Water Resource Management and Irrigation in Kansas: Current Concerns and Emerging Issues

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Micah Cameron-Harp, Ph.D.
Assistant Professor
Kansas State University,
Department of Agricultural Economics
Phone: (785)705-0015, Email: mcameronharp@ksu.edu

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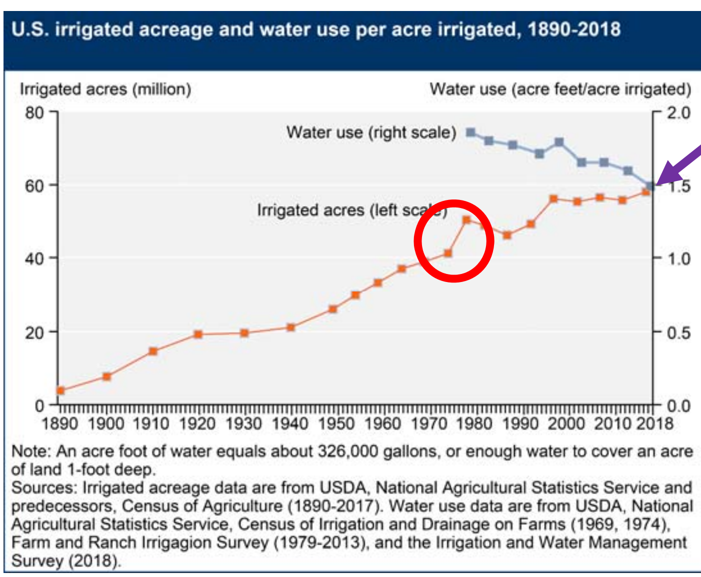
Research and Extension

United States Irrigation Development



24.3 million hectare

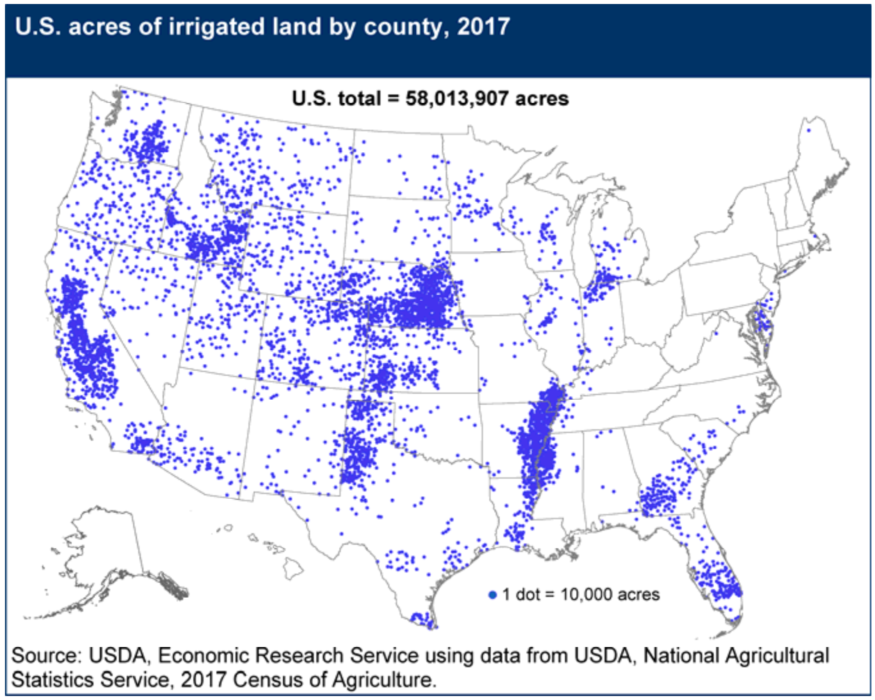
	Country/Territory/Region	Irrigated land (km^2)
	World	3,242,917
1	India	715,539
2	China	691,600
3	United States	234,782
4	Pakistan	193,400
5	European Union	154,540
6	Bangladesh	81,270
7	Iran	79,721
8	Brazil	69,029
9	Indonesia	67,220
10	Thailand	64,150

https://www.ers.usda.gov/topics/farm-practices-management/irrigation-water-use/

U.S. Irrigation

Share of Irrigated Land

- NE: 14.8%
- CA: 13.5%
- AR: 8.4%
- TX: 7.5%
- ID: 5.9%
- CO: 4.8%
- KS: 4.3%



KS Irrigation History

1. In Colorado and Kansas, the first large Arkansas River ditch water right was the Rocky Ford ditch diversion in 1874 (van Hook, 1933), and more irrigation from diversion of the Arkansas River followed in the 1880s (Erhart, 1969).

2. Large inter-annual variations in flow and upstream diversions of the Arkansas River slowed irrigation expansion in Kansas until the 1940s, when rapid expansion became possible due to the adoption of well drilling technologies from the oil industry and the availability of deep well pumps, internal combustion engines, and rapid

3. Expansion of irrigation in the Great Plains was greatly motivated by the drought of the 1950s and aided by the soldiers returning from World War II, reaching a high point in Kansas of 1.42 million ha in 1980 before declining to approximately 1.21 million ha by 2000 (Rogers

4. From 1998 to 2008, the irrigated area in the ten states overlying the High Plains aquifer increased by 11% but declined since 2008 by 7% to 9 million ha in 2018 (table 1) (USDA-NASS, 1998, 2008, 2013, 2019a). Kansas lost 10% of its irrigated area.

PAST, PRESENT, AND FUTURE OF IRRIGATION ON THE U.S. GREAT PLAINS

S. R. Evett, P. D. Colaizzi, F. R. Lamm, S. A. O'Shaughnessy, D. M. Heeren, T. J. Trout, W. L. Kranz, X. Lin

5. In Texas and Kansas, water availability is decreasing, almost entirely due to aquifer declines in those states, which rely on groundwater for irrigation on 83% and 96% of irrigated land, respectively.

6. Although conversion to more efficient irrigation systems and to crops that require less water has resulted in an overall 21% decline in seasonal irrigation applications, from 446 mm in 1998 to 353 mm in 2018, the percentage of decline varied by state. For example, seasonal irrigation application ….. decreased by …. 24% in Kansas over the 20-year period. ***This decrease is mostly due to conversion from gravity (furrow) to sprinkler irrigation.***

Rapid Expansion of Irrigation – 1970's

Economic Drivers
- Global commodity boom: 1972 USSR grain deal boosted U.S. exports & prices (Gardner, 2002)
- Inflation: Farmland & irrigation systems seen as safe investments (Gardner, 2002)
- Low pumping energy costs early in decade (Sloggett, 1992)

Technological Advances
- Center pivot irrigation perfected late 1960s, widely adopted in 1970s (Wheeler & Riggs, 1976)
- Center pivot patent expired in 1969, spurring manufacturer competition & adoption (Opie, 2000)
- Turbine & submersible pump improvements increased reliability (Keller & Bliesner, 1990)
- PVC/aluminum pipe lowered installation

Policy & Institutional Support
- USDA loan and cost-share programs accelerated adoption (USDA-ERS, 1982)
- States clarified or expanded water rights, prompting rapid drilling (Opie, 2000)
- Bureau of Reclamation projects delivered new surface water (BoR, 1977)

Climatic & Social Context
- Early 1970s droughts increased irrigation demand (Opie, 2000)
- Farm consolidation enabled large-scale capital investment (Gardner, 2002)
- Shift to high-value crops made irrigation economically essential (Stulp, 1978)

Number of Permits (1944 – 1984)

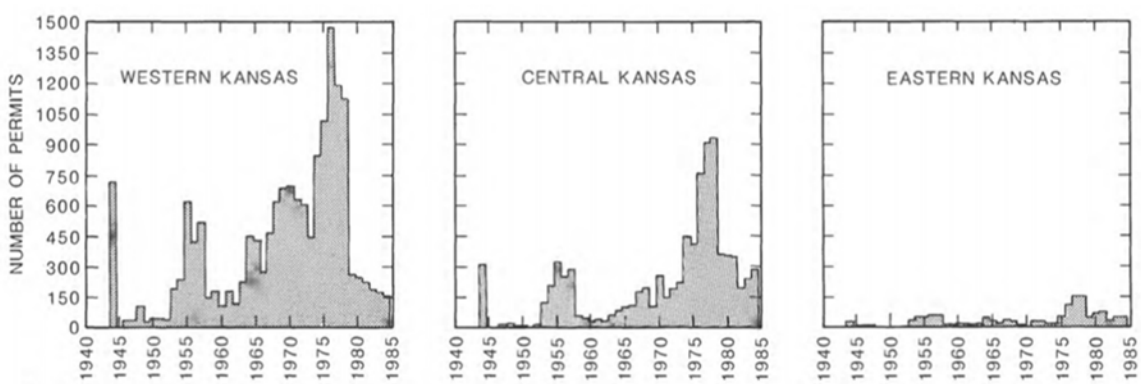


Figure 9.--Number of permits issued to appropriate water for irrigation, 1944-84.

Western KS Sandhills area south of the Arkansas River:
- Center Pivots increased from 1,084 to 2,826 from 1972 to 1975.

Great Bend Prairie south of Arkansas River:
- Center Pivots increased from 284 to 1,103 from 1972 to 1975.

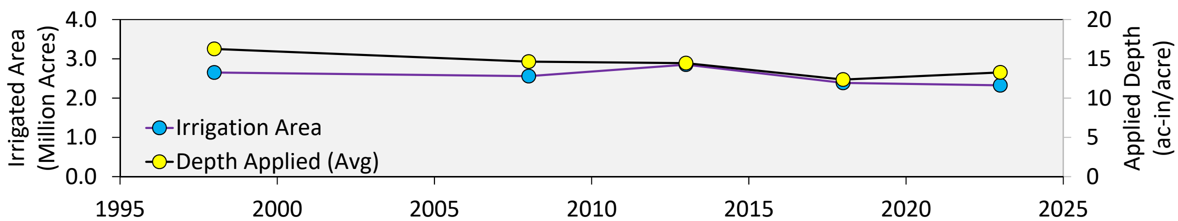
Kenny (1986): Water Demands in Kansas ,

KS Irrigation History

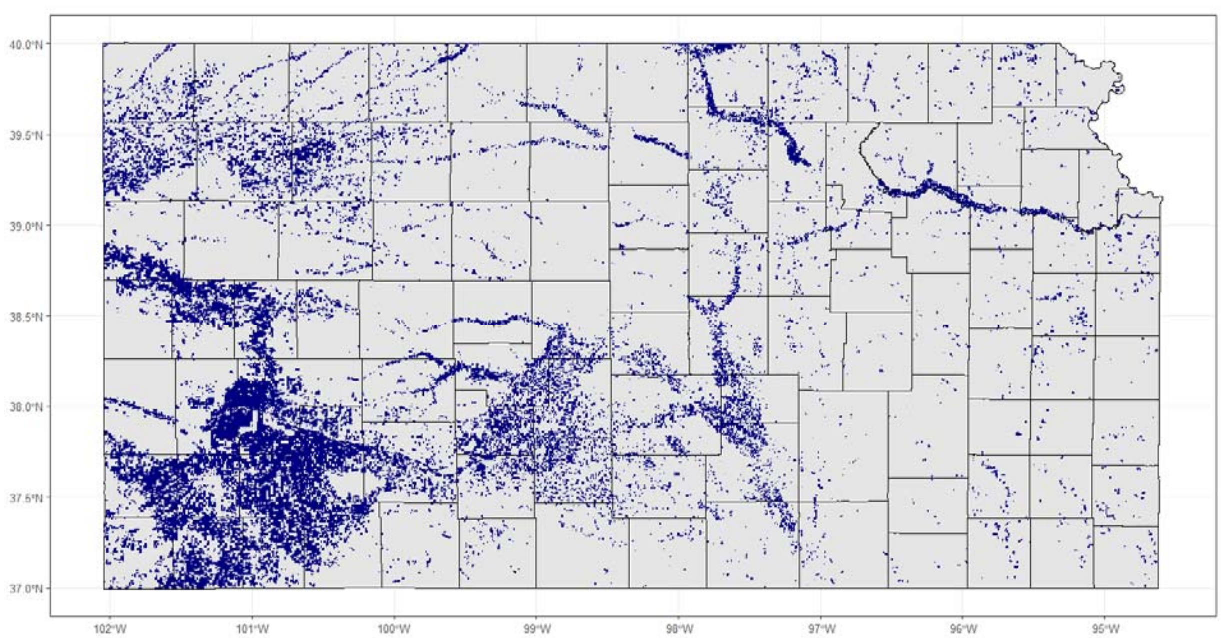
United States Department of Agriculture
Census of Agriculture Historical Archive

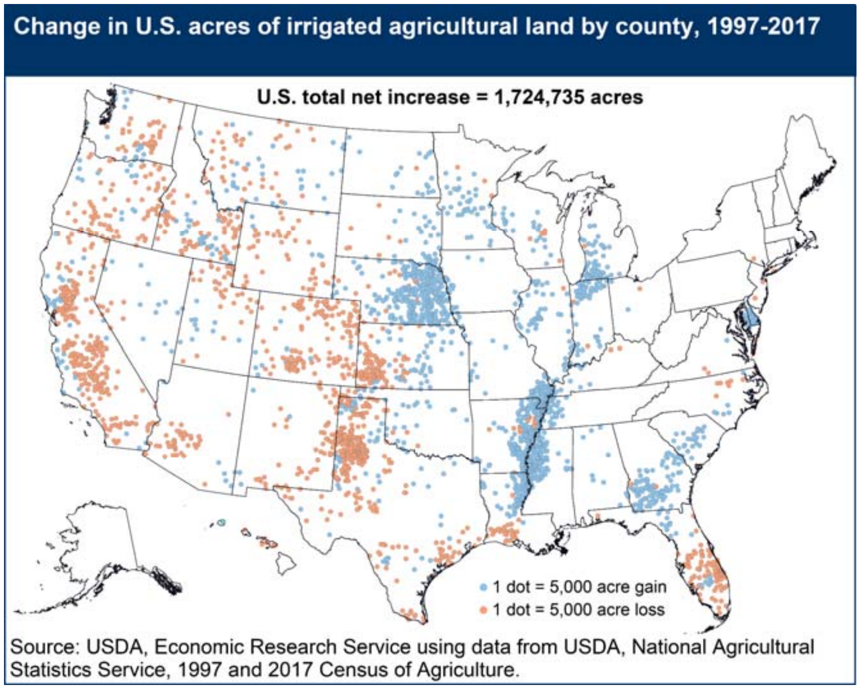
Table 1. Irrigated area, mean depth of water applied, and percentage of the irrigated area that depends on groundwater in the ten Great Plains states overlying the High Plains aquifer in 1998, 2008, 2013 and 2018, ranked by irrigated area in 2018. (USDA-NASS, 1998, 2008, 2013, 2019a).

	Irrigated Area (ha)					Depth of Water Applied (mm)				Percentage of Irrigated Area Dependent on Groundwater (%)			
State	2018	2013	2008	1998		2018	2013	2008	1998	2018	2013	2008	1998
Nebraska	3,102,274	3,357,977	3,331,418	2,303,608		193	296	243	266	91	92	94	89
Texas	1,652,515	1,817,882	2,110,132	2,119,621		399	394	388	435	83	90	87	87
Kansas	965,776	1,153,912	1,035,545	1,072,637		314	367	372	413	96	98	97	97
Colorado	994,767	934,659	1,109,453	1,190,704		476	546	490	523	47	43	43	45
Montana	865,979	757,745	735,328	704,522		363	407	419	505	3	3	2	3
Wyoming	631,920	573,972	572,963	620,586		443	449	617	553	11	10	7	6
New Mexico	273,200	281,114	322,431	291,509		604	575	696	732	58	58	66	59
Oklahoma	243,415	172,643	184,756	182,836		335	373	345	457	83	88	83	79
South Dakota	153,096	149,682	144,904	120,277		211	240	229	320	55	65	57	46
North Dakota	120,192	86,495	98,367	66,670		195	212	275	260	64	73	68	63
Total:	9,003,135	9,286,081	9,645,297	8,672,970	Mean:	353	386	407	446				

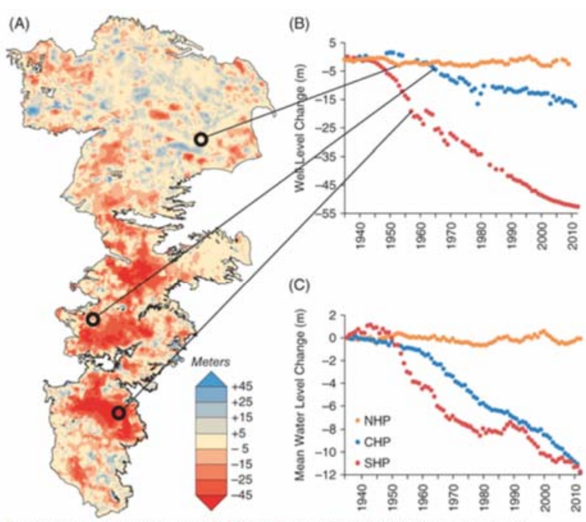


Authorized Places of Use (2020)

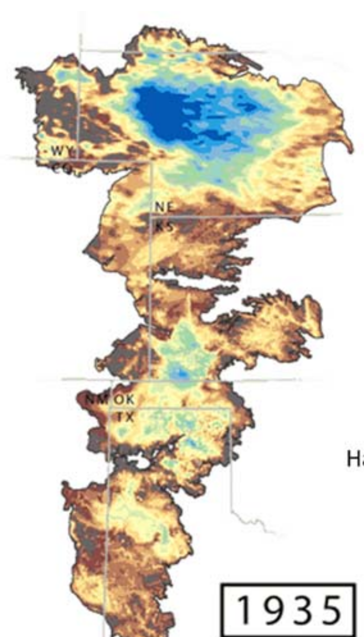




Ogallala Aquifer – Saturated Thickness

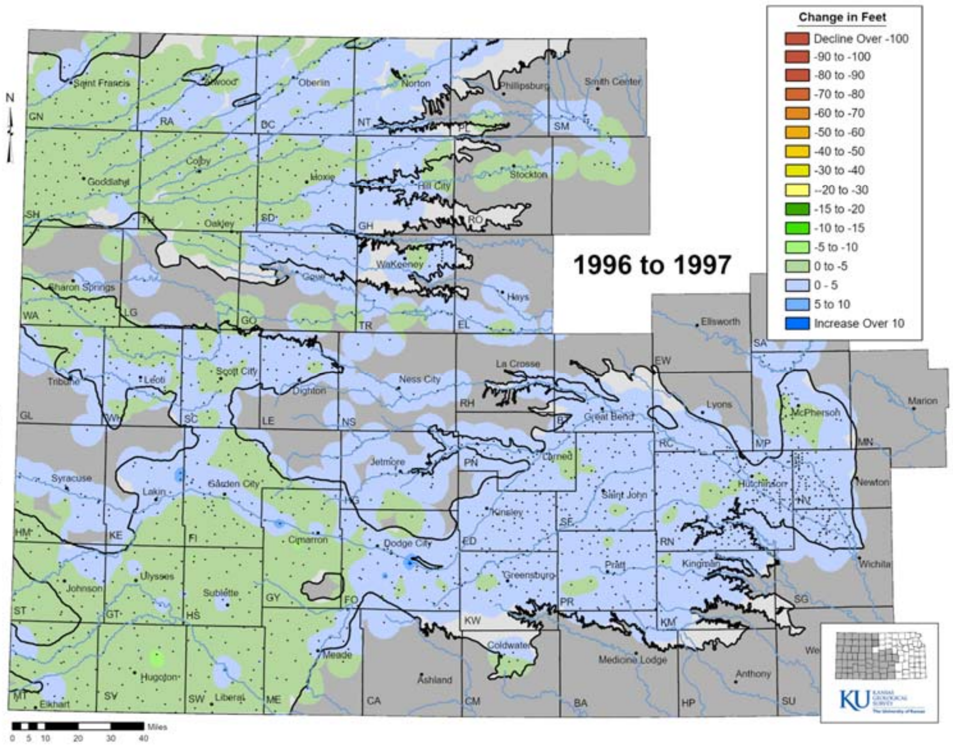


E. Haacker et al. (2015). Water Level Declines in the High Plains Aquifer: Predevelopment to Resource Senescence 54 (2): 231-242. DOI: 10.1111/gwat.12350



Haacker et al. 2015

Changes in Ogallala-High Plains Aquifer in Kansas



Economic impacts of changing aquifer conditions

- **Regional or system-scale:**
  - Between 1996 and 2005, estimated value of Kansas portion of the HPA fell by 6.5%, roughly $110 million dollars, per year (Fenichel et al. 2016).
  - LEMA implementation expected to increase cumulative net revenue for the rural economy in GMD3 (Golden & Guerrero, 2017).
- **Intensive and Extensive Margins:**
  - An additional acre-foot of saturated thickness is worth as much as $16/acre-foot.
  - Agricultural land value is 53% greater for irrigated acreage than non-irrigated in Kansas. The premium for irrigated acreage has grown by 1 percentage point per year on average over the past 25 years (Sampson et al. 2019).

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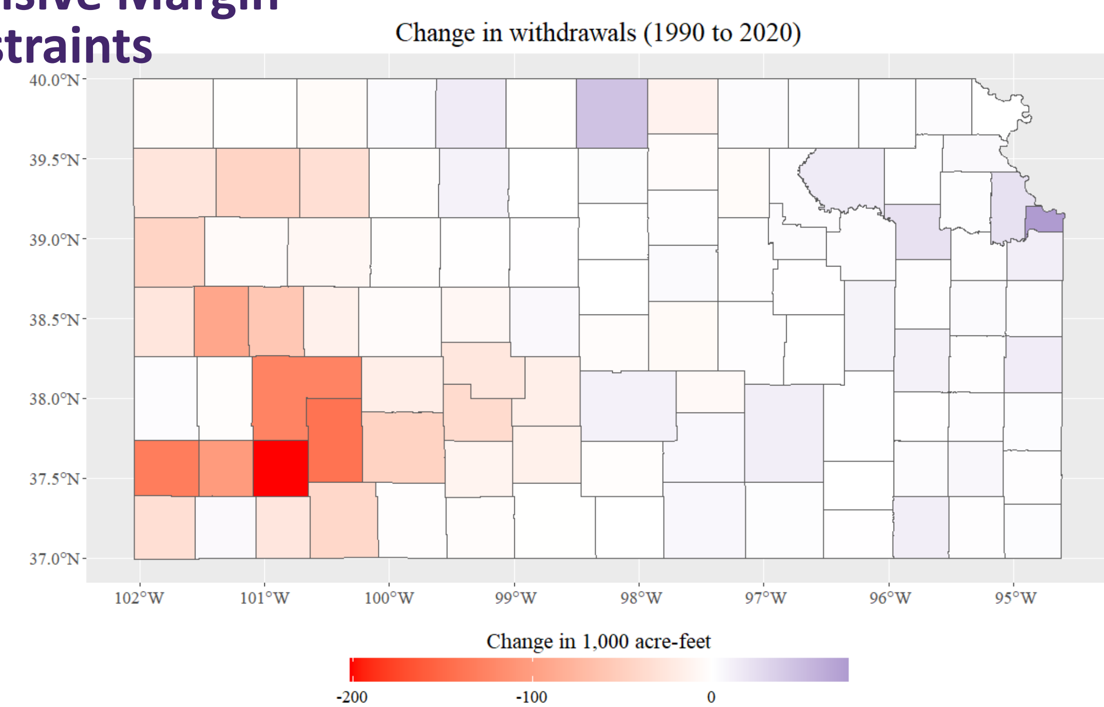
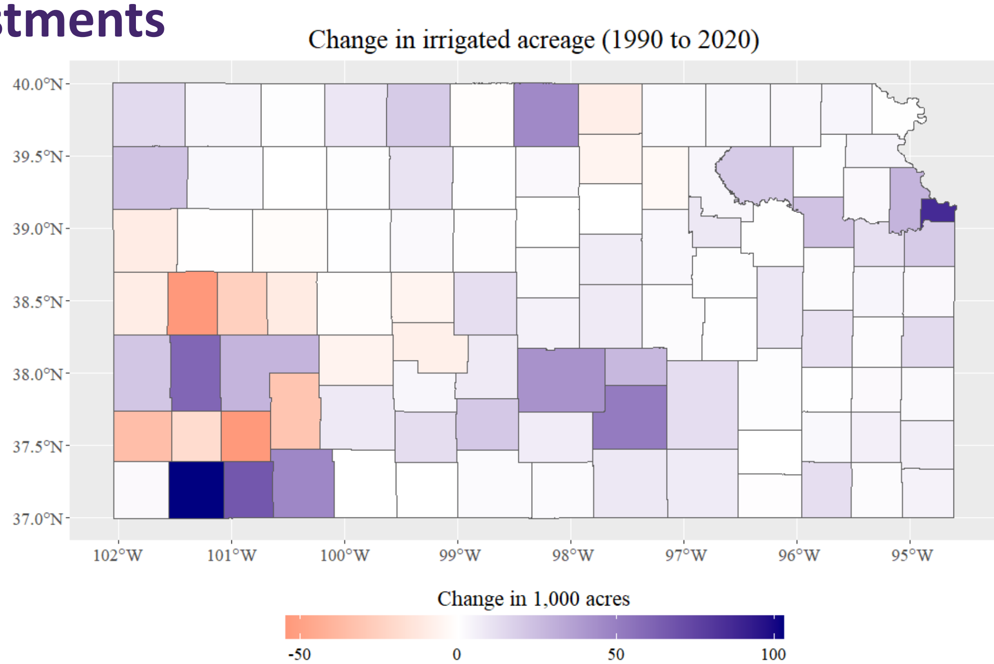
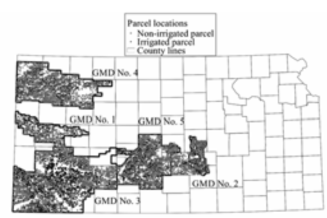
Intensive Margin Constraints

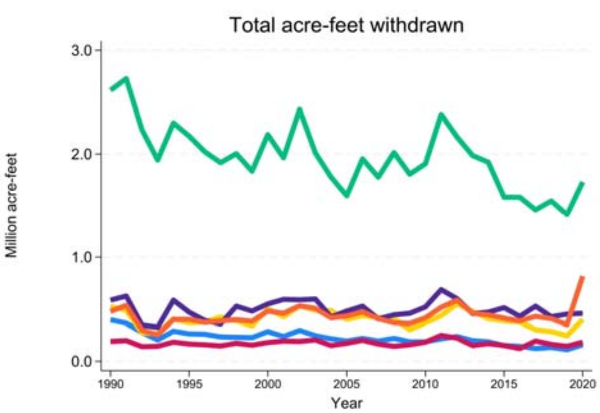


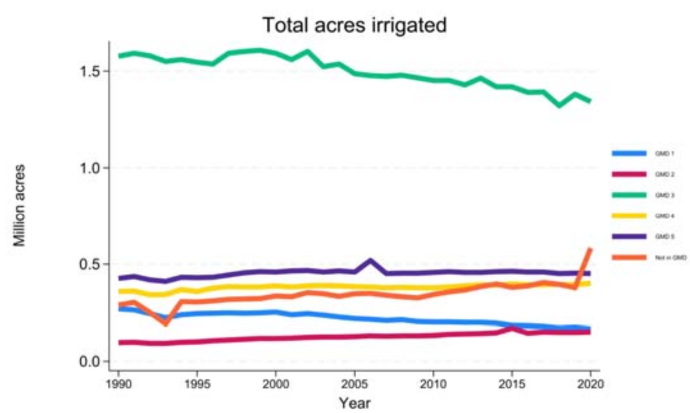
Extensive Margin Adjustments



Current regional trends







How do we mitigate overuse?

- Do Nothing?
- Retire Irrigated Acres?
- Education?
- Regulation?
- Technology & Innovation?

American Journal of Agricultural Economics | AAEA

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Targeting of Water Rights Retirement Programs: Evidence from Kansas

Andrew B. Rosenberg

"I find that every acre authorized for irrigation that is retired in the program represents about 1.28 acre-feet of water that would have been used each year. Further, I do not find evidence that farmers increase their water use in an effort to satisfy program eligibility requirements."

How do we mitigate overuse?

- Do Nothing?
- Retire Irrigated Acres?
- Education?
- Regulation?
- Technology & Innovation?

American Journal of Agricultural Economics | AAEA

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Social comparisons and groundwater use: Evidence from Colorado and Kansas

R. Aaron Hrozencik, Jordan F. Suter, Paul J. Ferraro, Nathan Hendricks

"The comparison intervention reduced average annual groundwater use by 4.05% [95% CI (−5.87%, −2.21%)], resulting in an aggregate reduction of more than 21,000 acre-feet per year at a cost less than $1.31 per acre-foot conserved. The estimated treatment effect was larger among irrigators with lower

How do we mitigate overuse?

- Do nothing?
- Retire Irrigated Acres?
- Education?
- Regulation?
- Technology & Innovation?

Kansas Department of Agriculture

Impairment Investigations

- Quivira National Wildlife Refuge Impairment Complaint
- Vested Right Haskell 03 Complaint

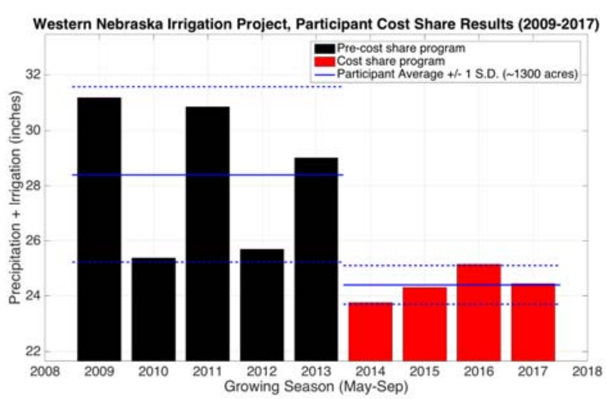
Impairment Complaint Procedures

First, if a water right holder believes that his or her water right is being impaired by the use of a newer water right, he or she must file a written complaint with the Chief Engineer or his or her authorized representative. That usually means the Water Commissioner over the DWR Field Office that serves the area where the water rights are held by the complainant. Examples of typical impairment complaints include:

- Surface water from a stream is not reaching a senior water right holder because of an upstream diversion by a junior water right;
- A well authorized by a senior water right is not able to pump a sufficient amount of water to satisfy that right because of significant impacts due to pumping at one or more nearby wells authorized by junior water rights.

Does Technology Reduce Irrigation?

- Central Nebraska Irrigation Project (2018-2021)
  - 50 Producers and 10 Control Fields
- Western Nebraska Irrigation Project (2014-2017)
  - 1300 acres



Technologies:

- Pivot Telemetry
- Soil moisture sensors
- Weather stations
- Geophysical mapping

Results post cost share:

- 95% of people keep pivot telemetry as it increases convenance (sticky technology)
- Only 10-15% of people kept soil moisture probes and weather stations, just not worth the hassle for most people
- Use of soil probes saved 3-4 in. in western NE, 1-1.5 inches in central NE

Trenton Franz – Personal Communication and Gibson et

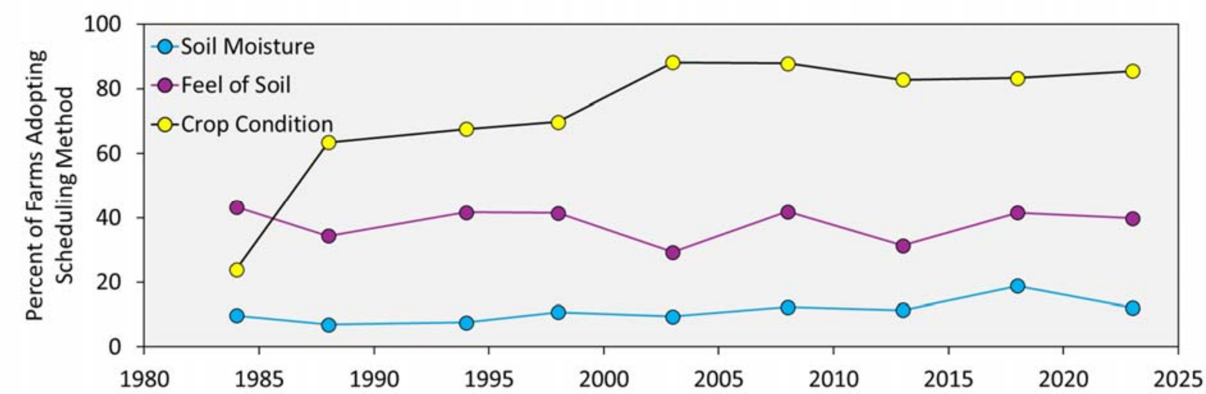
Technology Adoption

United States Department of Agriculture
Census of Agriculture Historical Archive

Table 25. **Methods Used in Deciding When to Irrigate: 2023**

[Excludes institutional, research, and experimental farms. For meaning of abbreviations and symbols see introductory text.]

Geographic area	Farms reporting any method	Farms reporting method used[1]									
		Condition of crop	Feel of soil	Soil moisture sensing device	Plant moisture sensing device	Commercial or government scheduling service	Reports on daily crop-water evapo-transpiration (ET)	Scheduled by water supplier	Personal calendar schedule	Computer simulation models	When neighbors begin to irrigate
Kansas	4,188	3,579	1,668	506	82	675	459	63	203	21	133



Irrigation System – Potential Application Efficiency

Furrow (Conventional): 45-65%

Furrow (Surge): 55-75%

Center Pivot: 75-85%

SDI: >95%

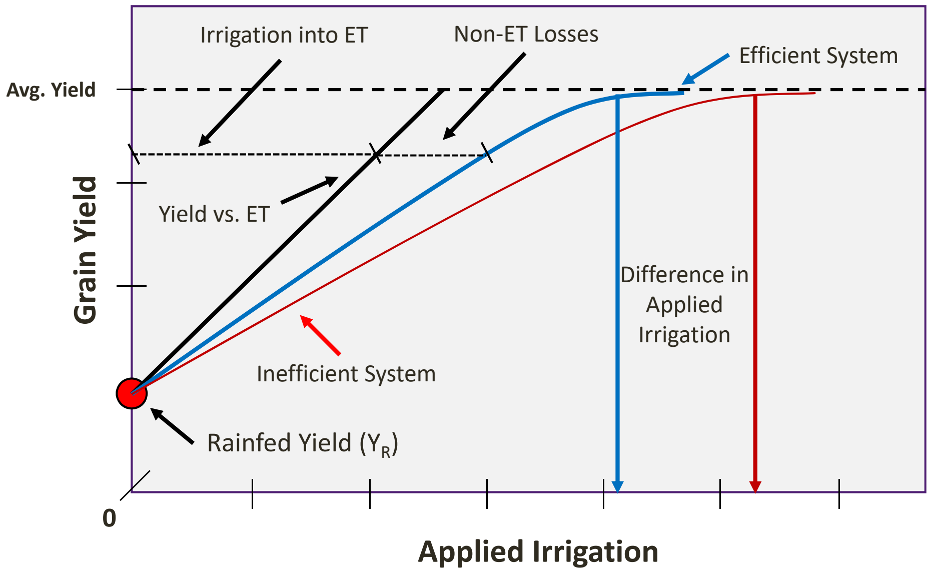
Center Pivot: 75-85%

Center Pivot (LEPA): 80-90%

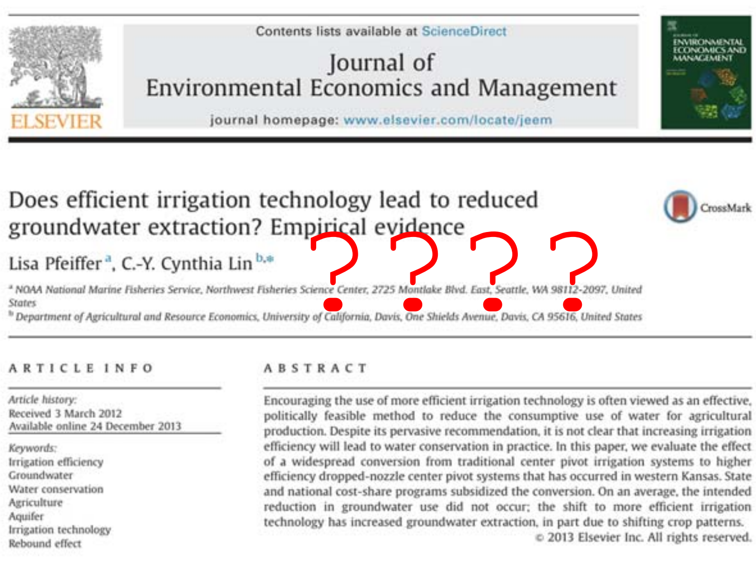
MDI and Surface Drip: 85-90%

Source: Irmak et al. (2011); Rudnick and Irmak (2015)

Crop Response to Irrigation



Does System Improvements Reduce Irrigation?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Does efficient irrigation technology lead to reduced groundwater extraction? Empirical evidence

Lisa Pfeiffer[a], C.-Y. Cynthia Lin[b,*]

[a] NOAA National Marine Fisheries Service, Northwest Fisheries Science Center, 2725 Montlake Blvd. East, Seattle, WA 98112-2097, United States

[b] Department of Agricultural and Resource Economics, University of California, Davis, One Shields Avenue, Davis, CA 95616, United States

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ABSTRACT

Encouraging the use of more efficient irrigation technology is often viewed as an effective, politically feasible method to reduce the consumptive use of water for agricultural production. Despite its pervasive recommendation, it is not clear that increasing irrigation efficiency will lead to water conservation in practice. In this paper, we evaluate the effect of a widespread conversion from traditional center pivot irrigation systems to higher efficiency dropped-nozzle center pivot systems that has occurred in western Kansas. State and national cost-share programs subsidized the conversion. On an average, the intended reduction in groundwater use did not occur; the shift to more efficient irrigation technology has increased groundwater extraction, in part due to shifting crop patterns.

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Does System Improvements Reduce Irrigation?

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Details Figures References Cited by

Efficiency and Water Use: Dynamic Effects of Irrigation Technology Adoption

Micah V. Cameron-Harp and Nathan P. Hendricks

PDF PDF PLUS Abstract Full Text Supplemental Material

Abstract

As global aquifer levels continue to decline, clarifying the impact of irrigation efficiency improvements on water resources is critically important. This study uses two transitions in irrigation technology to investigate whether rebound effects cause such efficiency improvements to increase resource extraction, a phenomenon known as Jevons's paradox. We demonstrate how staggered adoption of an irrigation technology and dynamic treatment effects cause two-way fixed effects (TWFE) to indicate the wrong sign for the effect on withdrawals. Using an estimator appropriate for these circumstances, we find no significant evidence of Jevons's paradox. The dynamic effects we find explain this discrepancy and, perhaps more important, reveal irrigators' process of adaptation to each new technology at the intensive and extensive margins.

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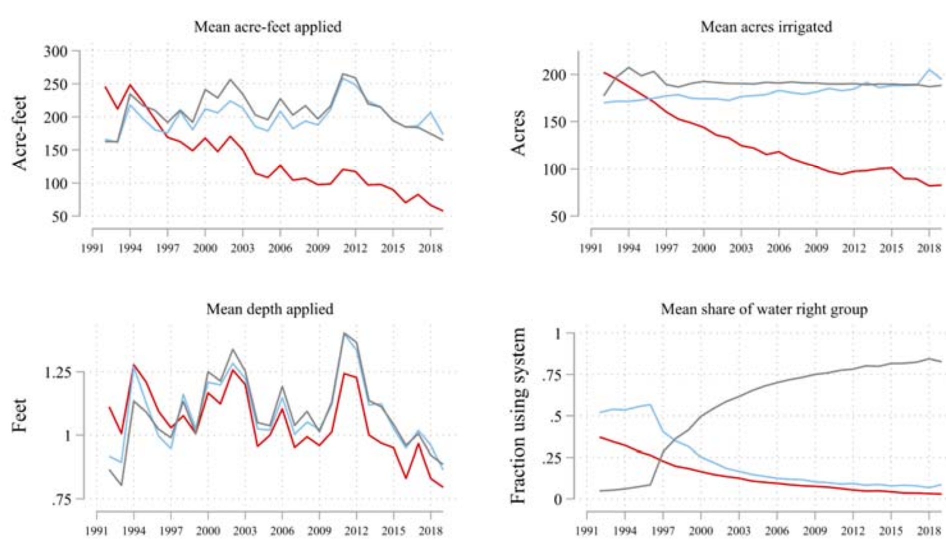
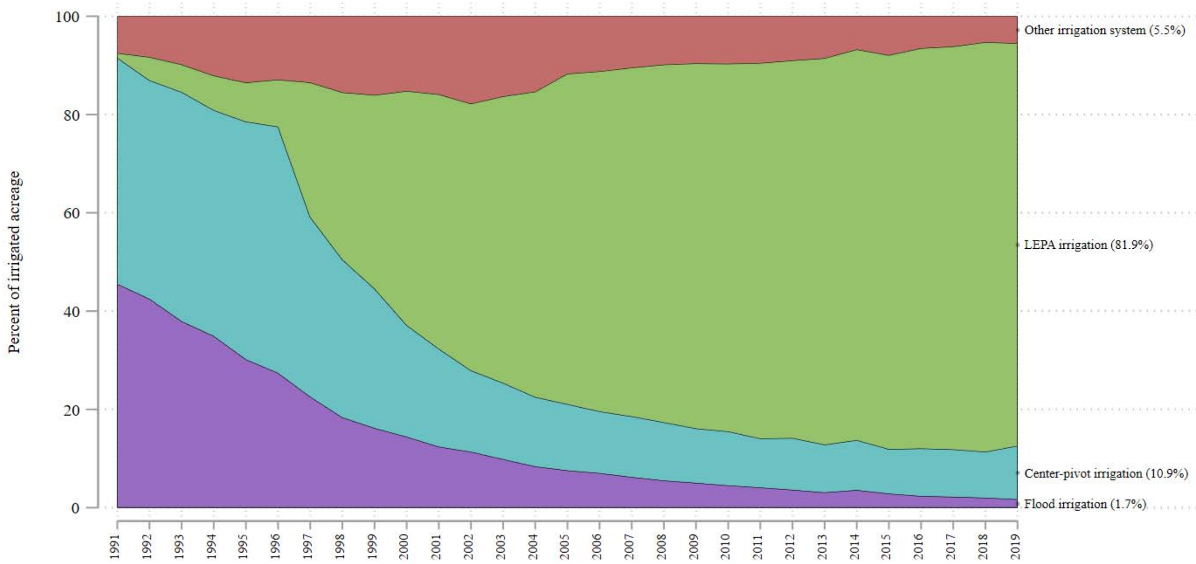
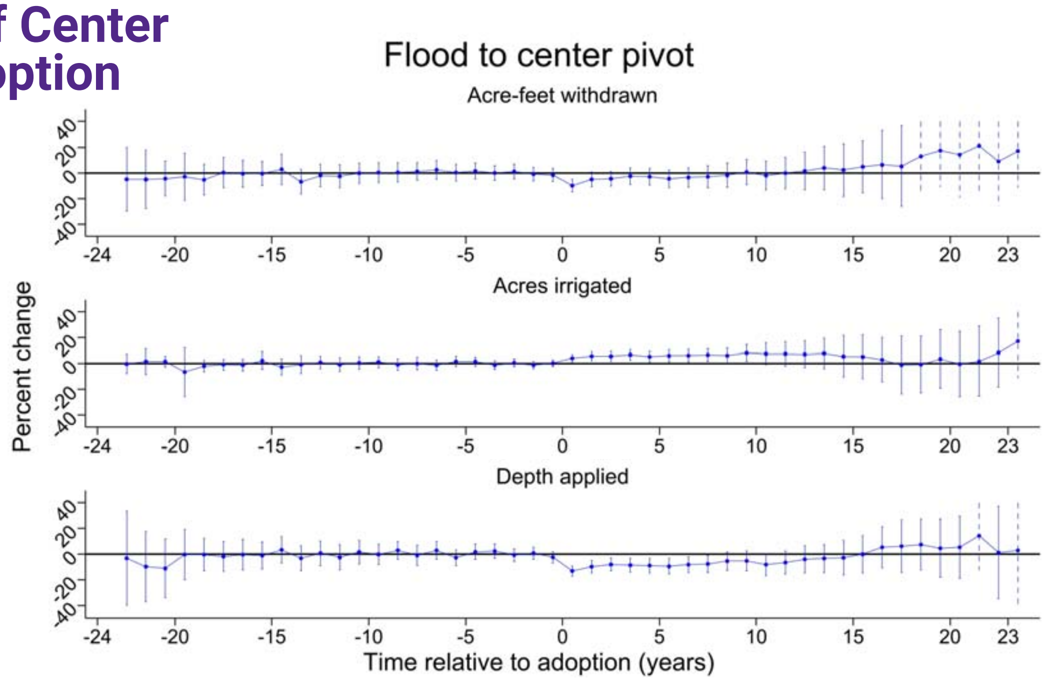


Irrigation Systems – Adoption over time

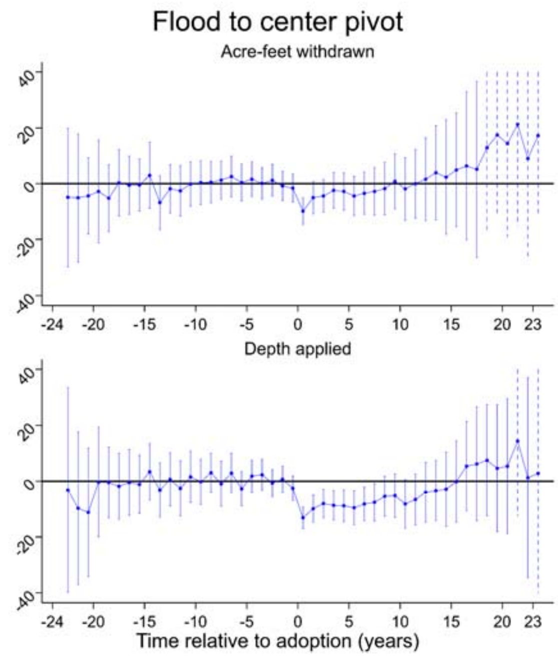


Effects of Center Pivot Adoption

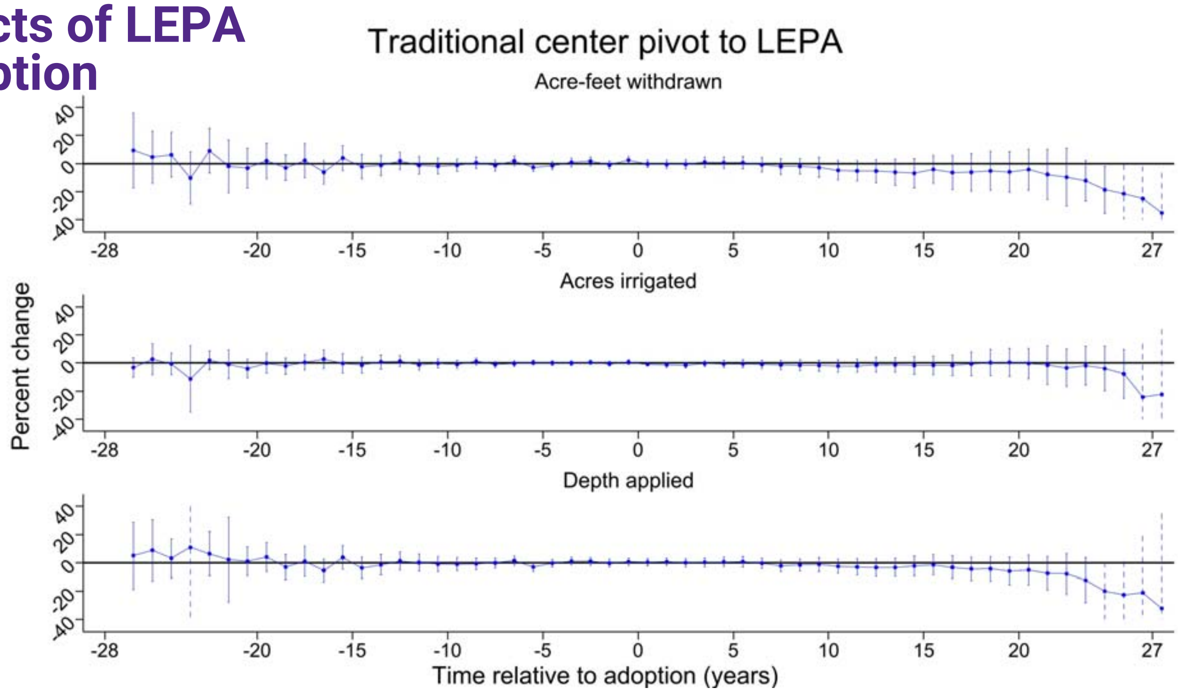


Effects of Center Pivot Adoption

- **Intensive and Extensive Margins:**
  - Irrigators made insignificant extensive margin adjustments, but made larger changes at the intensive margin (reduction in depth-applied)
  - Large (>20%) increase in efficiency from adopting center-pivot systems translated into immediate reductions in withdrawals and ability to maintain irrigated production longer in the future.

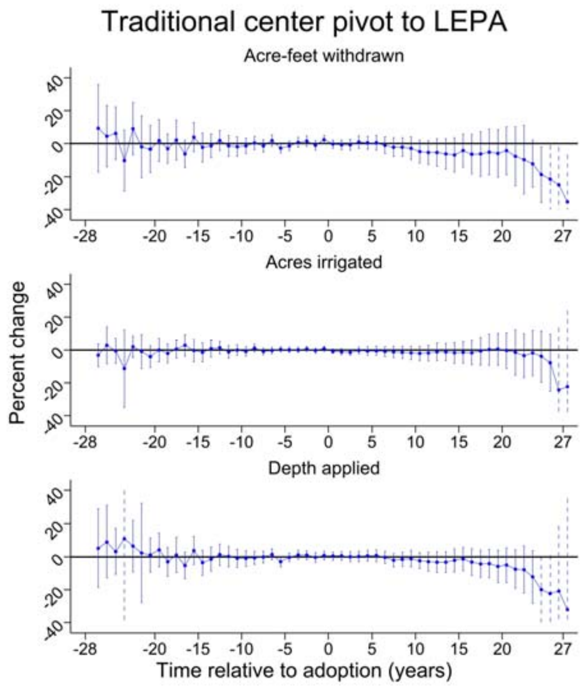


Effects of LEPA Adoption



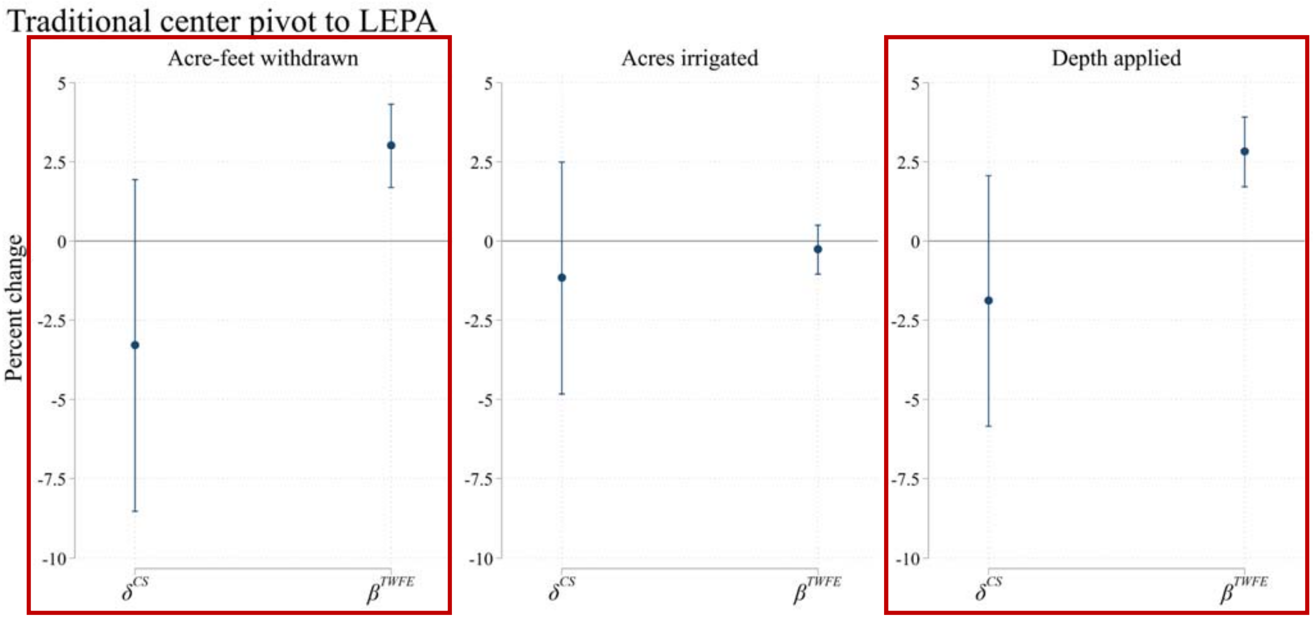
Effects of LEPA Adoption

- **Intensive and Extensive Margins:**
  - Minor, statistically insignificant effects in the near term consistent with smaller change in application efficiency.
  - Evidence that adoption facilitated long-term adaptation at the intensive margin for adopters.



K-STATE RESEARCH AND EXTENSION

Results – LEPA adoption



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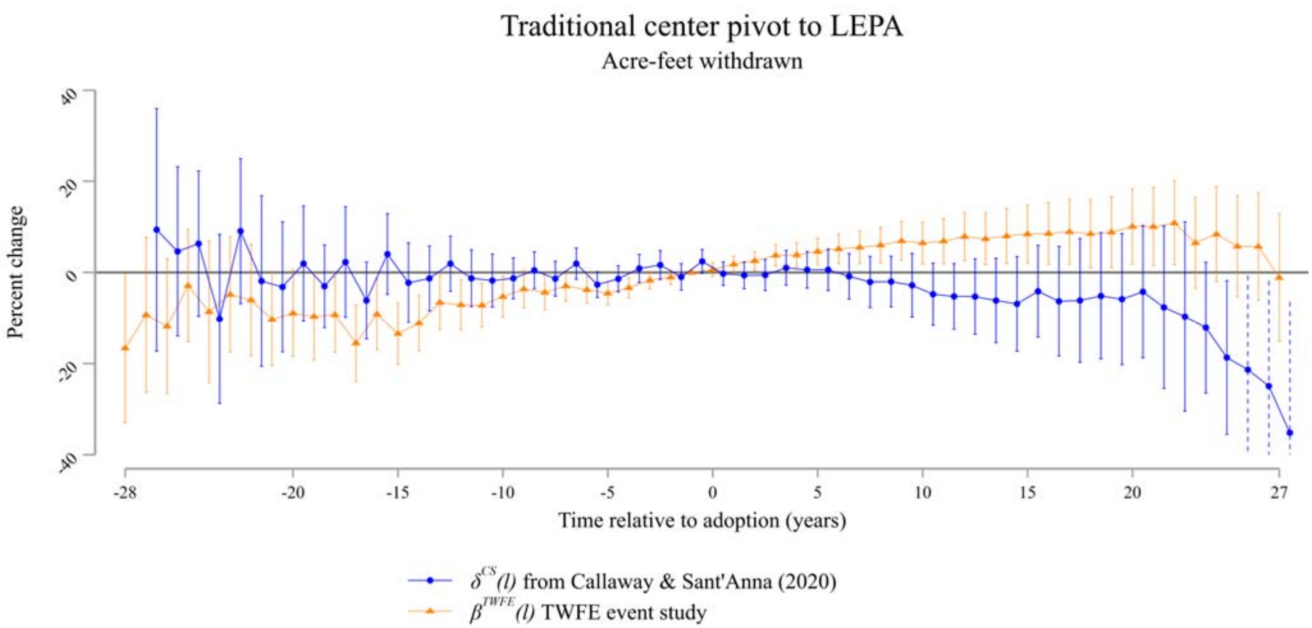

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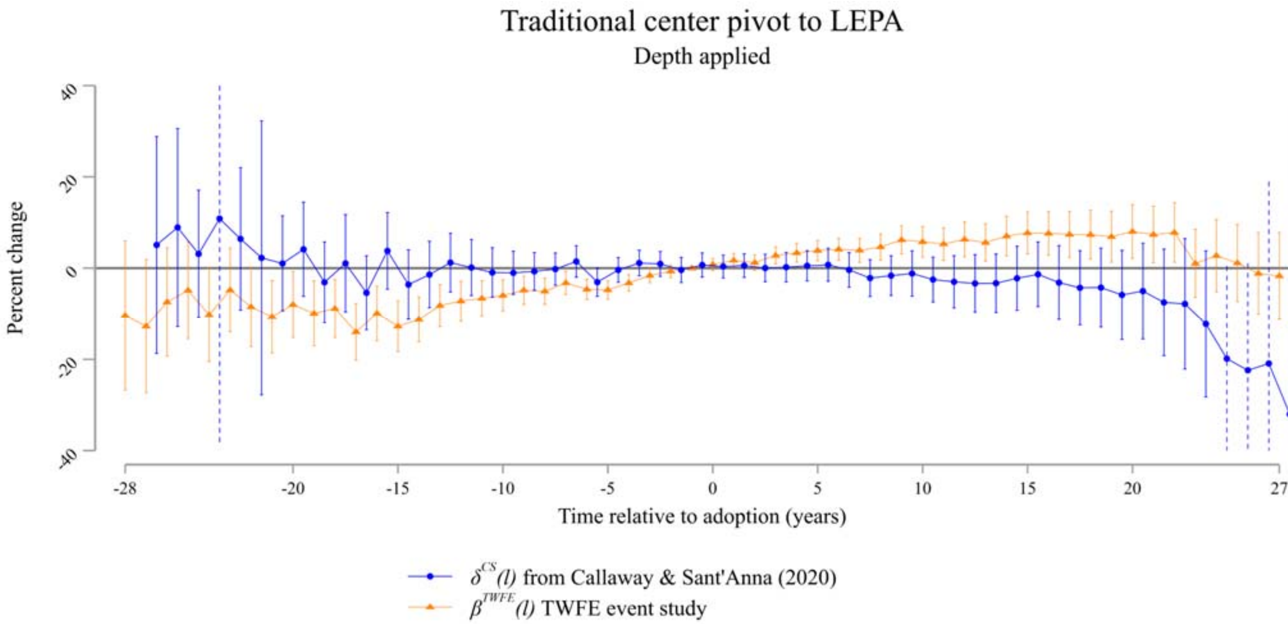
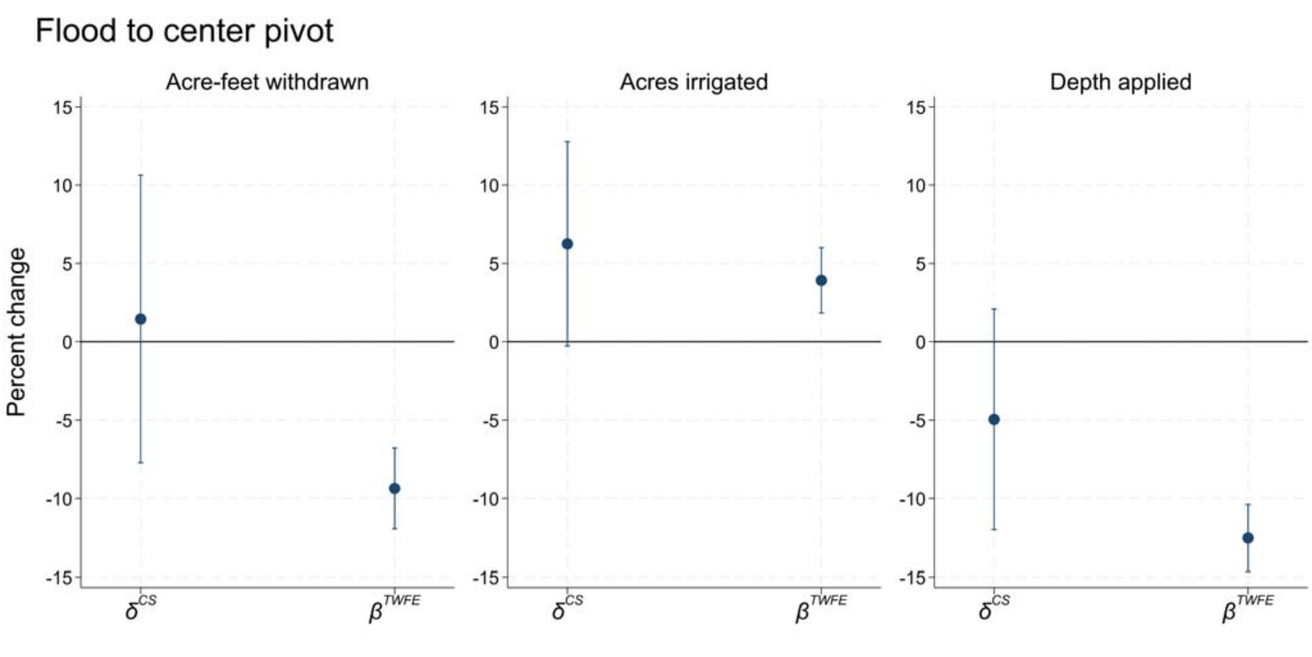


Results – Flood to Center Pivot



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