

Bioenergy Production Strategies and US High Plains Aquifer Optimization

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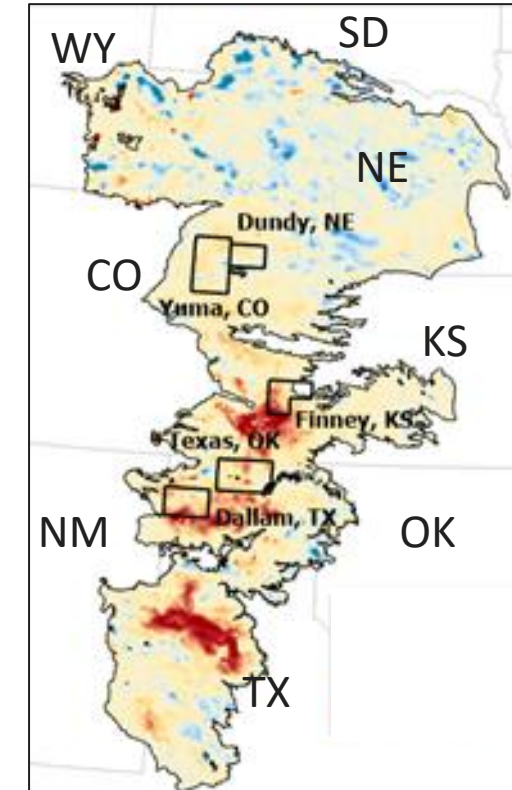


**2024 AAEA
Annual Meeting**
New Orleans, LA July 28-30, 2024
NEW ORLEANS MARRIOTT

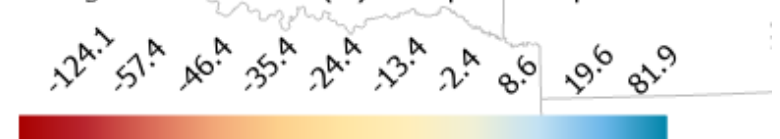
Overview

- Agricultural enterprise
 - Estimated **\$35 billion** in market sales (Scalon et al., 2012).
 - **39%** of crop cultivation / **30%** is irrigated by groundwater
- Irrigated production
 - Risk - declines in the Ogallala aquifer
 - Cause - withdrawals exceeds the recharge rate
 - Effects - decreased well capacities, lower crop yields, and higher extraction costs
- Production challenges
 - Less water-intense crops
 - Transitioning to dryland production
 - Pasture for livestock, or
 - Ceasing farming temporarily – by enrolling in conservation reserve program (CRP), or permanently.

Ogallala Aquifer



Change in water levels (m) from predevelopment to 2016



Adapted from, Deines et al. , 2019. Mapping three decades of annual irrigation across the US High Plains Aquifer using Landsat and Google Earth Engine. *Remote Sensing of Environment*, 233.

Purpose of the Study



Potential Biomass Opportunities

- **37%** of the total US renewable energy consumption – 50% domestic supply (US DOE)
- Corn feedstock – major use
- Cellulosic biofuel production: **less than the desired amount** set by the RFS

Reasons for short of target

- Producers' **lack of familiarity** with new perennial feedstocks & **conversion yields**
- **Dominance** of corn ethanol and soy biodiesel

Switchgrass, a native perennial

- **Drought tolerance** and reliance on fewer inputs,
- **High expected biomass yield**, and suitability to marginal and degraded lands.

Sorghum, used as either animal feed or bioenergy feedstock

- **Easily adopted** by due to its familiarity and short-term commitment
- Drought tolerant high yields with **reduced inputs**

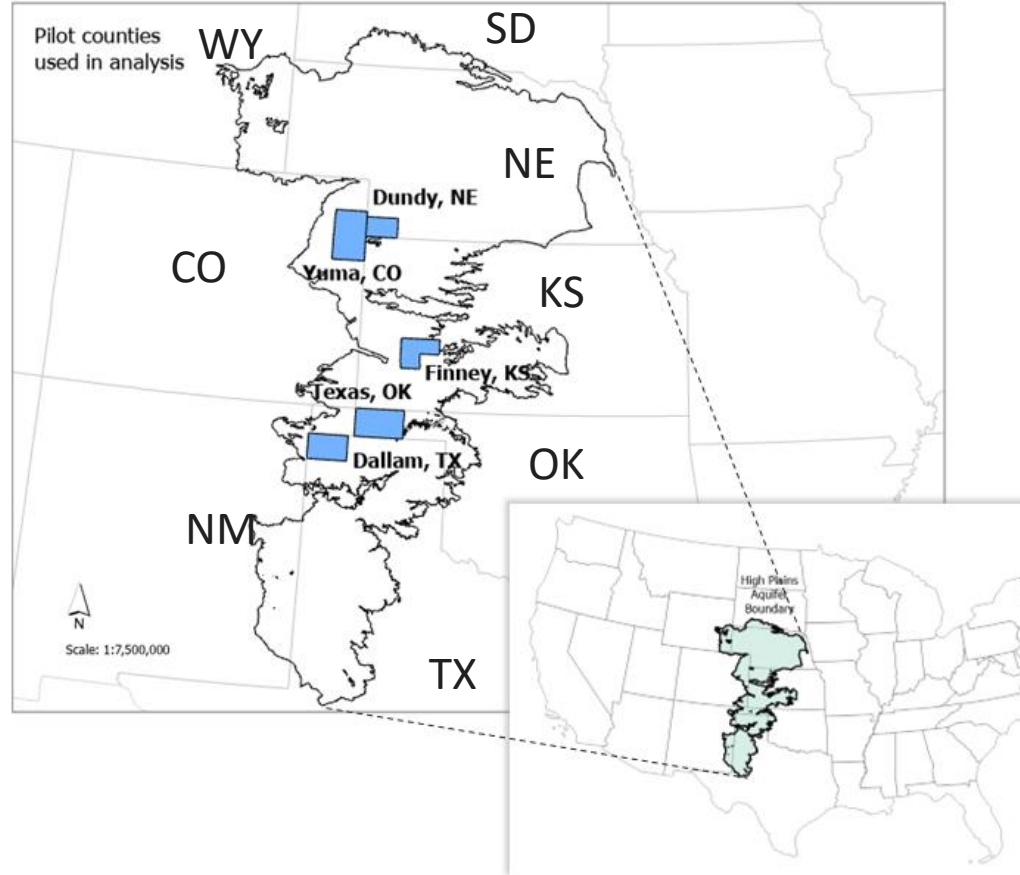
Purpose/Motivation

- Irrigated corn vs. irrigated sorghum
 - **Yield:** corn (~200 bu./ac.) > sorghum (~120 bu./ac.)
 - **Irrigation:** corn (~24 in) > sorghum (~12 in)
 - **Profit (π):** sorghum > corn; below 5 gallons per minute (GPM) per acre
 - **Production:** sorghum > corn; more bushels per unit of water **at lower well capacities (WC)**
- Estimate maximum long-term benefits of producing bioenergy feedstocks
 - Irrigated corn vs. Irrigated sorghum
 - Rainfed corn vs Rainfed sorghum vs. Switchgrass
- Production alternatives
 - Pasture
 - CRP

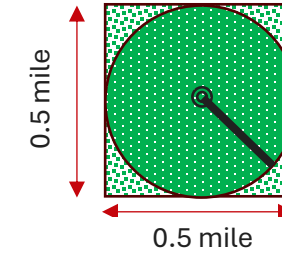
Methodology



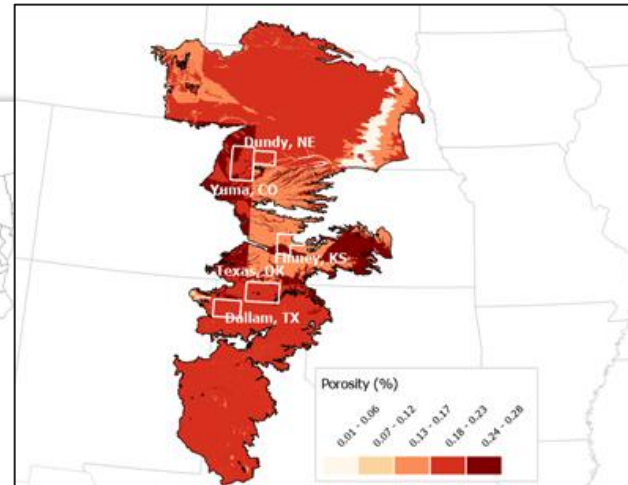
Pilot Analysis



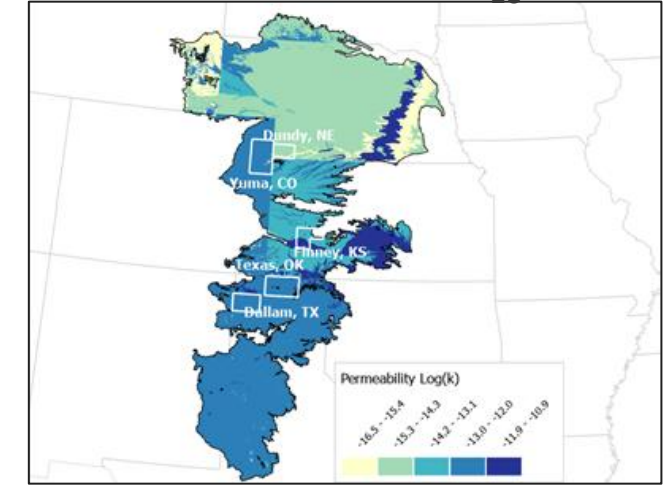
Representative Field (160 acres)



Specific Yield/Porosity (%)

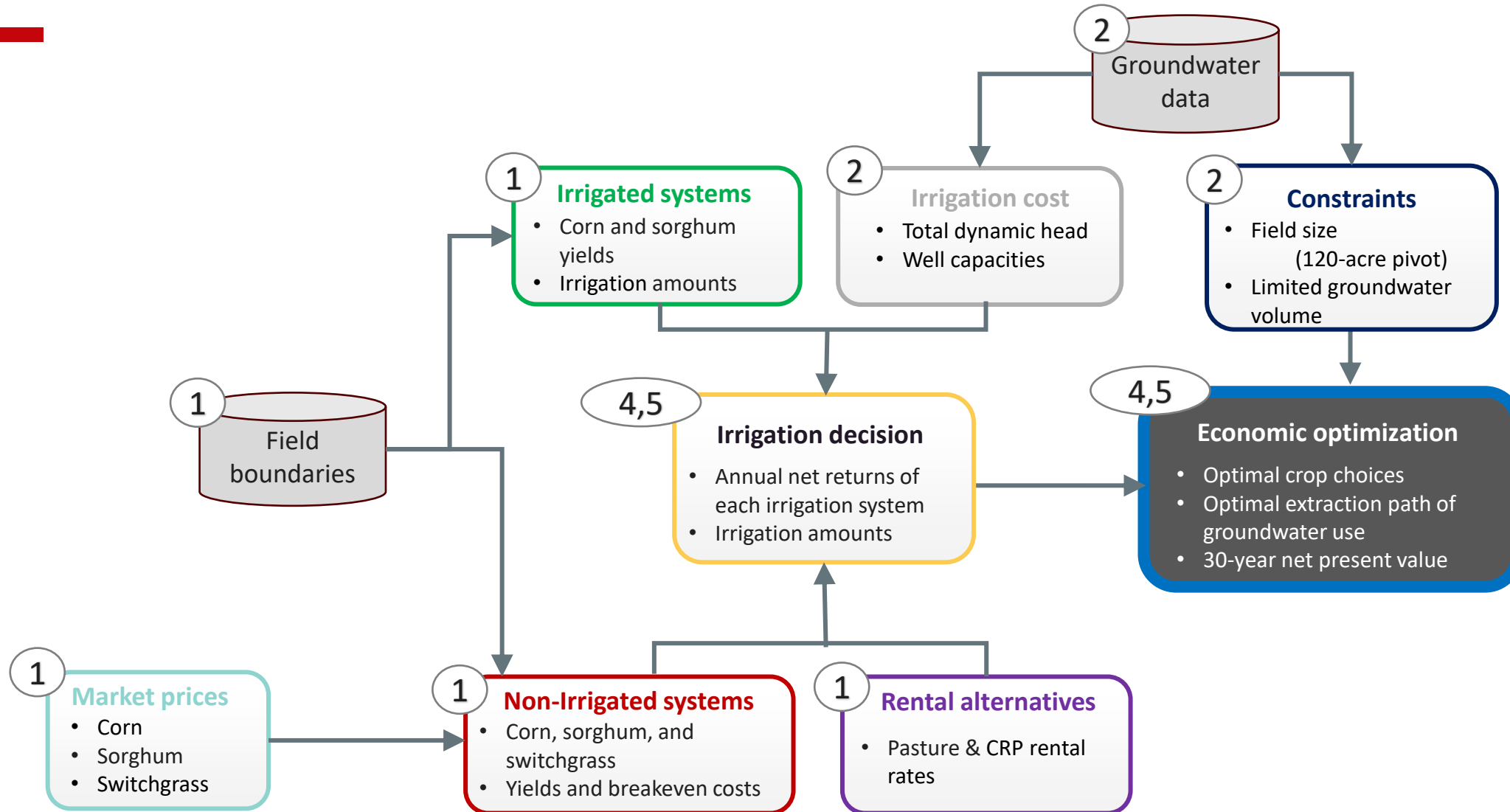


Permeability ($\log_{10} k$)

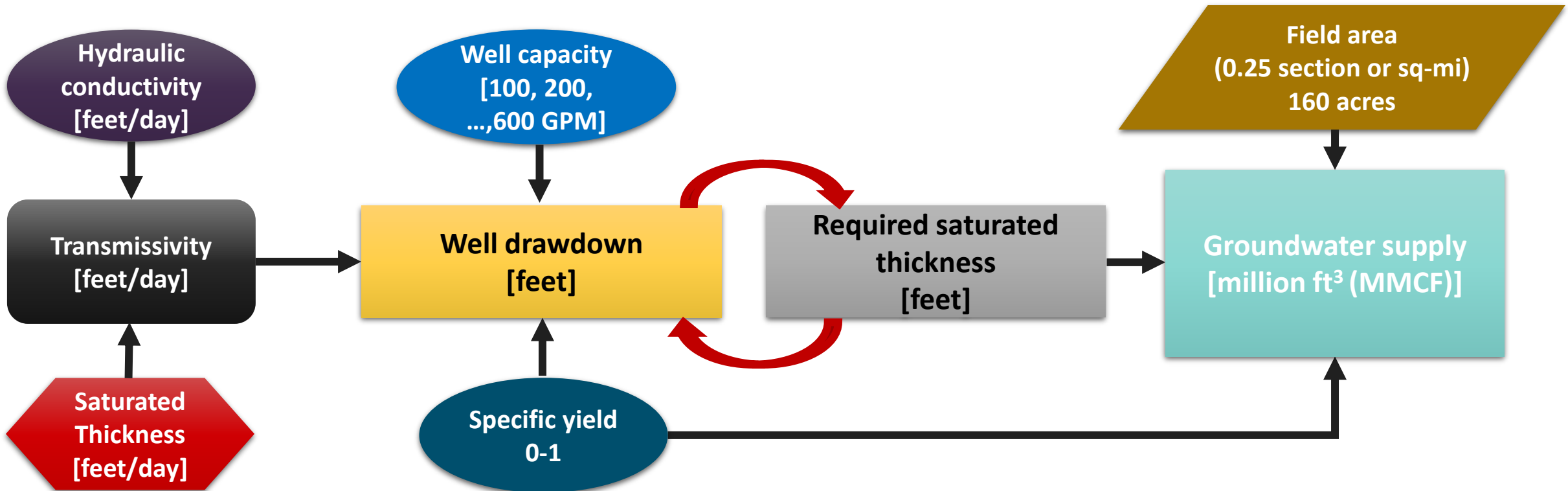


Gleeson, T., Moosdorf, N., Hartmann, J. and van Beek, L.P.H., 2014. A glimpse beneath earth's surface: GLoBAL HYdrogeology MaPS (GLHYMPS) of permeability and porosity. *Geophysical Research Letters*, 41: 2014GL059856

Framework



Groundwater Model



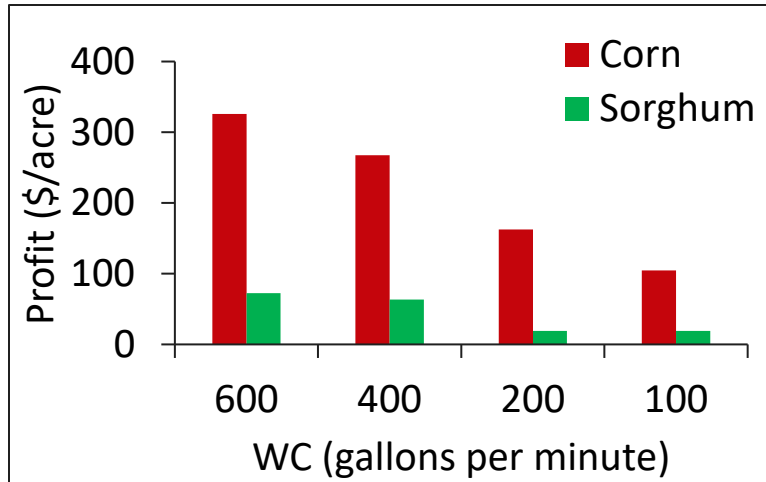
		Hydraulic conductivity			Groundwater for 600 GPM Wells	
	Porosity	(ft/day)	(m/day)		Saturated thickness ¹ (ft)	Remaining groundwater supply ² (MMCF)
Yuma, CO	0.27	25.92	7.90		50	94.18
Finney, KS	0.15	25.04	7.63		53	55.41
Dundy, NE	0.19	24.36	7.43		53	70.26
Texas, OK	0.22	25.63	7.81		51	78.28
Dallam, TX	0.22	25.63	7.81		51	78.28

Results

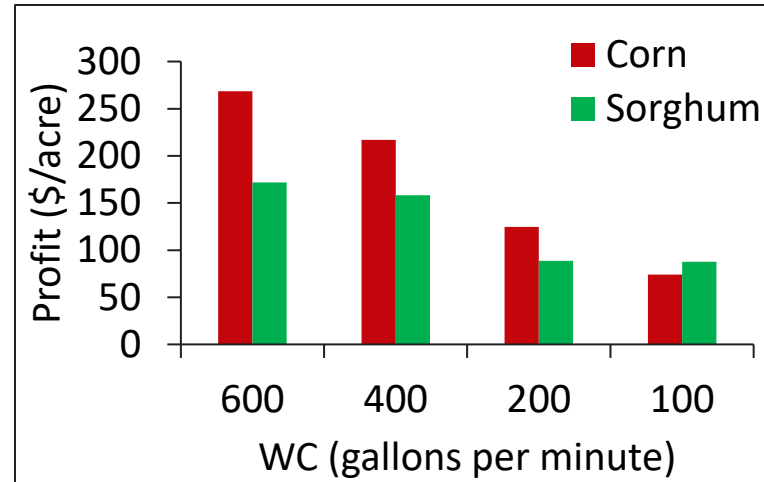


Static Budgets: Business As Usual

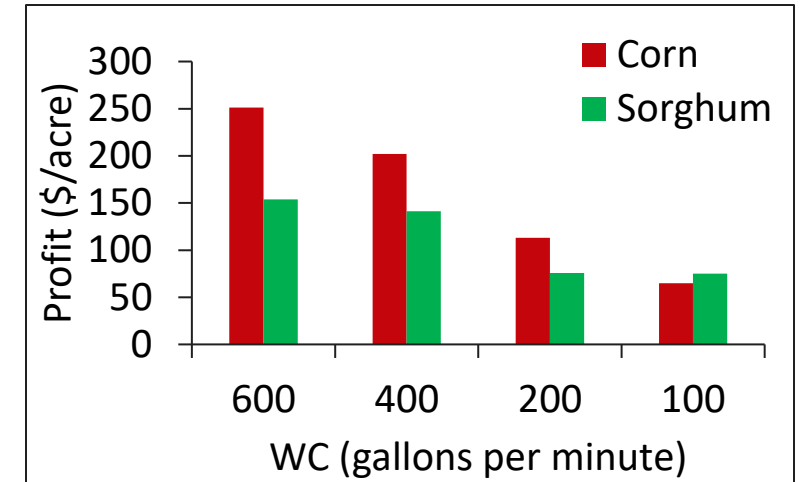
COLORADO



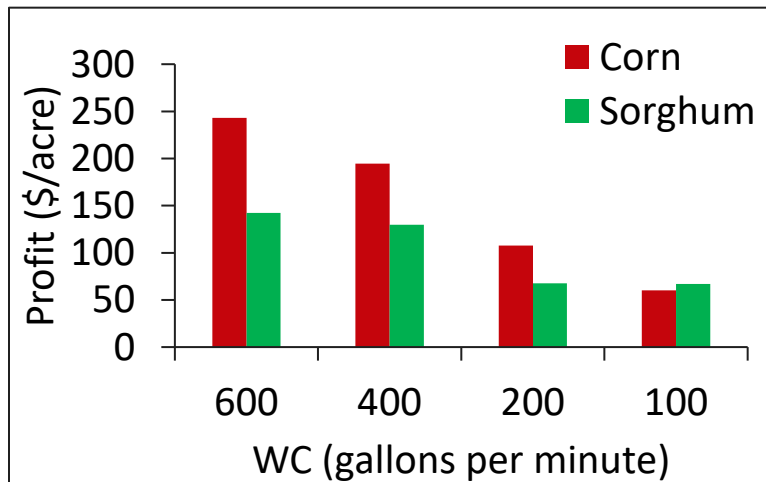
KANSAS



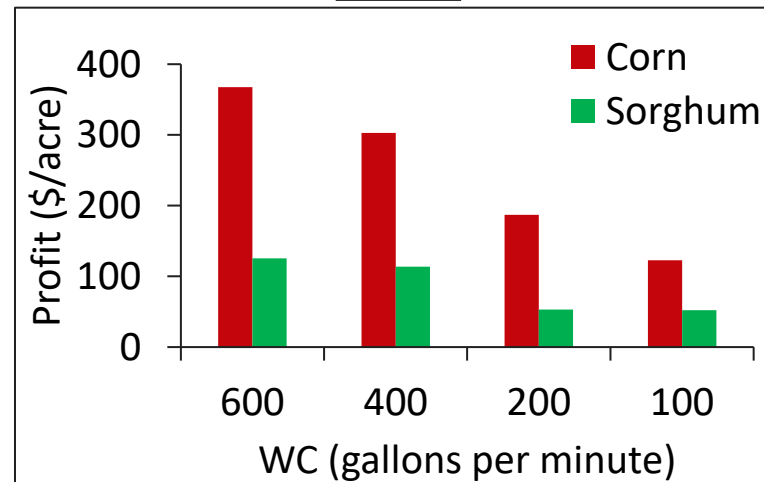
NEBRASKA



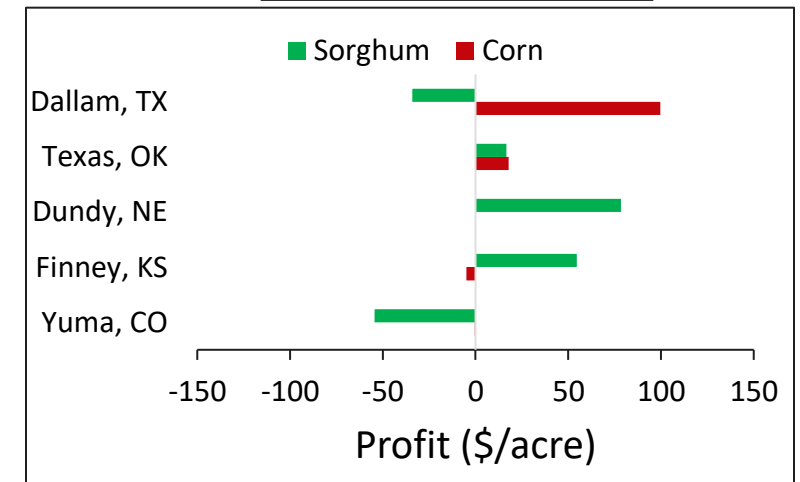
OKLAHOMA



TEXAS

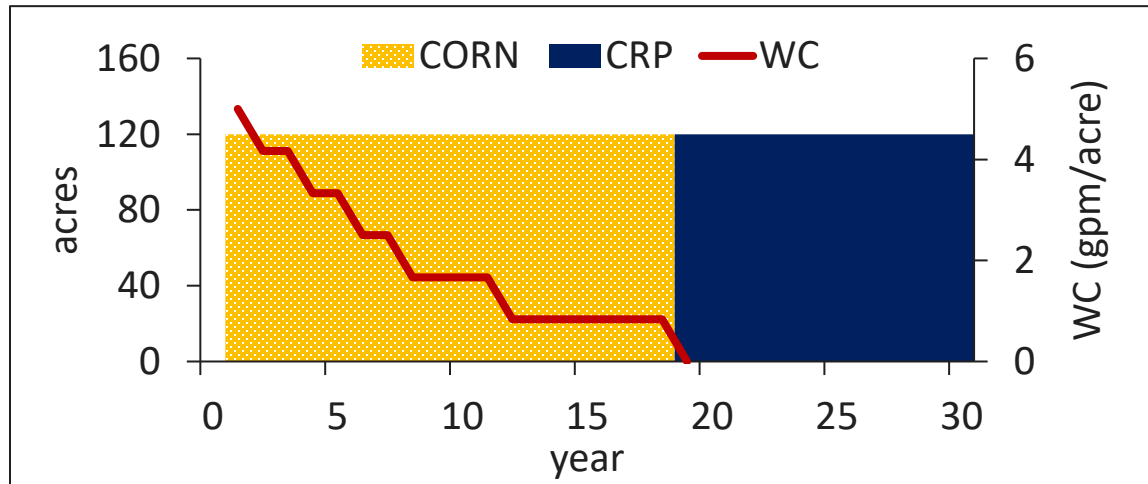


DRYLAND BUDGETS

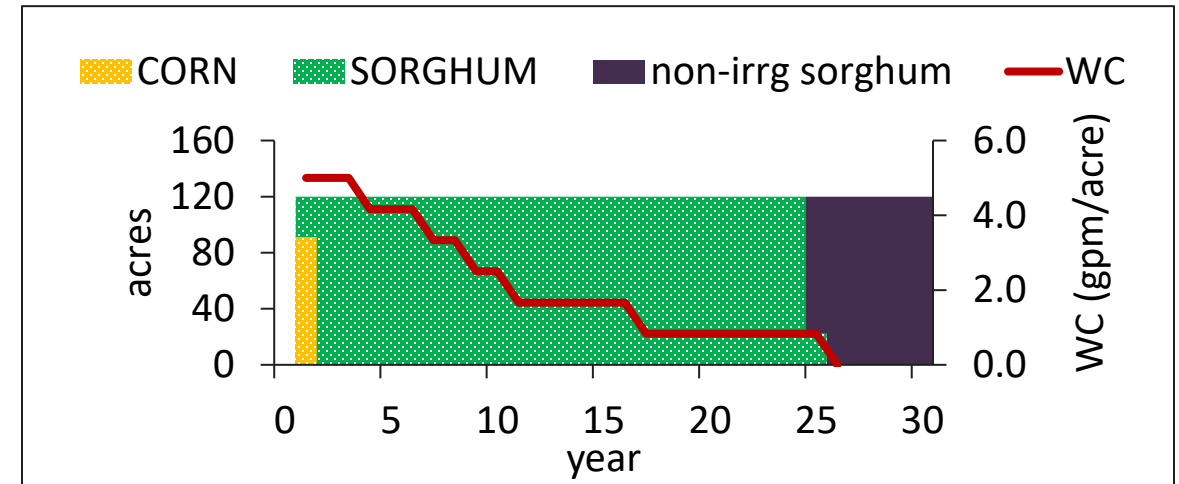


Programming Model: Optimal (Irrigated) Crop Choices

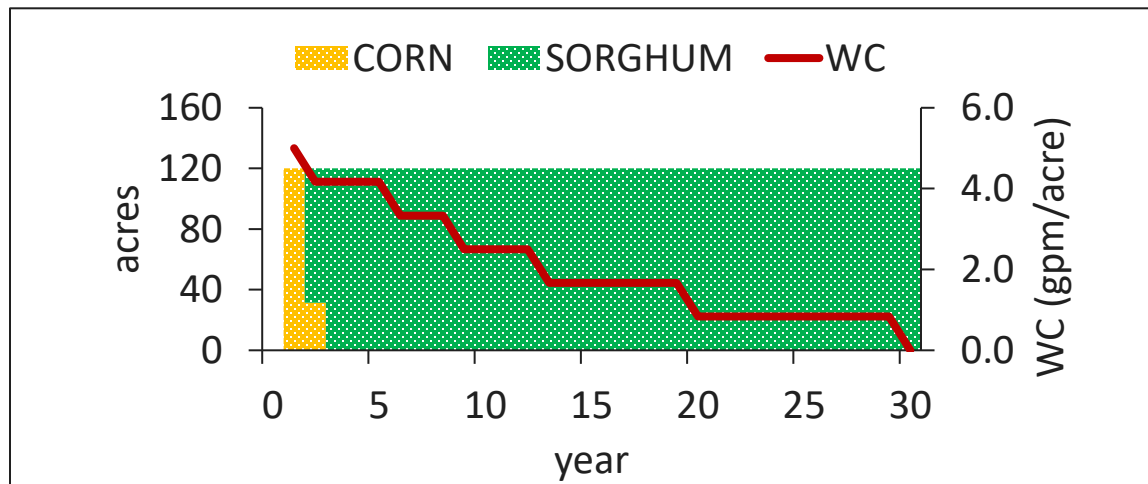
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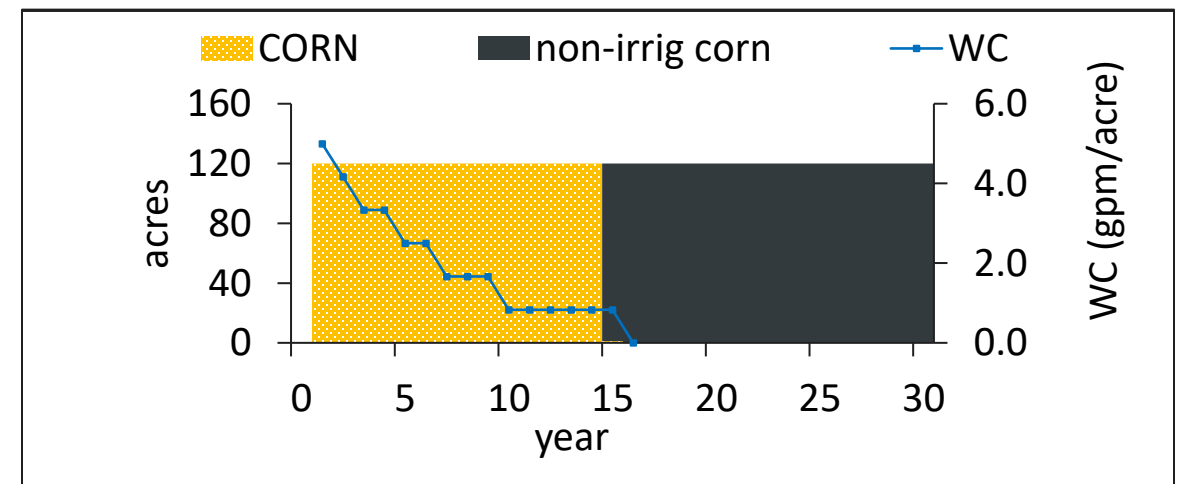
KANSAS



NEBRASKA



OKLAHOMA



Long-term Economic and Production Benefits

	Groundwater (MMCF ¹)	NPV ² (US \$)	Production (bushels ³)	Value of production (PV/MMCF)	Production Efficiency (bushels/MMCF)
Yuma, CO	94.18 [1]	\$321,695 [1]	268,221 [3]	\$3,416 [4]	2,848 [4]
Finney, KS	55.41 [5]	\$248,776 [5]	235,516 [4]	\$4,490 [1]	4,250 [1]
Dundy, NE	70.26 [4]	\$297,865 [3]	297,186 [1]	\$4,240 [2]	4,230 [2]
Texas, OK	78.28 [3]	\$257,810 [4]	277,471 [2]	\$3,294 [5]	3,545 [3]
Dallam, TX	78.28 [2]	\$300,426 [2]	210,873 [5]	\$3,838 [3]	2,694 [5]

¹Millions cubic feet (MMCF)

²Net present value (NPV)

³One bushel = 56 lbs.

Discussion and Conclusion

- Investing in a center pivot system and irrigating grain sorghum as WC declines below 5 GPM per acre in the US High Plains could maximize the value of the remaining groundwater resources.
- Crop producers in the High Plains could choose to irrigate corn when the irrigation capacity is sustainable to cover the costs of the groundwater resources.
- One of the main challenges we need to address is obtaining a more spatially complete and representative data to carry out the study for all the counties.
- Possible policy suggestions towards biofuels production and biorefinery locations.



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