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Impact of Saturated Thickness to Protect Farmers from Drought in High Plains Aquifer

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Background

- The High Plains aquifer is the primary source of water supply for irrigating major crops in the region including corn and soybeans
- Climate change is expected to reduce groundwater availability in High Plains Aquifer and increase extreme climatic events such as droughts.
- Aquifer depletion leads to lower well yields, which in turn diminish the effectiveness of irrigation against drought.

U.S Drought Monitor Categories

Category	Drought intensity level	Percentile chance	Possible impacts
D0	Abnormally dry	20 to 30	• Short-term dryness slowing planting, growth of crops or pastures
D1	Drought, moderate	11 to 20	• Some damage to crops, pastures • Streams, reservoirs, or wells low, some water shortages developing or imminent
D2	Drought, severe	6 to 10	• Crop or pasture losses likely • Water shortages common
D3	Drought, extreme	3 to 5	• Major crop/pasture losses • Widespread water shortages or restrictions
D4	Drought, exceptional	0 to 2	• Exceptional and widespread crop/pasture losses • Shortages of water in reservoirs, streams, and wells creating water emergences

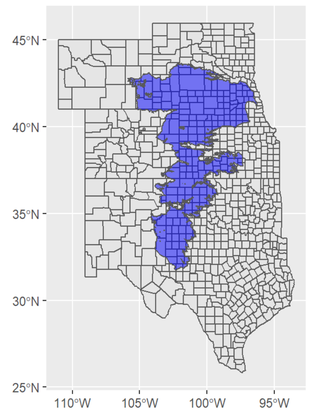

Figure 1: County-level map of High Plains Aquifer

Objectives

- Estimate the effect of saturated thickness to protect irrigated corn and soybeans production against severe drought in the High Plains Aquifer.
- Calculate the impact of aquifer depletion on farmers' ability to protect against severe droughts based on the regression results.

Data

Data:

- Irrigated corn and soybeans yields at the county level from 2000 to 2018 in the 8 states of high plains aquifer measured in bushels per acre
- County-level saturated thickness of High Plains Aquifer from the year 2000 to 2018 measured in feet
- Weekly drought index of the U.S Drought Monitor categories at the county-level in the High Plains Aquifer region

Methods

Empirical model:

$$Y = a + b_1\,Sat + b_2\,D0 + b_3 D1 + b_4\,dD2 + b_5\,D3 + b_6\,D4 + b_7\,(D0*sat) + b_8\,(D1*sat) + b_9\,(D2*sat) + b_{10}\,(D3*sat) + b_{11}\,(D4*sat) + b_{12}\,(d5*sat) + \in ct$$

Where Y stands for corn or soybean yields based on the time of the year (April through September, and May through October); a, b_n are parameters; $\in ct$ is error term

Results & Implications

Corn yield

	Dependent variable: value	
	(1)	(2)
DO	0.010	0.119
	(0.127)	(0.120)
D1	-0.603***	-0.365***
	(0.127)	(0.122)
D2	-0.143	-0.260**
	(0.125)	(0.123)
D3	-0.804***	-0.772***
	(0.153)	(0.152)
D4	-2.305***	-2.175***
	(0.262)	(0.232)
sat	1.356***	1.372***
	(0.372)	(0.368)
I (sat * y_d0)	0.003*	0.003*
	(0.002)	(0.002)
I (sat * y_d1)	0.005***	0.004**
	(0.002)	(0.002)
I (sat * y_d2)	-0.0001	0.001
	(0.002)	(0.001)
I (sat * y_d3)	0.003	0.004*
	(0.002)	(0.002)
I (sat * y_d4)	0.015***	0.014***
	(0.004)	(0.003)
Observations	1,911	1,911
R^2	0.721	0.724
Adjusted R^2	0.687	0.691
Residual Std. Error (df = 1706)	13.735	13.644
Note:	*p<0.1;* ***p<0.05;*** p<0.01	

Soybean yield

	Dependent variable: value	
	(1)	(2)
D0	-0.110**	-0.098*
	(0.046)	(0.052)
D1	-0.060	-0.073
	(0.047)	(0.052)
D2	-0.003	0.001
	(0.052)	(0.061)
D3	-0.513***	-0.560***
	(0.087)	(0.095)
D4	-0.428***	-0.448***
	(0.163)	(0.165)
sat	-0.123	-0.119
	(0.165)	(0.165)
I (sat * D0)	0.002**	0.002**
	(0.001)	(0.001)
I (sat * D1)	0.0005	0.001
	(0.001)	(0.001)
I (sat * D2)	-0.001	-0.001
	(0.001)	(0.001)
I (sat * D3)	0.004***	0.005***
	(0.001)	(0.001)
I (sat * D4)	0.002	0.002
	(0.002)	(0.002)
Observations	1,158	1,158
R^2	0.790	0.789
Adjusted R^2	0.755	0.755
Residual Std. Error (df = 993)	3.914	3.917
Note:	*p<0.1;* ***p<0.05;*** p<0.01	

- Regressions (1) runs April through September and regressions (2) runs May through October for each crop yield. Results indicates that saturated thickness help mitigate the effects of drought intensity levels in relation to its depths. The higher depths of saturated, the less yield is lost for every additional week of drought during growing season. Saturated thickness of the Ogallala aquifer will affect long-run irrigation and farming decisions in the region.
- Using the minimum required saturated thickness in the literature that varies 40 to 50 feet, farmers will still lose yield if one the statistically significant USDM categories occurs in the growing season.

References & Acknowledgments

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