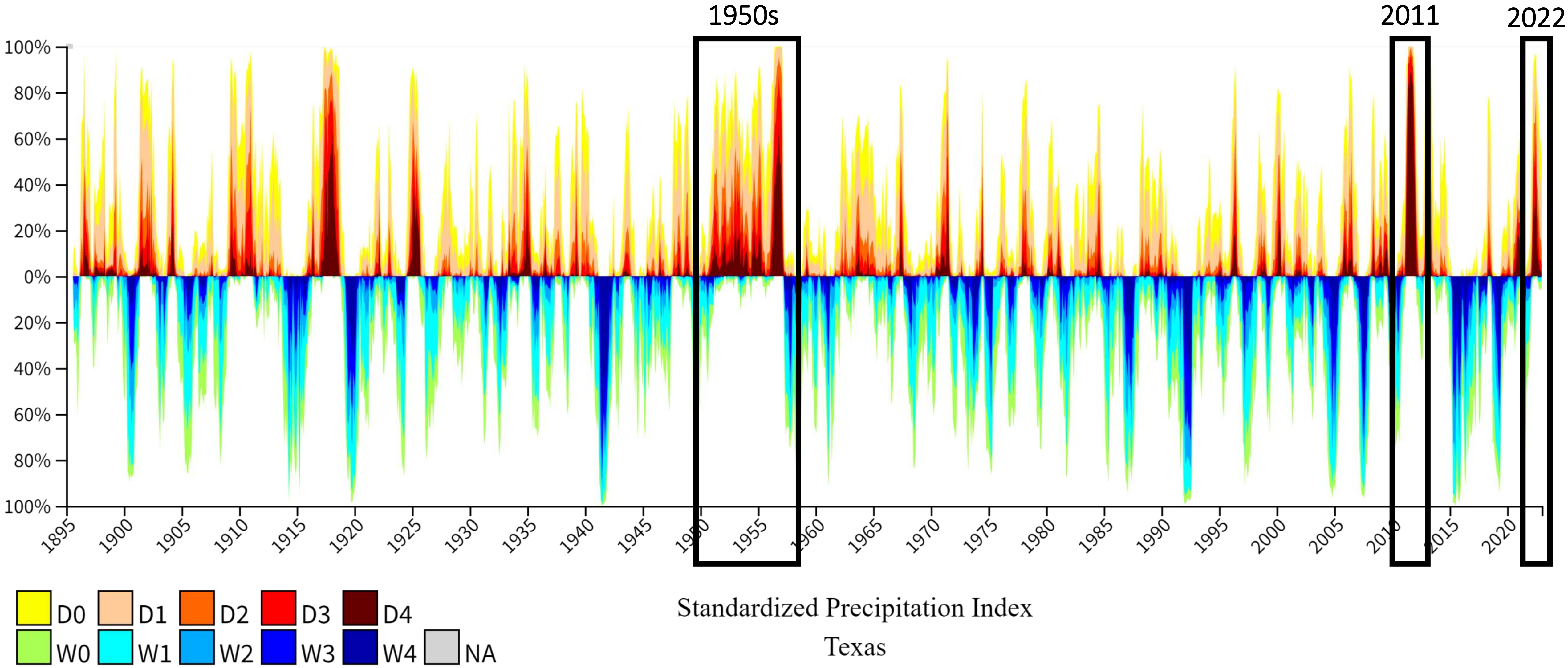




Increase in severe drought events in recent years across the state

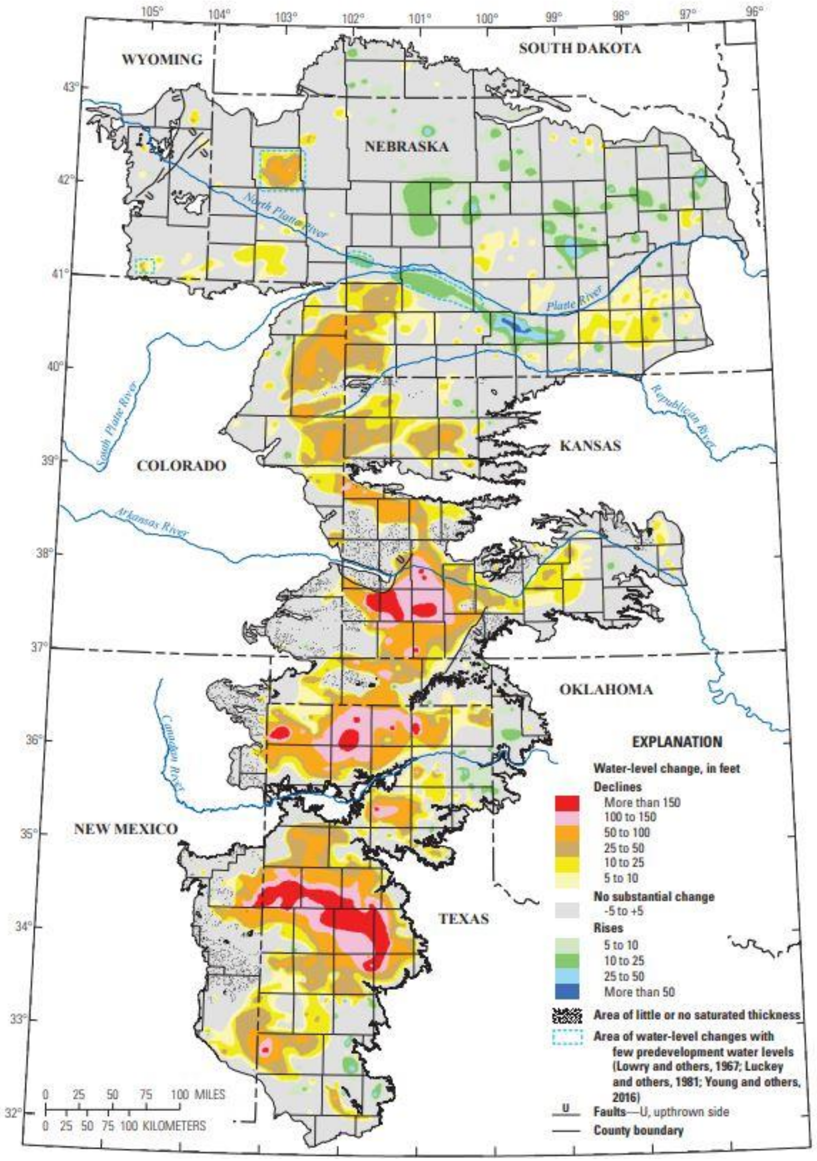
https://droughtmonitor.unl.edu

Drought Across the SHP

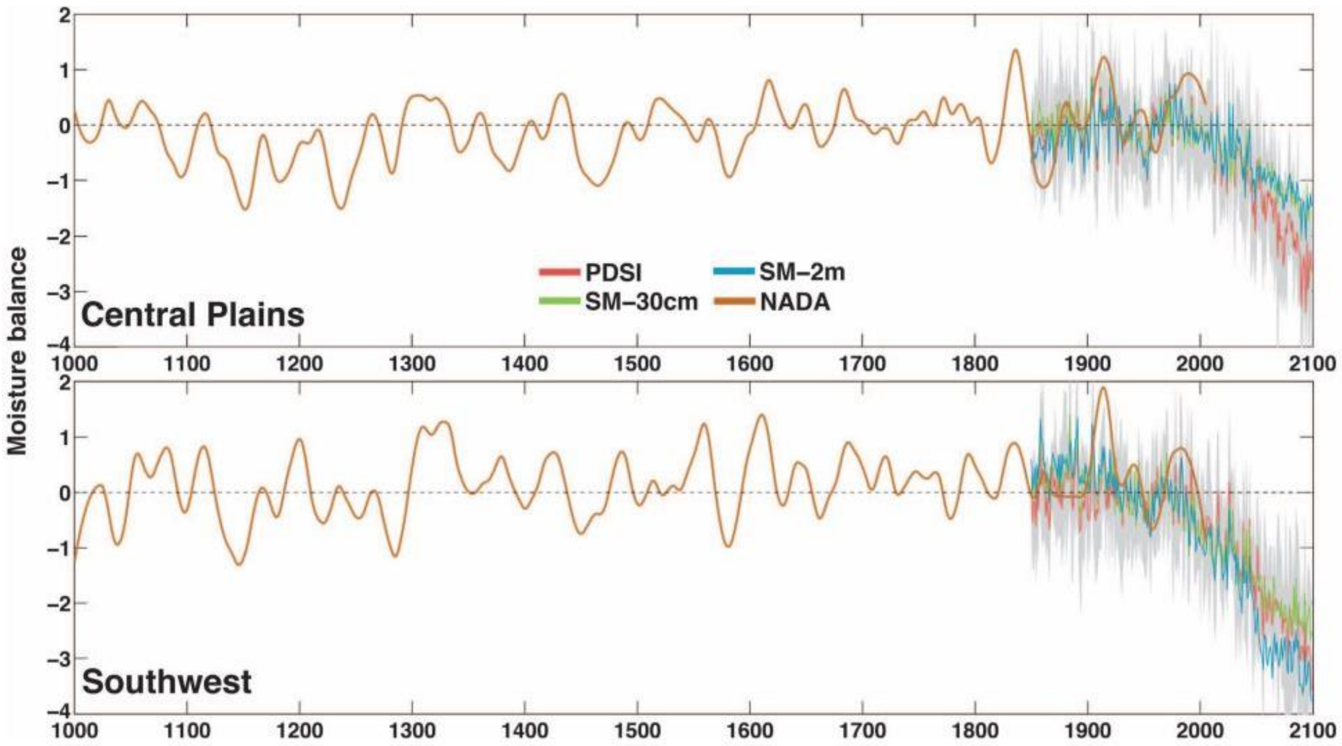


https://droughtmonitor.unl.edu

Dwindling Water Resources



McGuire, V.L., 2017, Water-level and recoverable water in storage changes, High Plains aquifer, predevelopment to 2015 and 2013–15: U.S. Geological Survey Scientific Investigations Report 2017–5040, 14 p., https://doi.org/10.3133/ sir20175040.



Cook, B.I., T.R. Ault, and J.E. Smerdon. 2015. Unprecedented 21st century drought risk in the American Southwest and Central Plains. Sci. Adv. 1:e1400082.

Loss of irrigation capabilities are happening concurrently with increased drought and ET

Extreme Weather Events

Increased amounts of extreme weather events in recent years

Time	Temperature	Dew Point	Humidity	Wind	Wind Speed	Wind Gust	Pressure	Precip.	Condition
11:53 AM	60 °F	55 °F	83 %	S	28 mph	38 mph	26.42 in	0.0 in	Cloudy / Windy
12:53 PM	64 °F	56 °F	75 %	SSW	25 mph	39 mph	26.37 in	0.0 in	Cloudy / Windy
1:00 PM	64 °F	56 °F	75 %	S	28 mph	38 mph	26.36 in	0.0 in	Haze / Windy
1:08 PM	65 °F	56 °F	73 %	S	26 mph	39 mph	26.35 in	0.0 in	Haze / Windy
1:53 PM	70 °F	57 °F	63 %	S	26 mph	38 mph	26.29 in	0.0 in	Fair / Windy
2:53 PM	76 °F	54 °F	46 %	S	33 mph	47 mph	26.21 in	0.0 in	Blowing Dust / Windy
3:53 PM	77 °F	52 °F	42 %	S	40 mph	66 mph	26.13 in	0.0 in	Blowing Dust / Windy
4:53 PM	76 °F	51 °F	42 %	S	38 mph	66 mph	26.11 in	0.0 in	Blowing Dust / Windy
5:53 PM	78 °F	19 °F	11 %	W	47 mph	66 mph	26.13 in	0.0 in	Duststorm / Windy
5:57 PM	74 °F	21 °F	14 %	WNW	49 mph	76 mph	26.14 in	0.0 in	Light Rain / Windy
6:04 PM	63 °F	29 °F	28 %	WNW	55 mph	76 mph	26.16 in	0.0 in	Light Rain / Windy
6:34 PM	57 °F	29 °F	34 %	WNW	58 mph	71 mph	26.21 in	0.0 in	Light Rain / Windy
6:53 PM	55 °F	28 °F	35 %	W	43 mph	63 mph	26.25 in	0.0 in	Light Rain / Windy
7:14 PM	54 °F	27 °F	35 %	W	47 mph	66 mph	26.26 in	0.0 in	Light Rain / Windy
7:40 PM	54 °F	20 °F	26 %	W	47 mph	67 mph	26.27 in	0.0 in	Heavy Duststorm / Wi
7:53 PM	52 °F	22 °F	31 %	WNW	48 mph	72 mph	26.27 in	0.0 in	Blowing Dust / Windy
8:04 PM	51 °F	25 °F	36 %	WNW	45 mph	74 mph	26.29 in	0.0 in	Blowing Dust / Windy
8:22 PM	50 °F	24 °F	36 %	W	41 mph	61 mph	26.30 in	0.0 in	Blowing Dust / Windy
8:41 PM	50 °F	22 °F	33 %	W	43 mph	56 mph	26.32 in	0.0 in	Blowing Dust / Windy
8:53 PM	49 °F	21 °F	33 %	W	38 mph	53 mph	26.33 in	0.0 in	Blowing Dust / Windy
9:53 PM	49 °F	12 °F	23 %	W	43 mph	60 mph	26.36 in	0.0 in	Blowing Dust / Windy
10:44 PM	47 °F	12 °F	24 %	W	33 mph	46 mph	26.37 in	0.0 in	Blowing Dust / Windy
10:53 PM	47 °F	12 °F	24 %	W	40 mph	52 mph	26.37 in	0.0 in	Blowing Dust / Windy
11:53 PM	45 °F	11 °F	25 %	W	37 mph	48 mph	26.39 in	0.0 in	Blowing Dust / Windy

Lubbock, TX – February 26th, 2023

https://www.wunderground.com/history/daily/766c153be1817aba3f28a9ad4be321c1223fab0405d171dcdbc7e4173ef85ac8/yesterday

Hardeman/Wilbarger County, TX; 2022

Photos by Paul “Bart” DeLaune


Lamesa
County Road 17
Seminole Rd


Dawson County, TX; 2021
Adam Springer


Kyle Russell Allen

Lubbock County, TX; 2020

Terry County, TX; 2022

Terry County, TX; 2022

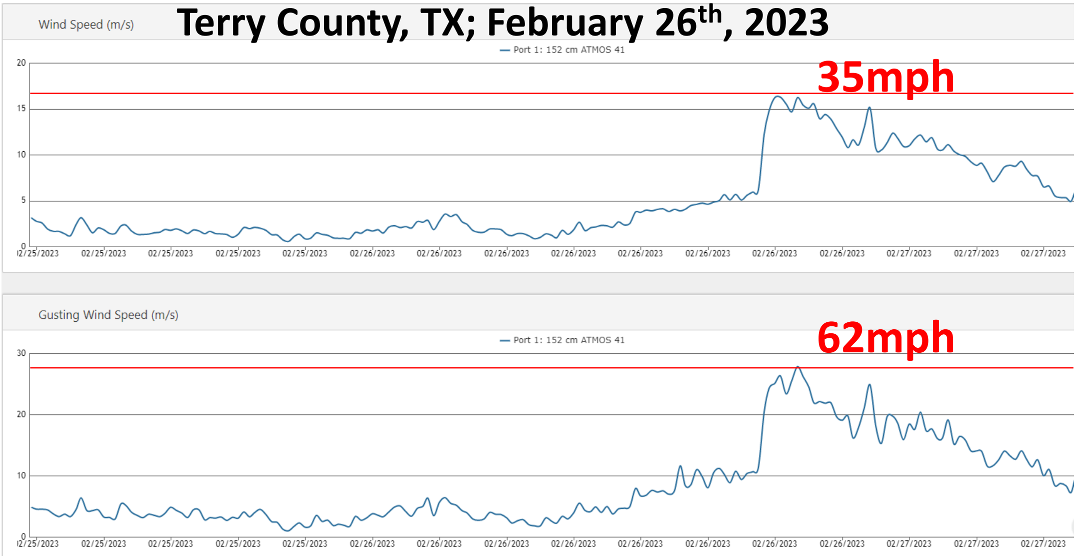
Extreme Weather Events

Terry County, TX; February 20-25, 2023

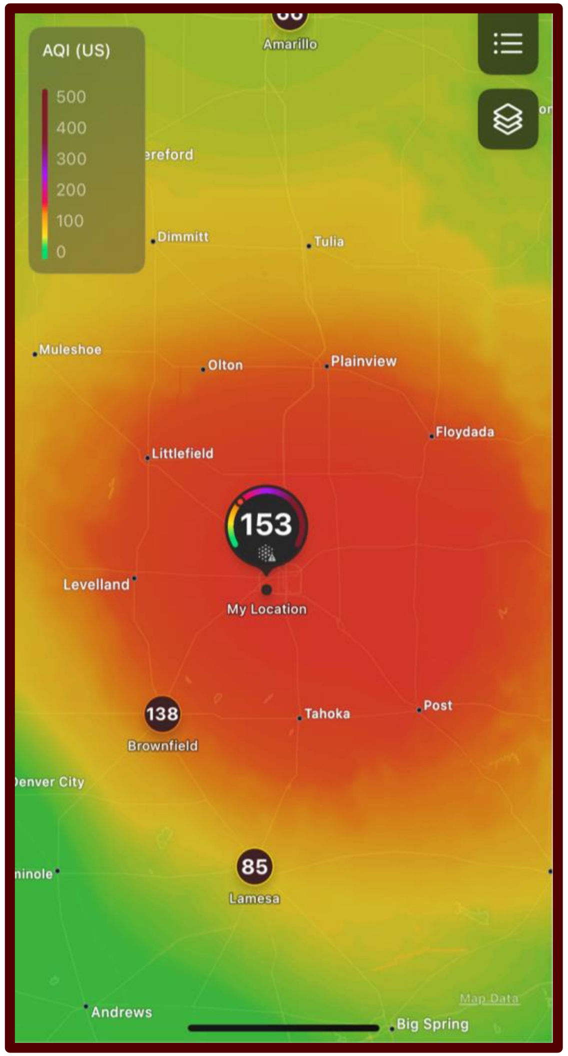
Lubbock County, TX; February 22nd, 2023

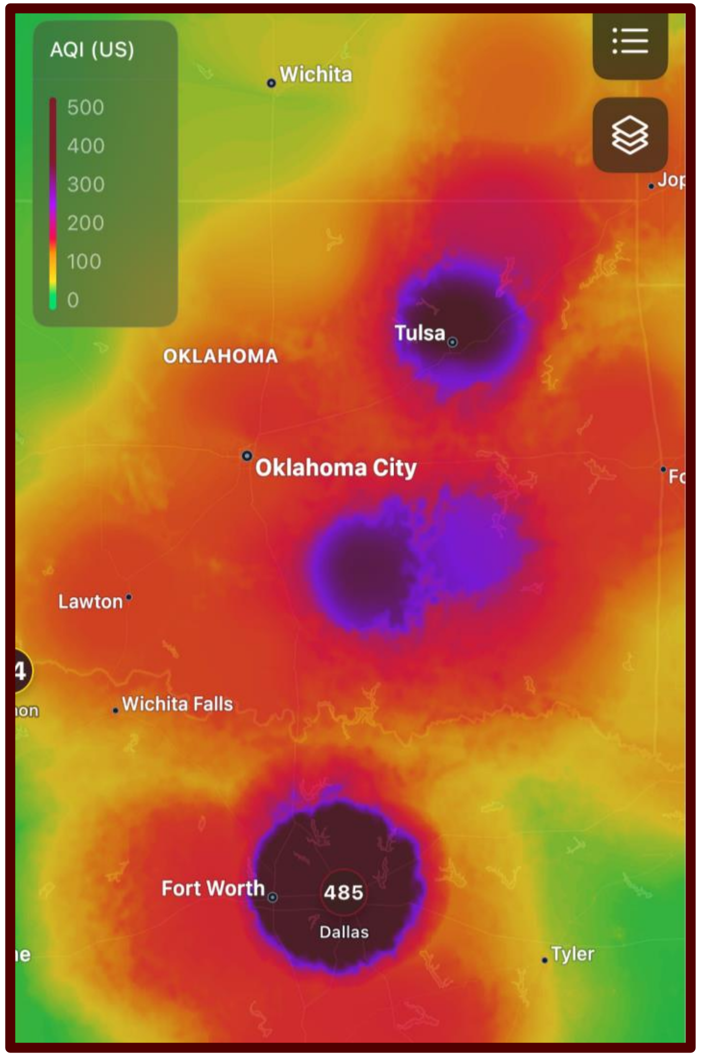
Extreme Weather Events

Terry County, TX; February 26th, 2023



Lubbock County, TX; February 26th, 2023





Air Quality Index – February 27th, 2023

Future of Agricultural Production in SHP

CLIMATE CHANGE AND FUTURE ANALYSIS: IS STATIONARITY DYING?

BRUCE A. MCCARL, XAVIER VILLAVICENCIO, AND XIMING WU

Increased ***climate variability*** has negative impact on yield

Increase in ***precipitation intensity*** has negative impact on yield

Severe drought (lower PDSI) has negative impacts on yield

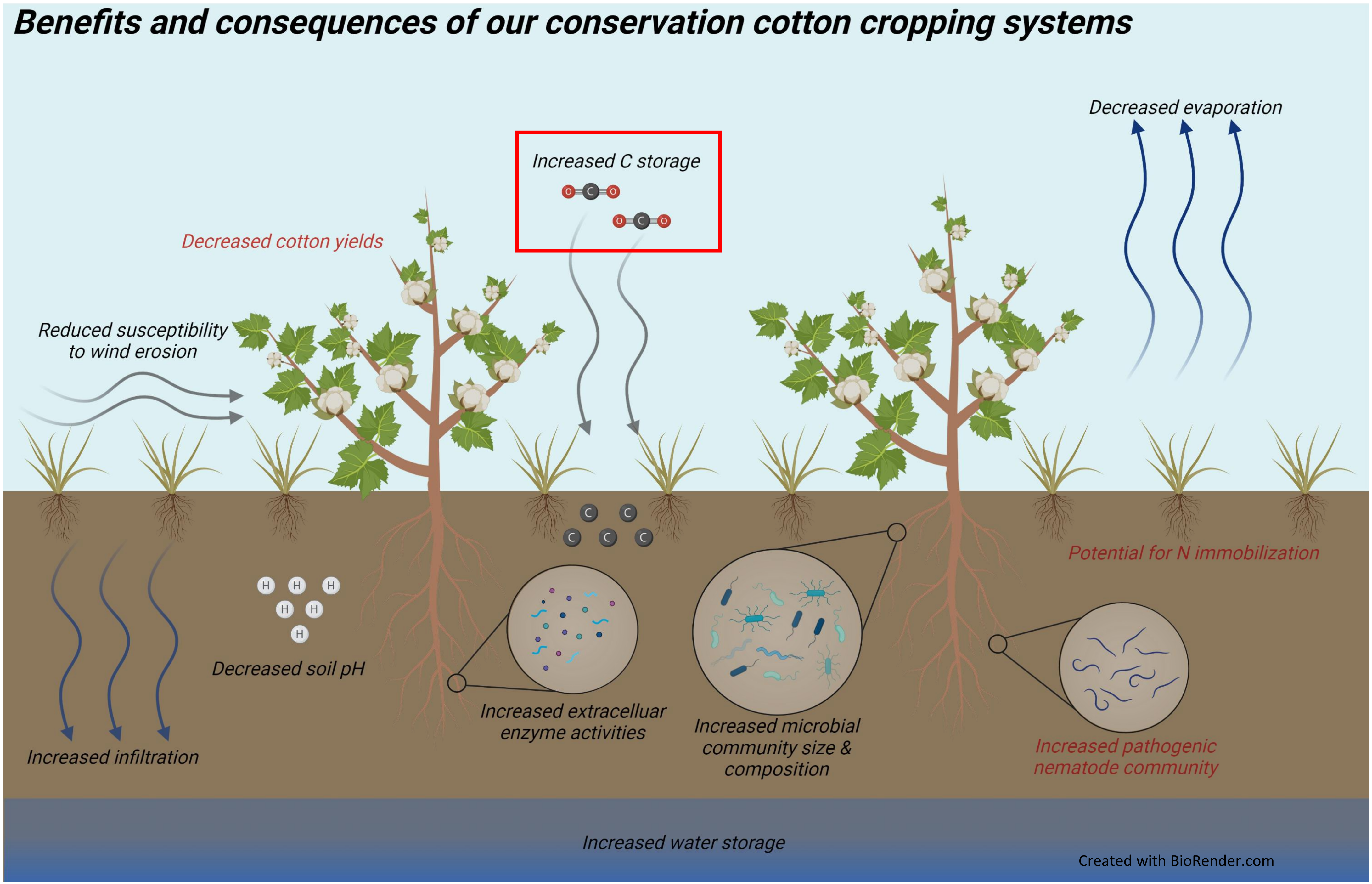
McCarl, B. A., Villavicencio, X., & Wu, X. (2008). Climate change and future analysis: is stationarity dying?. *American Journal of Agricultural Economics*, *90*(5), 1241-1247.

Adaptation:

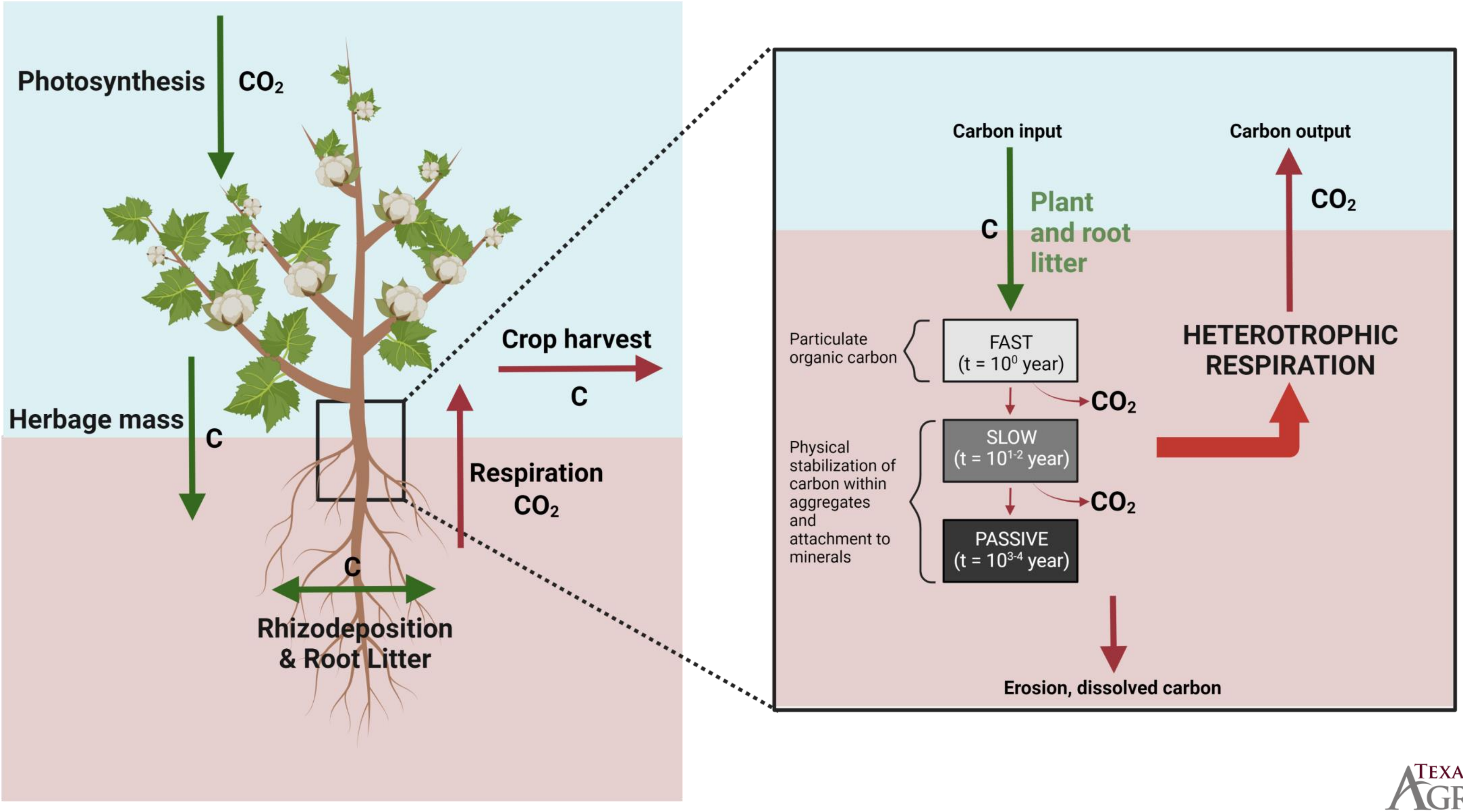
Adjustment in natural or human systems to a *new or changing* environment. Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.

Mitigation:

A human intervention to *reduce the extent of climate change by limiting drivers* (GHGs, reducing incoming radiation, increasing reflectivity ….).


Benefits and consequences of our conservation cotton cropping systems
Decreased evaporation
Increased C storage
Decreased cotton yields
Reduced susceptibility to wind erosion
Potential for N immobilization
Decreased soil pH
Increased extracelluar enzyme activities
Increased microbial community size & composition
Increased pathogenic nematode community
Increased infiltration
Increased water storage
Created with BioRender.com

Measuring Carbon Sequestration Potential



Greenhouse Gas Emission Monitoring

Agriculture and Food

AIMS Agriculture and Food, 4(1): 206–222.
DOI: 10.3934/agrfood.2019.1.206
Received: 31 October 2018
Accepted: 04 March 2019
Published: 15 March 2019

http://www.aimspress.com/journal/agriculture

Research article

Carbon dioxide mitigation potential of conservation agriculture in a semi-arid agricultural region

Mark D. McDonald[1,2,]*, Katie L. Lewis[1,2], Glen L. Ritchie[1,2], Paul B. DeLaune[3], Kenneth D. Casey[4] and Lindsey C. Slaughter[2]

1 Texas A&M AgriLife Research, Texas A&M University, Lubbock, TX, USA
2 Texas Tech University, Lubbock, TX USA
3 Texas A&M AgriLife Research, Vernon, TX, USA
4 Texas A&M AgriLife Research, Amarillo, TX, USA

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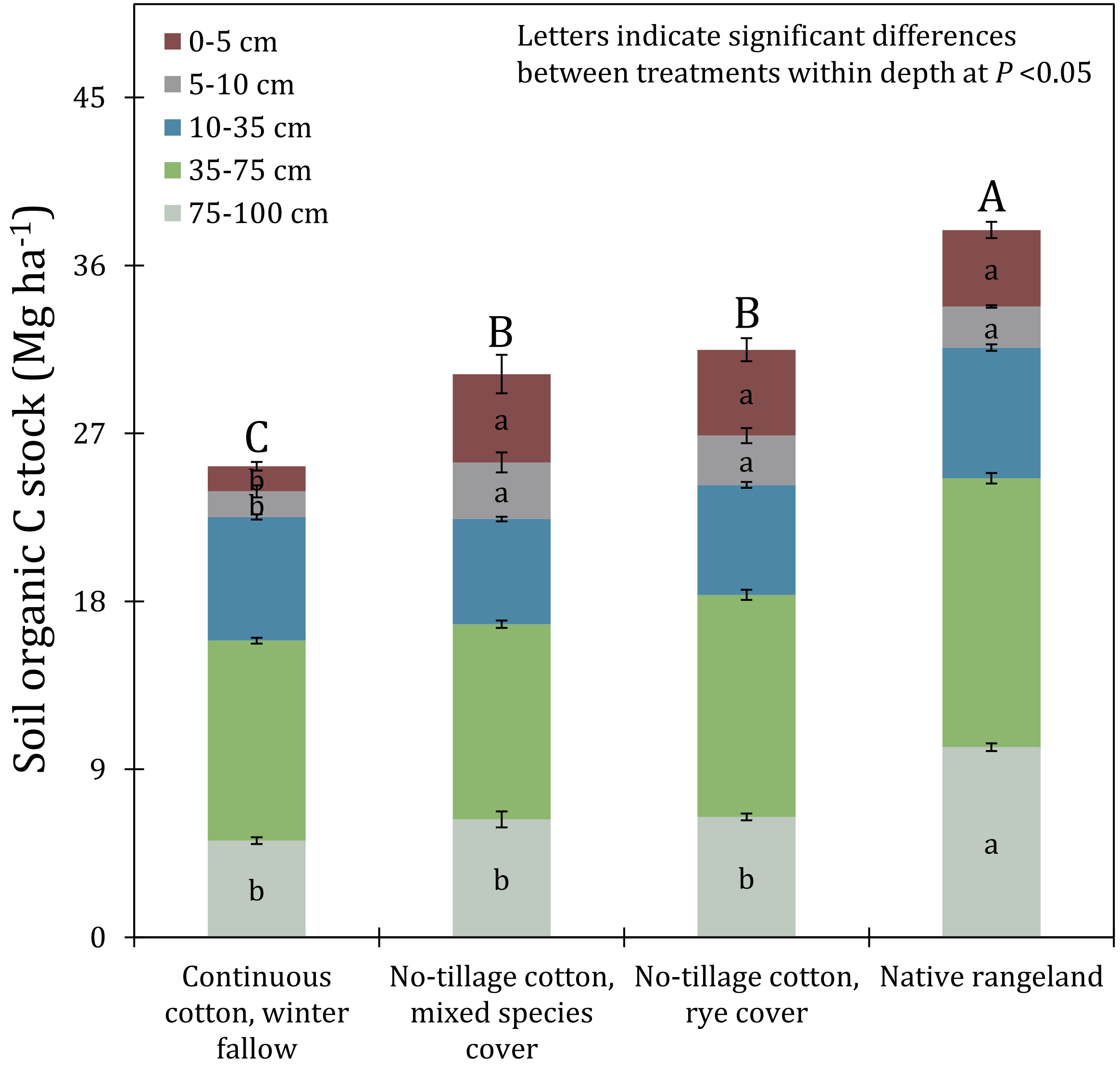
frontiers in Environmental Science

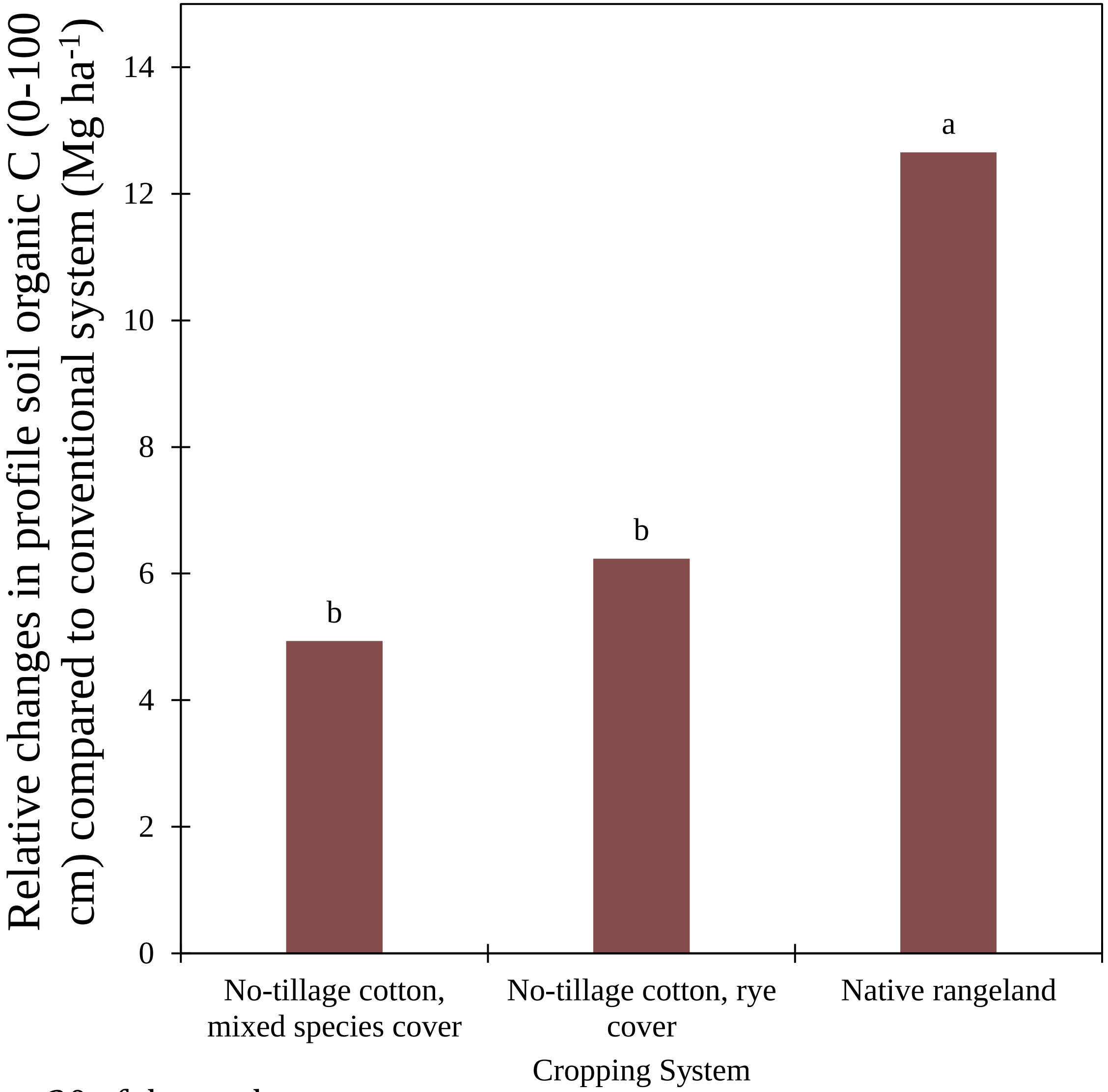
ORIGINAL RESEARCH
published: 11 November 2021
doi: 10.3389/fenvs.2021.702806

Nitrous Oxide Consumption Potential in a Semi-Arid Agricultural System: Effects of Conservation Soil Management and Nitrogen Timing on nosZ Mediated N_2O Consumption

Mark D. McDonald[1], Katie L. Lewis[2], Paul B. DeLaune[3], Thomas W. Boutton[4], Jacob D. Reed[5] and Terry J. Gentry[1]*

Soil Organic Carbon





*Samples collected in year 20 of the study

Carbon and Agriculture

The reality of C sequestration potential in semi-arid agroecosystems

Carbon markets and producers

Complexity of the issue at hand

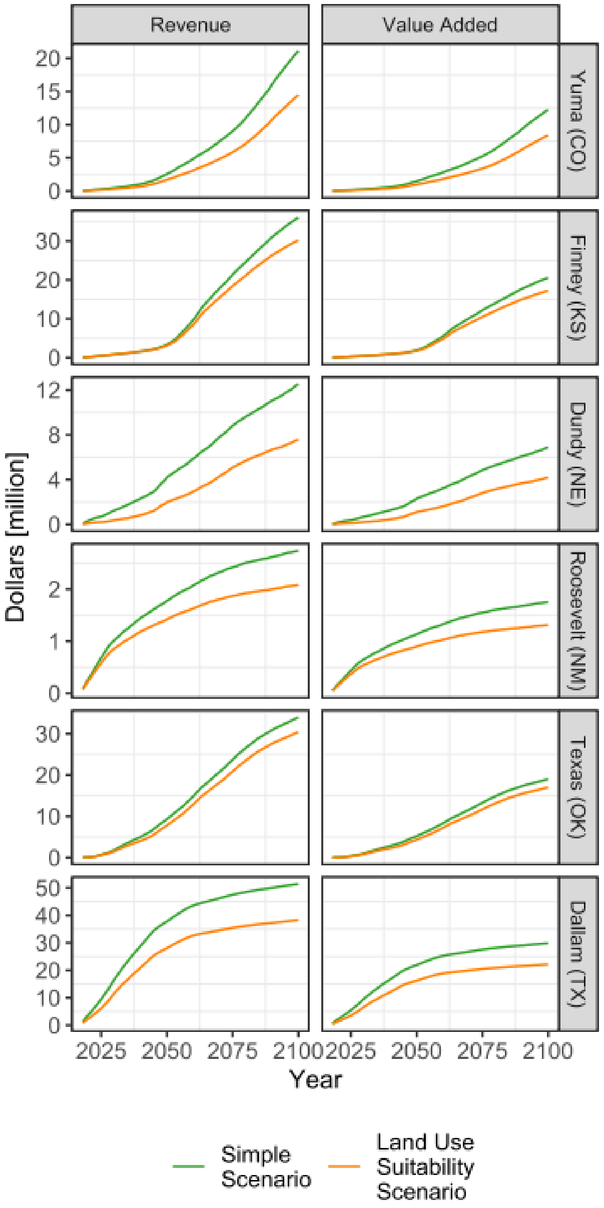
- CO_2 could positively effect yields of C3 crops such as cotton
- The role of technological progress and its impact on yields
- Relationship between drought and atmospheric CO_2 levels on crops

Attavanich, W., & McCarl, B. A. (2011). *The effect of climate change, CO2 fertilization, and crop production technology on crop yields and its economic implications on market outcomes and welfare distribution* (No. 321-2016-10981).

Attavanich, W., & McCarl, B. A. (2014). How is CO 2 affecting yields and technological progress? A statistical analysis. *Climatic change*, *124*, 747-762.

Economic Outlook of the SHP

Land Use Suitability



Ogallala vs. climate change in the SHP

Overestimation of land use suitability for future agricultural production

Overestimation of economic predictions

Showcases importance for immediate implementation to increase future resiliency of agroecosystems

Deines, J.M., Schipanski, M.E., Golden, B., Zipper, S.C., Nozari, S., Rottler, C., Guerrero, B. and Sharda, V., 2020. Transitions from irrigated to dryland agriculture in the Ogallala Aquifer: Land use suitability and regional economic impacts. *Agricultural Water Management*, *233*, p.106061.

Dryland Production

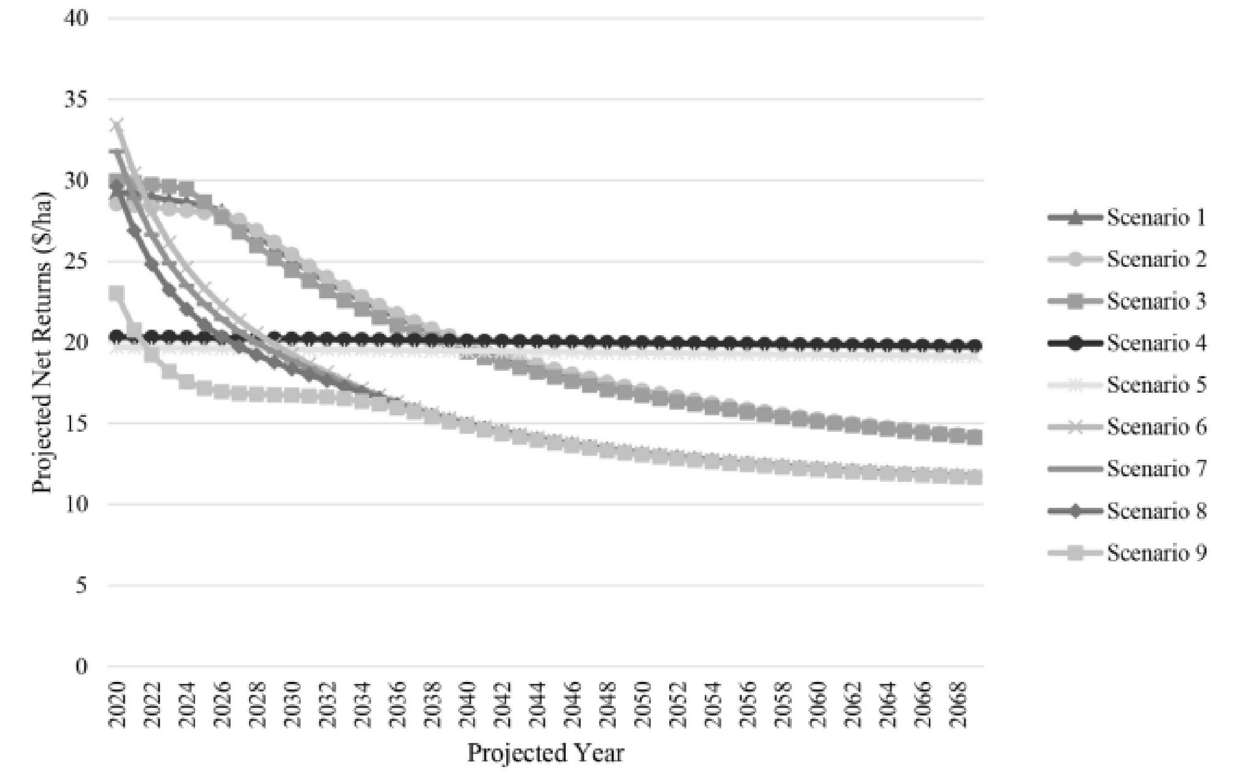


FIGURE 5 | Projected net returns ($ ha^{-1}) across nine field-level scenarios for a representative farm in Hale County, Texas.

TABLE 4 | Projected net returns ($ ha^{-1}) across nine field-level scenarios for a representative farm in Hale County, Texas.

Period	1	2	3	4	5	6	7	8	9
2020	179	174	183	124	120	204	194	181	141
2024	175	172	180	124	120	150	143	135	107
2029	158	160	154	124	120	121	119	115	102
2034	138	139	135	123	119	105	104	103	100
2039	124	125	121	123	119	94	93	93	92
2044	113	114	111	122	119	86	86	86	85
2049	105	106	103	122	118	81	81	81	81
2054	99	99	98	122	118	78	78	78	77
2059	94	94	93	121	118	75	75	75	75
2064	90	90	89	121	117	73	73	73	73
2069	87	87	86	121	117	72	72	72	71

Mitchell-McCallister, D., McCullough, R., Johnson, P. and Williams, R.B., 2021. An Economic Analysis on the Transition to Dryland Production in Deficit-Irrigated Cropping Systems of the Texas High Plains. *Frontiers in Sustainable Food Systems*, *5*, p.531601.

Discussion Questions

How do you convince commodity boards/agricultural producers to invest in climate mitigation strategies and research when they feel that they have a more immediate concern regarding limited irrigation across the region?

Based on the low carbon sequestration potential for producers in semi-arid environments. What economic incentives can be made to help implementation of carbon sequestration practices across the region?

Questions?

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