Renewable Energy and Farmland Market Dynamics

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Introduction: Farmland Price is important

- Farmland accounts for more than 80% of the value of total US farm assets (USDA, ERS).

Introduction: Farmland Price is important (continued)

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- Along with earnings from farming enterprises, the value of farmland has a significant impact on determining the well-being of farm households.

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- Along with earnings from farming enterprises, the value of farmland has a significant impact on determining the well-being of farm households.
- Farmland is not only the largest single investment in farmers' portfolios, but also the primary source of collateral for farm loans, which helps them to purchase additional farmland and farm equipments, or to finance farm expenses.

Modeling Farmland Price

- Farmland prices are influenced by two different categories of characteristics; farm and non-farm characteristics (Zhang and Nickerson, 2015).
  - Farm characteristics: Productivity, Acreage
  - Non-Farm characteristics: Proximity to solar energy, nearest distance to town, presence of natural amenities

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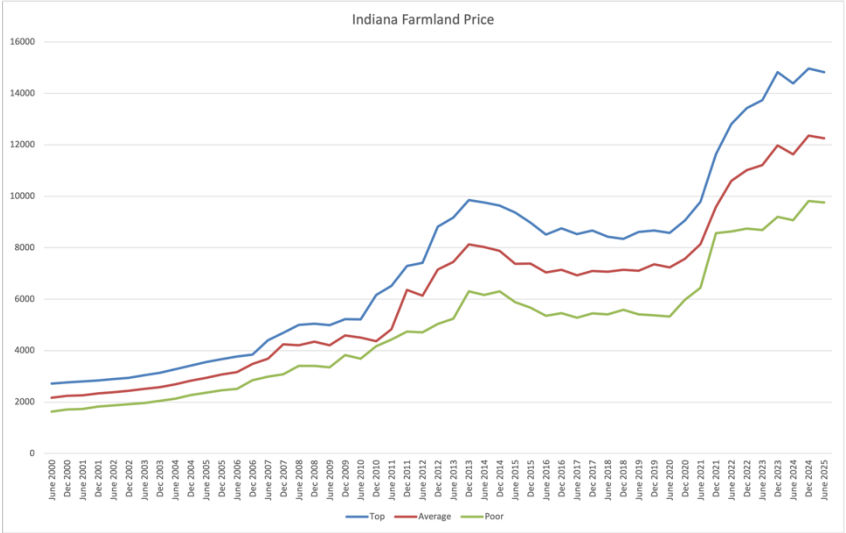
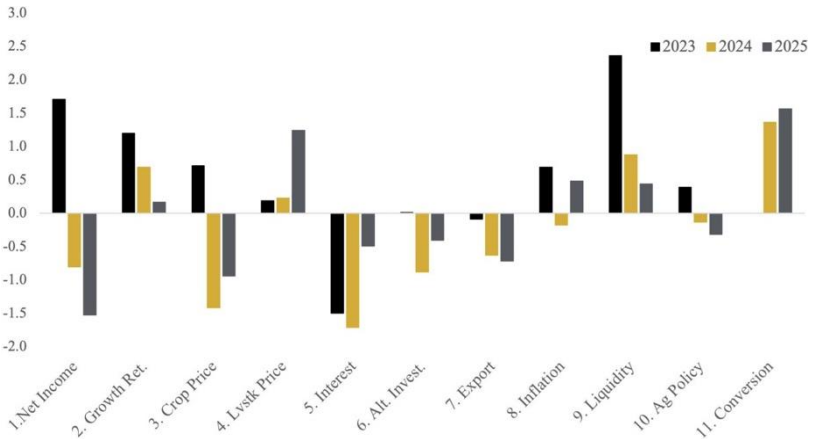
$$P_i = P_i\,(A_1, \ldots..A_j,\ B_1 \ldots\ldots B_k),\ i = 1, \ldots.., T \tag{1}$$

Indiana Farmland Values 2000–2025



What Drives Farmland Prices?



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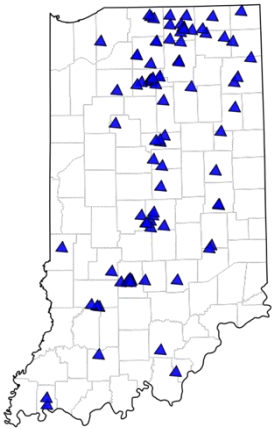
- Much of this expansion will occur on farmland, displacing cropland and affecting rural land markets (Schultz et al., 2021).
- This raises questions about how renewable energy projects influence farmland values and how landowners decide whether to convert their land.

Solar Energy Growth in Indiana

Indiana solar sites (2015)



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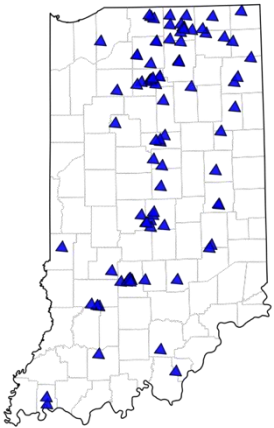

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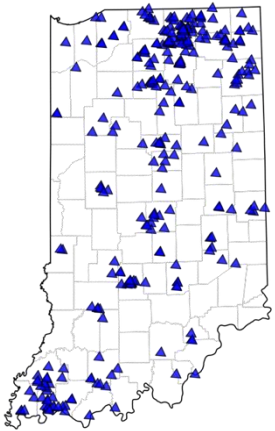
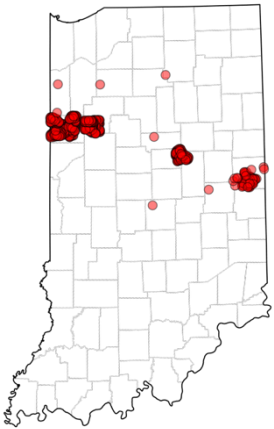
Indiana Solar Sites (2020)



Wind Energy Growth in Indiana

Wind turbine sites (2015)



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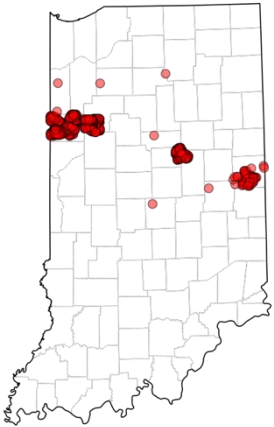

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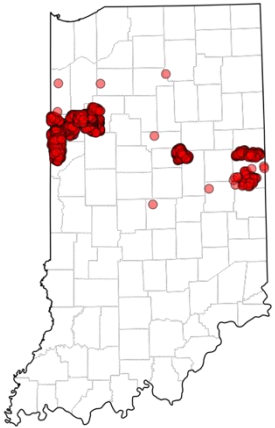
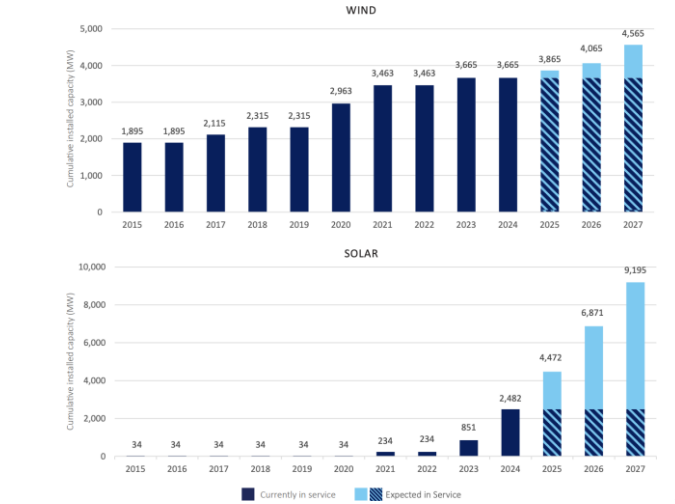


Expected Wind and Solar Growth in Indiana



Source: IURC (2025) Annual Report

Landowner Options have increased!

- Landowners have multiple options for how to use farmland: they may continue farming, engage in renewable energy projects, or engage in other current or future land conversions.

Landowner Options have increased! (continued)

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Landowner Options have increased! (continued 2)

- Landowners have multiple options for how to use farmland: they may continue farming, engage in renewable energy projects, or engage in other current or future land conversions.
- These options reflect the heterogeneous uses of farmland, which differ not only in their monetary returns but also in non-monetary attributes, such as whether land stays in agricultural production or retains flexibility for future development.

Land Uses and Contracts

- Farming: $250 to $350/acre; steady but modest returns; strong cultural and identity value.
- Wind leases (3 phases):
  - Option phase (5–7 yrs): $5 to $50/acre annually; landowners may receive signing bonuses of $1k to $10k
  - Construction phase (< 2 yrs): transitional payments offsetting lost crop production
  - Operations phase (25–35 yrs):
    - Scheme 1: Payments based on electricity generation capacity, typically $5k–$10k/MW
    - Scheme 2: Broader distribution, $1k–$3k per turbine plus $5–$50/acre across the property.
  - Extras: $1–$2/foot for access roads and transmission lines; compensation for tax increases; escalation clauses (1–2% fixed or CPI-based).

Land Uses and Contracts (continued)

- Solar leases (3 phases):
  - Option phase (5–7 yrs): $10–$50/acre annually; signing bonuses of $1k–$10k for key landowners.
  - Construction phase (< 2 yrs): transitional payments offsetting lost crop production
  - Operations phase (25–35 yrs): annual payments of $1,000–$1,700/acre; some contracts include $20–$40/acre for non-panel land within the lease.
  - Extras: $1–$2/foot for access roads and transmission lines; compensation for tax increases; escalation clauses (1–2% fixed or CPI-based).

Lease Payments

Lease	Quantity	Payment	Subtotal	Total
Crop Production	80 acres	$300		$24,000
Wind Power				
scheme 1	5 MW - 1 turbine	$7,500	$37,500	
	1,600 ft - access road	$1.50	$2,400	
	1,300 ft - power transmission	$1.50	$1,950	
	77 acres - crop production lease	$300	$23,100	
				$64,950
scheme 2	5 MW - 1 turbine	$2,000	$2,000	
	1,600 ft - access road	$1.50	$2,400	
	1,300 ft - power transmission	$1.50	$1,950	
	80 acres - payment	$30	$2,400	
	77 acres - crop production lease	$300	$23,100	
				$31,850
Solar Power				
	61 acres - solar power generation	$1,250	$76,250	
	19 acres - crop production lease	$300	$5,700	
				$81,950

Source: Author conversation with Indiana wind and solar power generation developers

Beyond Lease Payments

- Adoption decisions are not determined solely by financial returns.

Beyond Lease Payments (continued)

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- County zoning regulations create binding constraints on renewable energy development.

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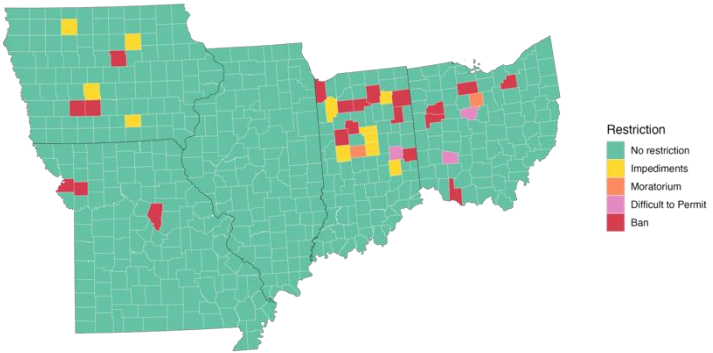
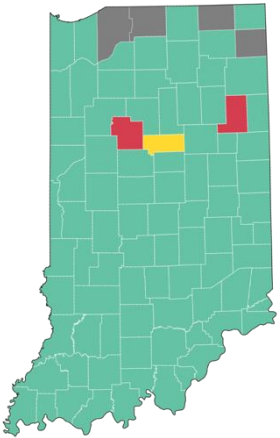


Source: USA Today's "Green Energy Nationwide Bans" article (2023).

Zoning Regulations in Indiana

Zoning Regulations (2015)



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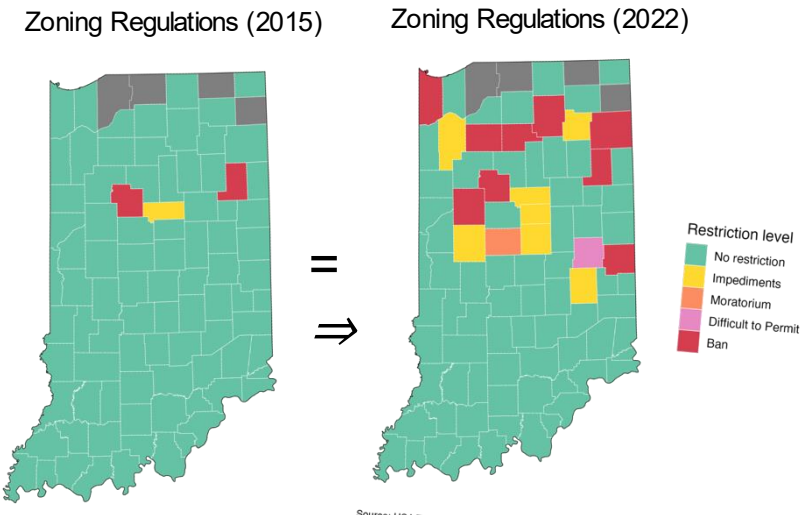

Question 1

- How Does Farm Income Affect Solar and Wind Adoption Rates?

Farm Income and Solar Adoption

		Land Use Ranked Second			
	ALL	Agriculture	Residential	Solar	Wind
Farm Return	-0.132	-1.006**	-0.680	0.448	-0.636
	(0.184)	(0.404)	(0.897)	(0.299)	(0.511)
Obs.	3958.000	475.000	863.000	1348.000	1272.000

Standard errors in parentheses, $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.010$
Control, Year and County fixed effect coefficients are not reported in the table above.

- In purely agricultural counties, farming returns do not affect adoption. Landowners either accept because leases pay more than farming, or reject because they value keeping land in production.

Farm Income and Wind Adoption

			Land Use Ranked Second		
	ALL	Agriculture	Residential	Solar	Wind
Farm Return	-0.286*	-0.853***	2.139	-0.747**	-0.348
	(0.168)	(0.235)	(1.375)	(0.296)	(0.427)
Obs.	3958.000	475.000	863.000	1348.000	1272.000

Standard errors in parentheses, $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.010$
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Question 2

- How Does Being Closer to Solar Energy Impact Farmland Prices?

Solar Impact on Farmland Price

	log(Price/Acre)								
	(0.1)	(0.2)	(0.3)	(0.4)	(0.5/OLS)	(0.6)	(0.7)	(0.8)	(0.9)
Solar_Distance	−0.008**	−0.011***	−0.013***	−0.014***	−0.015***	−0.016***	−0.016***	−0.017***	−0.019***
	(0.004)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$(\text{Solar\_Distance})^2$	−0.00006	0.00001*	0.0001**	0.0002***	0.0002***	0.0002***	0.0002***	0.0002***	0.0003***
	(0.0001)	(0.00001)	(0.0001)	(0.00005)	(0.00005)	(0.00005)	(0.00005)	(0.00005)	(0.0001)
	(0.008)	(0.0062)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Observations	40,817	40,817	40,817	40,817	40,817	40,817	40,817	40,817	40,817

*** ,**, and * denote 1%, 5%, and 10% significance levels
Controls, County and Year fixed effect coefficients are not reported in table above.

- Solar energy farms provide premium to its neighboring farmland. An increase in distance from solar energy farms causes price drop ranging from 0.8% to 1.9%.

The Impact Is Highest for High-Value Land.

	log(Price/Acre)	
	(0.01)	(0.99)
Solar_Distance	−0.002	−0.021***
	(0.007)	(0.004)
(Solar_Distance)^2	−0.0002	0.0003***
	(0.0001)	(0.0001)
Observations	40,817	40,817

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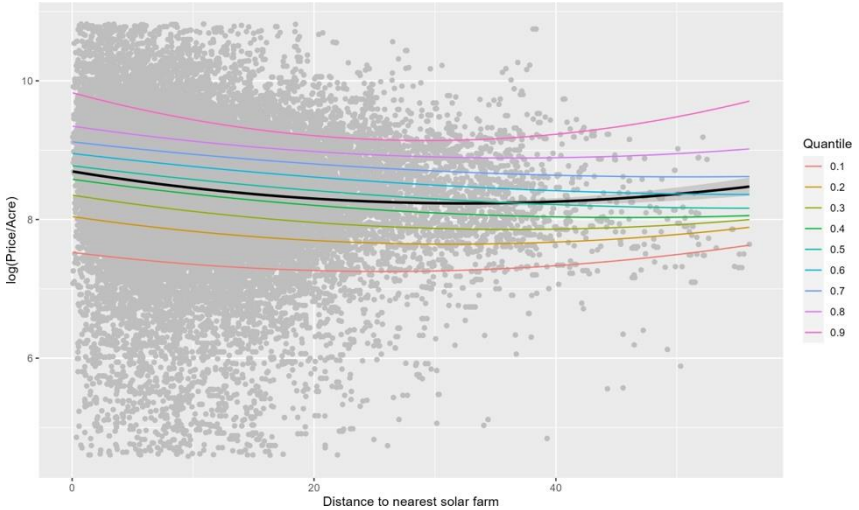
- High value farmland experiences a greater premium.

Relationship Between Farmland Price and Proximity to Solar Energy



Beyond Renewable Energy

- Renewable energy is not the only force reshaping farmland markets.

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- Indiana recently experienced one of the largest state-led land acquisitions in the Midwest, the IEDC land acquisition in Boone County starting late 2021.

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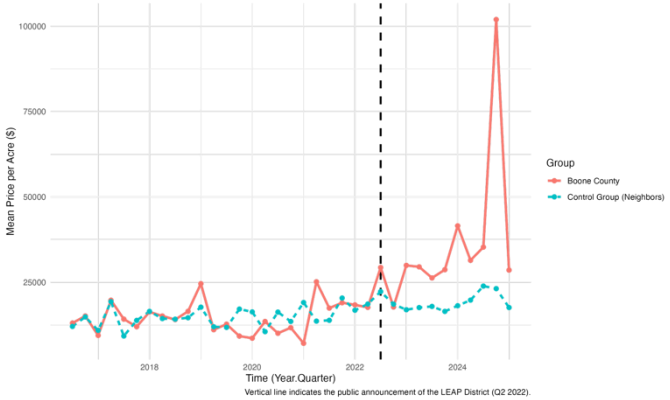


IEDC Impact on Farmland Price

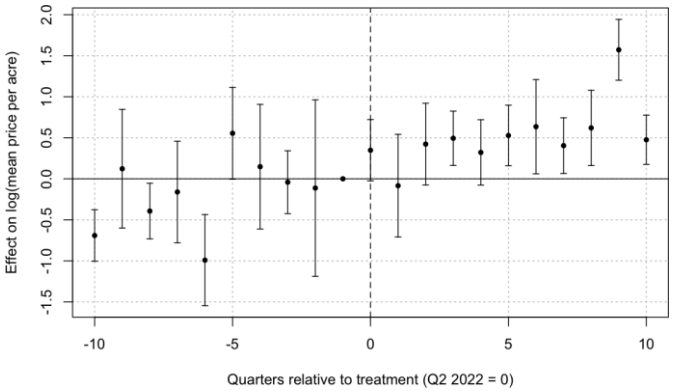
Variable	Model 1	Model 2	Model 3	Model 4
Localized Effect (Treated × Post)	0.338***	0.358***	0.458***	0.438***
	(0.093)	(0.094)	(0.078)	(0.075)
Spillover Effect (Neighbors × Post)	-	-	0.067*	0.074*
			(0.041)	(0.040)
Controls	Neighbor	Neighbor	Rest of IN	Rest of IN
Year Fixed Effects	No	Yes	No	Yes
County Fixed Effects	No	Yes	No	Yes

Note: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

Standard errors are in parentheses.

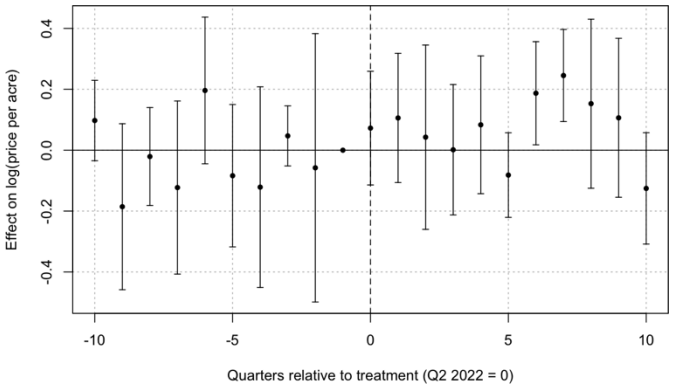
- The IEDC's large-scale land purchases increased farmland prices in Boone County by approximately 40%, with spillover effects raising prices in neighboring counties by about 7%.

Localized Dynamic Effect



- The localized price effect emerges roughly two quarters after the project announcement.

Spillover Dynamic Effect



- Spillover effects in neighboring counties appear only after five to six quarters.

Conclusions/Takeaways

- Farmland continues to appreciate.
  - Indiana land values have grown steadily, driven by both agricultural and non-agricultural factors.

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- Landowners now face more choices: continue farming, lease to energy developers, or other land conversion.

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- Renewable energy is expanding rapidly, and much of this growth is occurring on farmland.
- Landowners now face more choices: continue farming, lease to energy developers, or other land conversion.
  - These choices are shaped by financial incentives, zoning restrictions, and local attitudes.

Conclusion - Research-Based Insights

- **Relationship between solar energy and farmland price**
  - Solar energy farms provide premium to its neighboring farmland.

Conclusion - Research-Based Insights (continued)

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- **IEDC Land Acquisition**
  - The LEAP project in Boone County caused a sharp jump in nearby farmland prices, with additional spillover effects in neighboring counties.

Thank You!

Questions, Suggestions?

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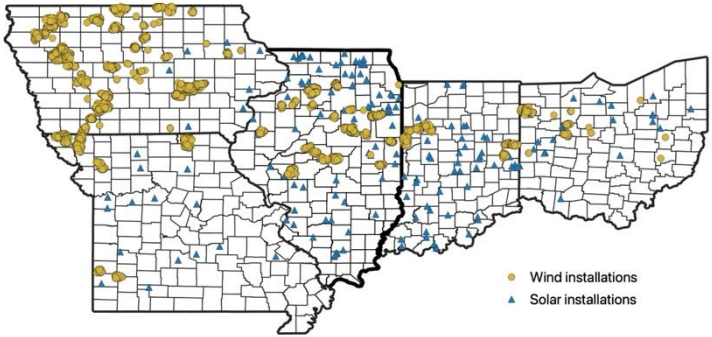
Main Findings

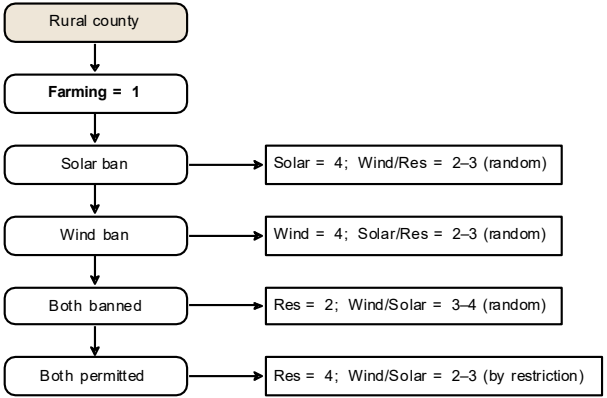
- **Main findings:**
  - Landowners are at the **monetary decision margin** only in limited cases, mainly in counties with potential for residential or commercial development.
  - In purely agricultural counties, farming returns do not affect adoption. Landowners either accept because leases pay more than farming, or reject because they value keeping land in production.
  - Adoption is also shaped by how leases affect farming: solar removes cropland, while wind allows continued production on most of the parcel.

Study Area



Land Use Preference Ranking

- We rank county land-use preferences using urban/rural status and renewable-energy regulations.



Similar ranking process is applied to urban counties.

Table: Land Use Preference Ranking

Land Use	*Ranking*			
	1	2	3	4
Agriculture	2550	475	479	454
Solar Energy	0	1348	1286	1324
Wind Energy	0	1272	1344	1342
Residential	1408	863	849	838