Do Flexible Water Allocations Reduce Groundwater Extraction?

Evidence from Multi-Year Flex Accounts in Kansas

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Groundwater in Kansas: the situation

- The Ogallala is the largest freshwater aquifer in North America — and in decades-long decline
- Kansas water levels fell **more than 1.5 feet** in a single recent year (Kansas Geological Survey, 2024)
- Irrigation access is worth an estimated **$3.8 billion** of western Kansas land value
- Lost saturated thickness is projected to cut returns to land by **$34 million/yr** by 2050 (Hendricks et al., 2022)

This is a balance-sheet problem

Water in the ground is capitalized into land values. Depletion shows up on your members' equity, their collateral, and their borrowing base — not just in the well log.

And the clock is now statutory

Kansas has moved from voluntary concern to required planning.

Water rights are property — and property is hard to change

- Building a rights system is expensive: measurement, adjudicating decades of historical claims, permanent administration
- What comes out is a **durable property interest** — and holders defend it
- Changing a right's quantity, timing, or transferability must clear protections for **senior** users
- Those transaction costs deter reallocation even where the gains are large (Colby, 1990; Womble and Hanemann, 2020)

Why the MYFA is worth studying

Kansas allocated these rights under what critics called a "policy of planned depletion" — a fixed quantity each year, forfeited if unused.

The MYFA is a **rare case** where the terms of existing rights were actually modified for conservation — and it did it **without taking anything away**.

That is why a voluntary, right-preserving tool is worth a careful look: it is the kind of change that can actually happen.

HB 2279 put every GMD on a deadline

we are here

Apr 2023	Jul 2024	Jul 2026	Ongoing
HB 2279 signed	Priority areas of concern identified	**Action plans due to chief engineer**	Review at least every 5 years

- Districts must flag areas where the aquifer's **usable lifetime is 50 years or less**
- Then submit a **water conservation and stabilization action plan** — the chief engineer reviews it within 90 days, and can write one himself if a district doesn't (Kansas Legislature, 2023)

The plans are in. The live question is **which tools go inside them** — and what each one actually delivers.

My research: how do producers adapt to scarcity?

Technology
More efficient irrigation does not automatically save water — adoption can raise use as saved water is put back on the field
(Cameron-Harp and Hendricks, 2025; Pfeiffer and Lin, 2014)

What water is worth
Groundwater is priced into land: access alone carries a **∼71% premium** (∼$1,445/acre), and larger, more senior rights sell for more
(Sampson et al., 2019; Edwards et al., 2025)

Local regulation
Sheridan 6 LEMA: irrigator-driven cuts extended the aquifer's usable life, with farm returns holding up
(Orduña Alegría et al., 2024; Golden and Leatherman, 2015)

Allocation flexibility — today
Can we change *when* water may be used, rather than *how much*, and still conserve?
Multi-Year Flex Accounts

Common thread: producers respond to the **rules and prices they actually face** — so the design of the rule decides the outcome.

Today's question

Research question
Does enrolling in a Multi-Year Flex Account change how much groundwater a producer pumps?

Why it belongs in this conversation:

- A MYFA is **voluntary**, keeps the underlying water right intact, and requires **no mandated cutback**
- That makes it one of the few conservation tools that can go into an action plan without a fight
- But nobody had measured what it does to actual pumping

Where this ends up
Enrollment cuts annual withdrawals by roughly **12.5%**. Flexibility *conserves*.

"Use it or lose it" distorts pumping

Standard water right — a *hard cap*

- Fixed quantity **every single year**
- Unused allocation is forfeited on December 31
- Incentive to pump water you don't need
- No cushion carried into a dry year

Multi-Year Flex Account — a *soft cap*

- One **five-year** aggregate budget
- Bank unused water across years
- Voluntary, and it expires — you renew or revert
- Kansas, 2012 (SB 272)

The open question: does flexibility **conserve** water, or just **move** pumping between years?

What a MYFA actually does

- Annual limit is **suspended for five years** and replaced with one aggregate budget
- Budget = **5**× average annual use over the 2000–2009 base period (or 5× a crop water requirement)
- **No annual ceiling** during the term — use it when the crop needs it
- Apply to DWR; at the end, renew or revert to annual allocation

In our data: **753** water right groups enrolled between 2012 and 2020 — about **80%** signed up in 2012, right after the drought.

Where a MYFA sits in the Kansas toolkit

Tool	Who starts it	Who it binds	What it changes
Annual water right	—	every right holder	Fixed quantity each year; unused is forfeited
MYFA	**the right holder**	**only the enrollee**	**Timing** — a 5-year budget replaces the annual limit
LEMA	GMD board, approved by the chief engineer	everyone in the area	**Quantity** — a locally negotiated cut
IGUCA	chief engineer, on a GMD request, a petition, or his own review	everyone in the area	**Quantity** and permitting, imposed

Sheridan 6 shows what the binding version delivers: a locally negotiated **20% cut over five years**, met without hurting profitability (Golden and Leatherman, 2015).

Note the family resemblance — Sheridan 6 also runs on a *five-year* allocation. A LEMA is flexibility *plus* a cut; a MYFA is **flexibility alone**.

Two ways this could go

Story 1: it conserves

Once leftovers carry forward, there is no reason to run the pivot in September just to protect next year's allocation. Water left in the ground **keeps its value**.

Story 2: it just reshuffles

Pump less in wet years, more in dry ones, and the five-year total lands in the same place. Flexibility buys resilience, not conservation.

- The concern is not hypothetical: simulation work finds soft caps raise drought-year pumping and streamflow depletion, even while raising farm profits (Young et al., 2021)
- Both stories are internally consistent — which one holds is an **empirical** question

So: first work out what theory says to look for, then go to the data.

The key idea: saved water gains a price

Under an **annual cap**, an acre-foot you don't pump by December 31 is worth exactly zero.

Under a **five-year budget**, that same acre-foot is **insurance against the next dry year** — it has a price even if you never pump it.

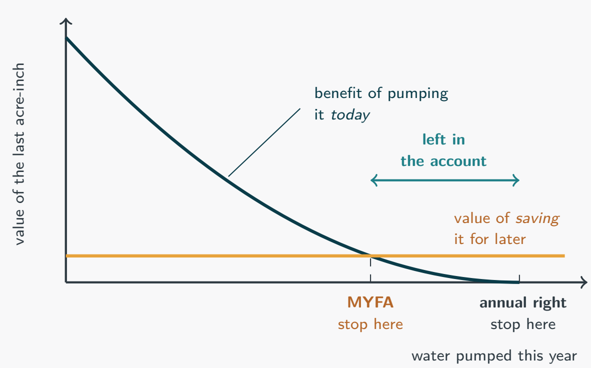
That price is a real **cost of pumping today**. It is the one thing a soft cap has and a hard cap does not.

Three consequences

1. **You stop short.** The last acre-inch now competes with its value next season
2. **You build a cushion** larger than any single-year allocation could give you
3. **Dry years cluster here** — so a dry season makes saving *more* valuable, not less

Conservation is not a side effect of the MYFA. It is built into what a multi-year budget *is*.

The control rule: pump until the two values meet



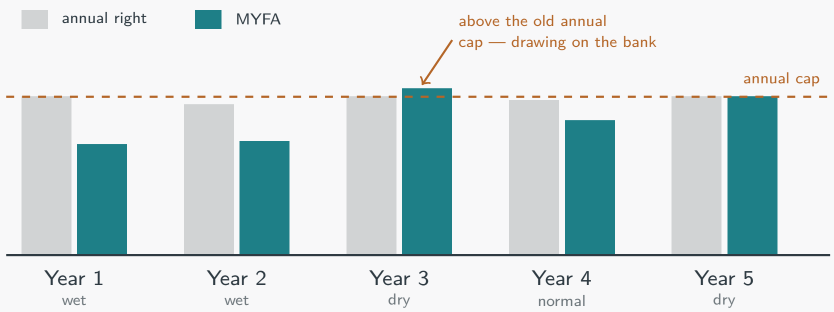
Schematic — not drawn to the estimated scale.

The rule

$$\underbrace{\pi'(q_t+\varepsilon_t)}_{\text{worth of the last acre-inch today}} = \underbrace{\delta\,\mathbb{E}[\mu]}_{\text{what that water is worth next year}}$$

- Under an **annual right**, saved water is worth zero — the line sits on the floor, so you pump until the last acre-inch is worthless
- Under a **MYFA** the line **lifts off the floor**, and you stop where the curve meets it
- Rain shifts the curve; the **height of the line** is what the policy changes

What banking looks like over one five-year term



Annual right: little reason to leave anything behind in a wet year, and no way to carry a wet year forward into a dry one.

MYFA: hold back when rain does the work, spend the balance when it doesn't. In this illustration the five-year total is **12% lower** — and it is lower *because* the wet-year savings were worth keeping.

When does flexibility actually conserve?

The saving motive beats the drawdown motive when rainfall is **variable**, has a **bad left tail**, and **dry years cluster** — and when producers plan ahead.

Western Kansas, May–Sept rainfall

Year-to-year variability (CV)	0.34
1 year in 10 at or below	47 mm
against a median of	76 mm
Dry-follows-dry correlation	+0.24

So we go looking for

- **P1.** Average pumping **falls** under a MYFA
- **P2.** The effect is **weaker** for producers who enroll in a drought — there is nothing to bank

Every condition the theory needs is satisfied here. Western Kansas is close to the best case for a soft cap.

Data and approach

- Kansas **WIMAS** water-use reports — what producers actually reported pumping
- ≈**13,000** water right groups, **2001–2021** (240,000 group-years)
- **753** of them enrolled in a MYFA
- Outcomes: total water use, **depth applied** (af/acre), crop acres
- Rainfall at each field's location as a control

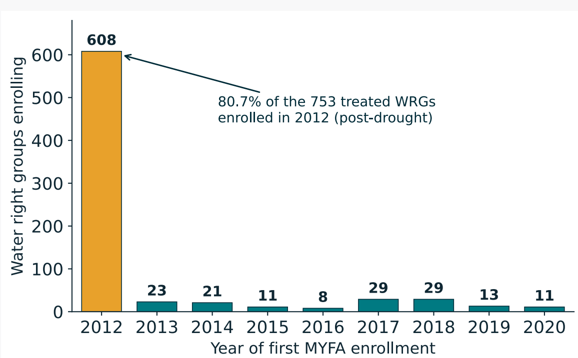
How the comparison works

Enrollees are compared to **similar non-enrollees in the same GMD**, before versus after enrollment.

Because accounts expire, we also track what happens once a producer reverts to an annual right.

Estimator details in the backup slides, and happy to go deeper in questions.

Who signed up, and where

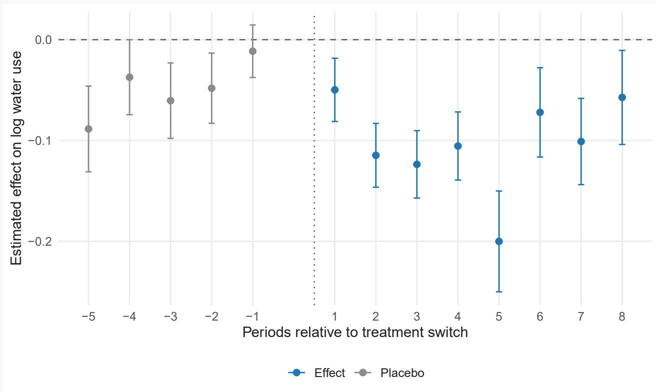


Year of first enrollment — **80%** came in 2012, the program's first year, right after the drought.

GMD	WRGs	Enrolled	Rate
1	955	23	2.4%
2	1,348	131	**9.7%**
3	4,921	161	3.3%
4	2,258	56	2.5%
5	3,466	382	**11.0%**
All	12,948	753	5.8%

Uptake is very uneven: GMDs 2 and 5 enroll at four times the rate of the others, and GMD 5 alone accounts for half of all enrollees.

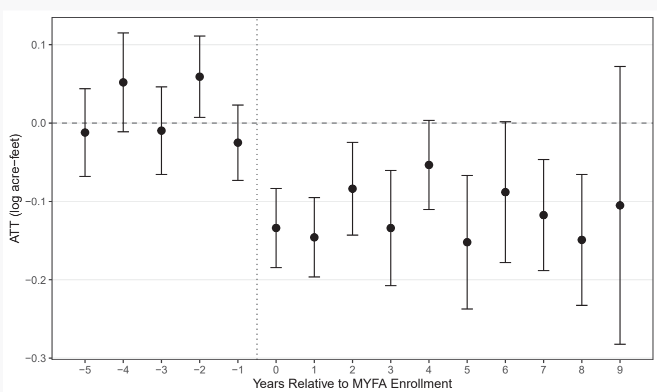
Result 1: MYFAs cut withdrawals about 12.5%



- Reduction in **every year** after enrollment
- Shows up **immediately** — not after a learning period
- Still there **after the account expires** and the annual right returns
- Average: −12.5%

Years 1–5 are inside the flex term; years 6–8 are after it expired. Vertical bars are 95% confidence intervals.

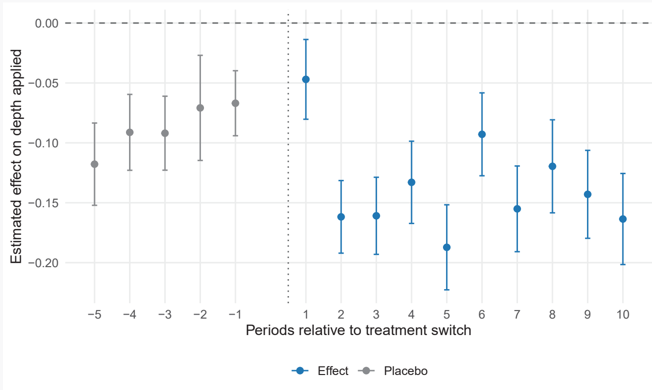
Does a second method agree?



- A **different comparison method**, same data, different assumptions
- Same sign, same timing, same ballpark: −11% against −12.5%
- Wider bands — it uses fewer comparisons, so it is less precise

When two approaches that lean on different assumptions land in the same place, the finding is not an artifact of one of them.

Result 2: efficiency, not fallowing



Water applied per acre

- Down **about 17%**
- Roughly **2.3 acre-inches** less per acre per year

Irrigated acres **hold steady**. Producers are watering the same ground more carefully — not idling it.

The same intensive-margin adjustment found under Sheridan 6 (Drysdale and Hendricks, 2018; Deines et al., 2019).

And the crop mix barely moves

Crop	Acres	95% CI
Wheat	+10.2	[0.6, 19.8]
Sorghum	+6.3	[−2.4, 15.1]
Alfalfa	+5.2	[−7.7, 18.0]
Soybeans	−2.1	[−6.7, 2.5]
Corn	−4.2	[−21.0, 12.5]

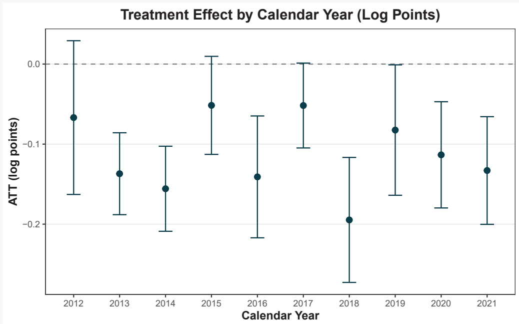
Effect of enrollment on acres planted, per water right group.

- Only **wheat** moves detectably — about **10 more acres** per group
- Corn, soybeans, sorghum, and alfalfa are not distinguishable from zero
- Wheat is less water-intensive, and much of its water comes from winter and spring rain — a modest extra margin of saving

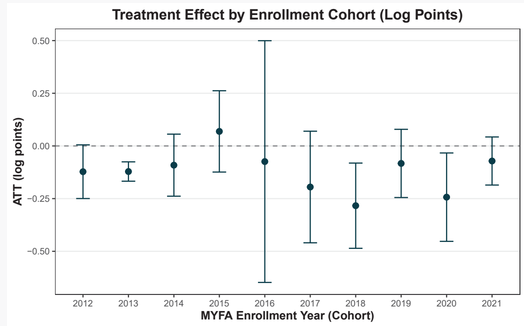
The headline for this room

Enrollees are not switching crops or idling ground. They are growing **the same things on the same acres** with less water.

Result 3: the effect follows the weather



By calendar year — largest in mixed-to-favorable years



By enrollment year — 2013 signers best measured

- Conservation concentrates in years when rainfall left something **worth banking**
- Enrollment-year pattern points the same way, but drought cohorts are small — suggestive, not settled

What that adds up to

- Average water right group pumps **167 acre-feet**/yr
- A 12.5% cut is about **21 acre-feet per group, per year**
- Across ∼750 enrolled groups: roughly **15,000 acre-feet a year**
- That is about what a small Kansas town uses annually

Is the number solid?

The headline survives the checks I can throw at it. Depending on how conservatively you read the pre-enrollment trends, the effect lands somewhere between roughly **4% and 23%** — and about **9%** if you drop the single district that supplies half the enrollments.

Negative and meaningful either way.

And it comes from producers volunteering — nobody was told to cut back.

What it means for a cooperative

Volumes should hold

Acres stay put and the crop mix barely moves — so enrollment is unlikely to move your members' **bushels, inputs, or delivery patterns** much. The saving comes out of applied water.

Uptake looks information-driven

80% enrolled in a single year, right after a drought, and district uptake runs from 2% to 11%. That spread is hard to explain by hydrology alone — it looks like **who heard about it, and when**.

Balance sheets benefit

Groundwater is capitalized into land. Slowing decline protects **member equity and collateral** (Sampson et al., 2019; Edwards et al., 2025).

The honest caveat

These are averages over producers who *chose* to enroll. A member with no slack in a dry year has less to gain — and I cannot yet measure that member well.

Co-ops sit where that information moves — agronomists, board rooms, marketing conversations.

What this means

Flexibility is not a loophole

A multi-year budget puts a **price on water you leave in the ground** — a conservation incentive built into the instrument, not a hoped-for side effect.

For the tools going into HB 2279 action plans:

- -12.5% withdrawals and -17% water per acre, from a **voluntary** program with no mandated cutback
- Immediate, persists past expiration, and lands hardest in years with slack to bank
- One caution: flexibility also lets pumping concentrate in a drought. Where a stream is connected, pair the budget with an annual ceiling (Young et al., 2021)

Temporal flexibility, often viewed with suspicion, can **line up private incentives with aquifer conservation**.

Thank you

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Backup: how the effect is estimated

Preferred: de Chaisemartin and D'Haultfœuille (2024)	**Complement: Callaway and Sant'Anna (2021)**
• Treatment **switches on *and* off** — MYFAs expire, so most modern DiD estimators mis-code post-expiration years as treated • Switcher–stayer comparisons **within GMD**: a weaker parallel-trends requirement • Recovers post-expiration dynamics	• Doubly-robust group-time ATTs • Clean **cohort** and **calendar-year** aggregation • Absorbing-state coding (a caveat) — used for heterogeneity, not the headline

Sample: WRGs in GMDs, 2001–2021, non-LEMA, deduplicated ($N = 239{,}947$). SEs clustered at the water right group.

Backup: headline estimates

	Estimate (log pts)	Approx. %
dCdH within-GMD (preferred)	−0.133***	−12.5%
Depth applied (dCdH, ac-ft/acre)	−0.192***	−16.7%
Callaway–Sant'Anna (baseline)	−0.116***	−11%
C–S not-yet-treated only	−0.242***	−21%
C–S + pre-treatment use control	−0.087***	−8.3%
Bilinski–Hatfield residualized (V1)	−0.229	−20%

*** $p < 0.001$.

Sample: WRGs in GMDs, 2001–2021, non-LEMA, deduplicated ($N = 239{,}947$).

Backup: is it real? A conservative reading

- Within-GMD comparisons shrink the worst pre-enrollment placebo from −0.128 to −0.089, but a residual pre-trend remains
- Formal bounds (Rambachan and Roth, 2023; Bilinski and Hatfield, 2024) *bracket* the effect:

Counterfactual assumption	Implied ATT
Pre-trend = 100% selection	≈ −4%
Headline (within-GMD)	−12.5%
Pre-trend residualized out	≈ −23%

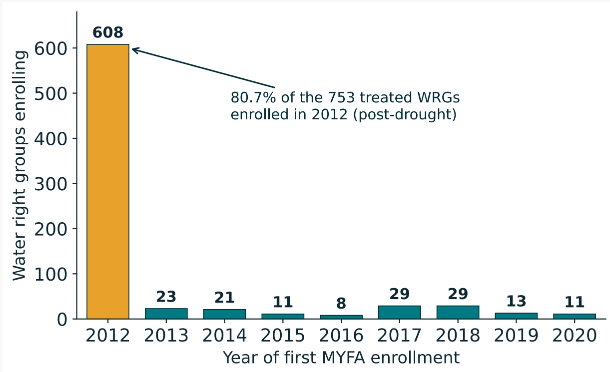
The headline is a **conservative midpoint** — if anything biased *toward* zero, not away.

Backup: leave-one-GMD-out

	Log water use	Depth applied
Full sample	−0.133***	−0.192***
Drop GMD 1	−0.136***	−0.196***
Drop GMD 2	−0.117***	−0.187***
Drop GMD 3	−0.164***	−0.212***
Drop GMD 4	−0.139***	−0.208***
Drop GMD 5	−0.095***	−0.128***

GMD 5 supplies 50.7% of treated WRGs and 52% of active-MYFA observations. Dropping it attenuates the effect by about a third but leaves it negative and significant — and it shrinks the pre-trend violation by a similar fraction.

Backup: enrollment timing & program term



Year of first MYFA enrollment; 753 treated WRGs.

Program term

- Each MYFA runs **5 consecutive years**
- Then **renew** or **revert** to annual allocation — treatment is **reversible**
- Non-consecutive re-enrollers excluded for a clean definition

Adoption is front-loaded: the 2012 cohort's term (2012–16) plus its post-2016 reversion is what identifies the **post-expiration** dynamics.