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Ag Economics, Kansas State University

Soil Health Practices and Farm Financial Performance (Part 2)

Authors:

Delide Joseph
Jennifer Ifft
Cesar Guareschi
Matthew Sanderson
Megan Hughes
Charles Rice

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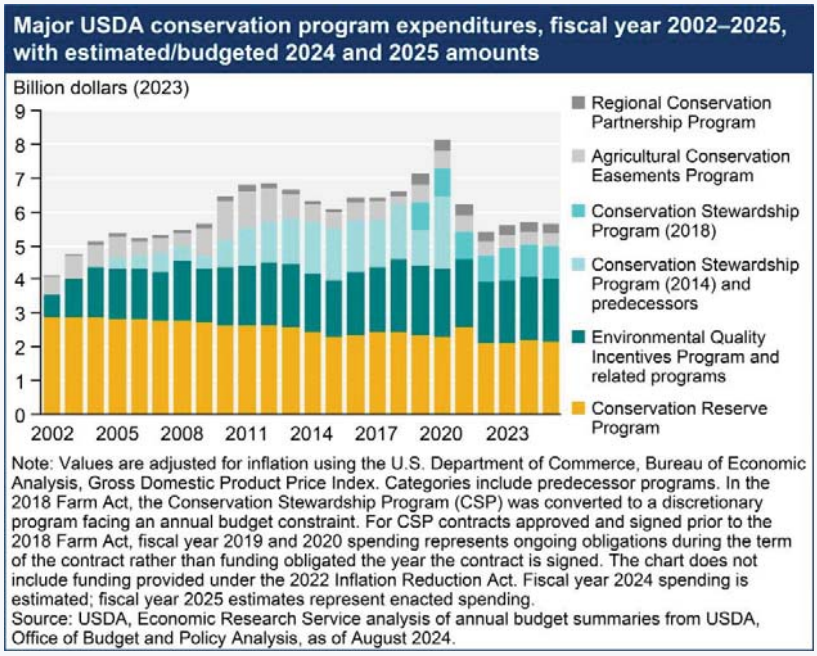
Motivation

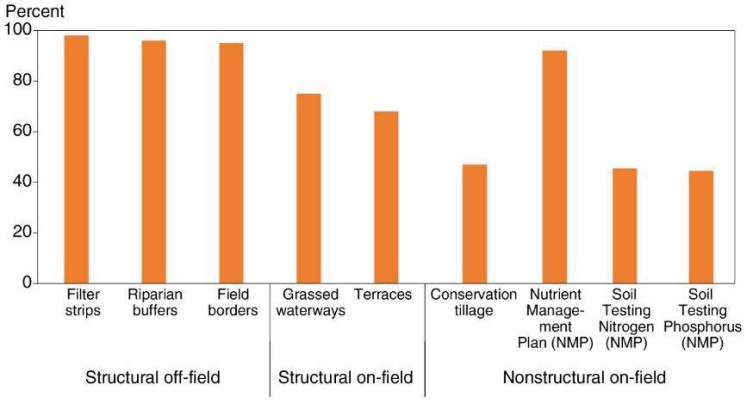
I Research Background & Motivation



An increasing number of private initiatives and USDA programs offer $$$ for adoption of practices or some type of carbon offset

Research Background & Motivation

The percentage of program participants who would not have adopted a practice without a conservation payment varies by practice



Note: Conservation payment could come from Federal, State, or local sources. While USDA is the largest single source of conservation payments, many agricultural States also have conservation payment programs.
Source: USDA, Economic Research Service (ERS) analysis using data from ERS and USDA, National Agricultural Statistics Service, Agricultural Resource Management Survey, 2009-12.

- *Practices that are not profitable are not sustainable*
- *Conflicting information on the costs and benefits of conservation practices*

Research Background & Motivation

TENNESSEE LOOKOUT

HEALTHCARE EDUCATION ENVIRONMENT POLITICS IMMIGRATION INVESTIGATES CASH FOR CLOUT

AGRICULTURE

Tennessee farmers turn to regenerative agriculture techniques to restore soil, environment

Principles include crop rotation and introduction of livestock in fields

Stark County farmers say regenerative practices are the future of farming

Ideastream Public Media | By Stephen Langel
Published February 27, 2024 at 6:33 AM EST

Nebraska Examiner

GOVERNMENT & POLITICS ENVIRONMENT & AGRICULTURE LABOR & GROWTH SOCIAL SERVICES EDUCATION HOUSING

ENVIRONMENT & AGRICULTURE

Farmer/advocate pitches 'regenerative agriculture' practices during farm tour

Christensen says such practices can reduce nitrate pollution in groundwater and rivers, resulting in healthier soil for future generations

AFN

Regenerative agriculture must 'pay dividends' on yields and livelihoods to increase farmer adoption, says survey

September 30, 2024 | Jennifer Marston

By Kansas Living on February 1, 2021

HOW REGENERATIVE AGRICULTURE IS IMPROVING FARMING

Four Reno County farmers try regenerative agriculture practices

I

Research Background & Motivation

The impacts of conservation practices on profitability are challenging to measure and quantify

- Data availability
- Combinations of practices
- Correlation vs causation?
  - Are more (or less) profitable farms more likely to adopt conservation practices, or do these practices have direct impacts that impact profitability

Chapter II

Research Questions

Research Questions

The BIG question

Do conservation practices pay?

In partnership with KFMA (Kansas Farm Management Association)

- Are KFMA farms that adopt conservation practices more profitable than farms who do not?
  - Yields
  - Expense measures
- Does the combination of practices make a difference?

Research Questions

Previous findings

Existing literature provides evidence of environmental and agronomic benefits of soil health practices. (Bergtold et al., 2017; Khangura et al., 2023a; Manzeke-Kangara et al., 2023; McCauley & Barlow, 2023; Myers et al., 2019; Rehberger et al., 2023)

But

Economic impacts are underexplored.

- Most research focuses on individual practices: No-till farming, Cover cropping, Crop rotation

Existing research provide inconsistent findings

- Positive financial impacts (Hughes & Langemeier, 2020; LaCanne & Lundgren, 2018)
- Negligible or negative effects (Plastina et al., 2018; Schnitkey et al., 2024).

Few studies examine the combined adoption of multiple practices.

- Cover cropping and tillage practices (Dozier et al., 2017; Snapp & Surapur, 2018; Nouri et al., 2019)

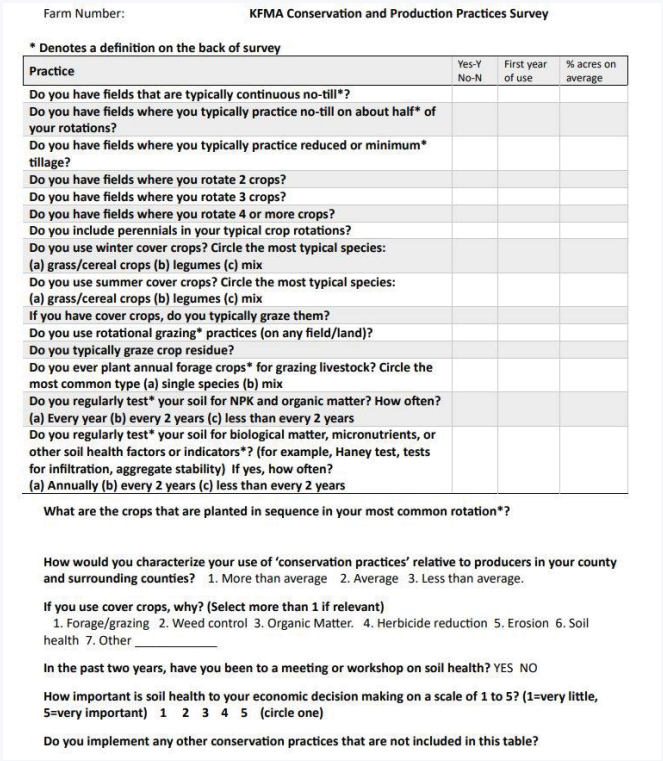
Many farmers hesitate to adopt soil health practices due to uncertainty about financial returns, implementation costs, and risk exposure (Sellars et al., 2023).

Chapter III

Summary of Part 1

Data

- **Kansas Farm Management Association**
  - Comprehensive Kansas farm-level information
  - Detailed data on farm characteristics, crop and livestock production, income, expenses, and financial metrics
  - Used widely in agricultural economics research
- **Survey**
  - Supplementary data on the adoption of conservation practices



Farm Number: **KFMA Conservation and Production Practices Survey**

*** Denotes a definition on the back of survey**

Practice	Yes-Y No-N	First year of use	% acres on average
Do you have fields that are typically continuous no-till*?			
Do you have fields where you typically practice no-till on about half* of your rotations?			
Do you have fields where you typically practice reduced or minimum* tillage?			
Do you have fields where you rotate 2 crops?			
Do you have fields where you rotate 3 crops?			
Do you have fields where you rotate 4 or more crops?			
Do you include perennials in your typical crop rotations?			
Do you use winter cover crops? Circle the most typical species: (a) grass/cereal crops (b) legumes (c) mix			
Do you use summer cover crops? Circle the most typical species: (a) grass/cereal crops (b) legumes (c) mix			
If you have cover crops, do you typically graze them?			
Do you use rotational grazing* practices (on any field/land)?			
Do you typically graze crop residue?			
Do you ever plant annual forage crops* for grazing livestock? Circle the most common type (a) single species (b) mix			
Do you regularly test* your soil for NPK and organic matter? How often? (a) Every year (b) every 2 years (c) less than every 2 years			
Do you regularly test* your soil for biological matter, micronutrients, or other soil health factors or indicators*? (for example, Haney test, tests for infiltration, aggregate stability) If yes, how often? (a) Annually (b) every 2 years (c) less than every 2 years			

What are the crops that are planted in sequence in your most common rotation*?

How would you characterize your use of 'conservation practices' relative to producers in your county and surrounding counties? 1. More than average 2. Average 3. Less than average.

If you use cover crops, why? (Select more than 1 if relevant)
1. Forage/grazing 2. Weed control 3. Organic Matter. 4. Herbicide reduction 5. Erosion 6. Soil health 7. Other _____

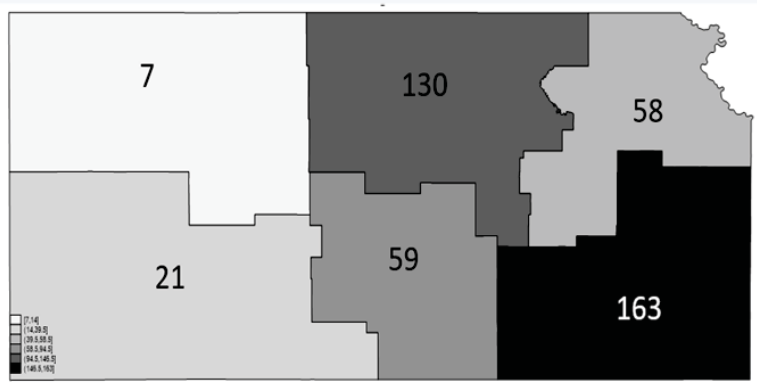
In the past two years, have you been to a meeting or workshop on soil health? YES NO

How important is soil health to your economic decision making on a scale of 1 to 5? (1=very little, 5=very important) 1 2 3 4 5 (circle one)

Do you implement any other conservation practices that are not included in this table?

Summary of Part 1

Survey Details



KFMA region distribution, 2023.

Soil Health Practice	Yes	No	% Yes
Continuous No-till	256	182	58%
Reduced Tillage	246	192	56%
Cover Crop	199	239	44%
3 or More Crops Rotation	276	162	63%
Graze Cover Crop	114	324	26%
Rotational Grazing	110	328	25%
Workshop on Soil Health	156	282	35%
Soil Test for Biological Matter	134	304	31%
Soil Test for NPK	431	7	98%
Annual Forage Crop	95	343	22%
Grazing Crop Residue	176	262	40%

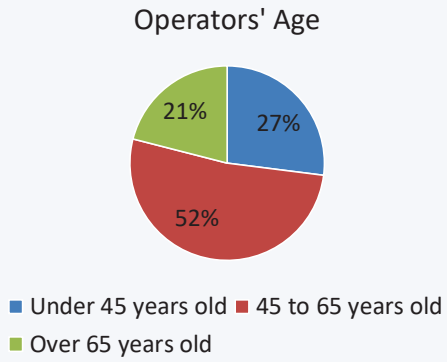
Summary of Part 1

Survey Details

Region	% with Cover Crop	% with Continuous no-till	% with 3 or more crop rotation
North Central	62%	63%	32%
South Central	44%	29%	26%
Southwest	36%	9%	22%
Northeast	63%	46%	11%
Northwest	30%	23%	14%
Southeast	50%	33%	25%

Summary of Part 1

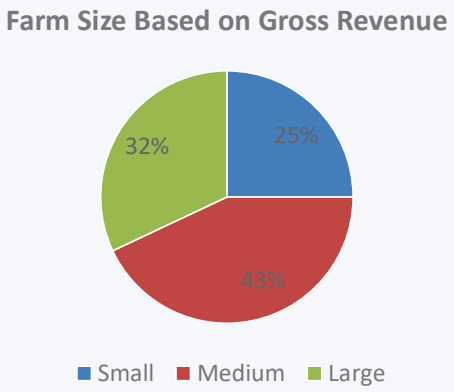
Survey Details

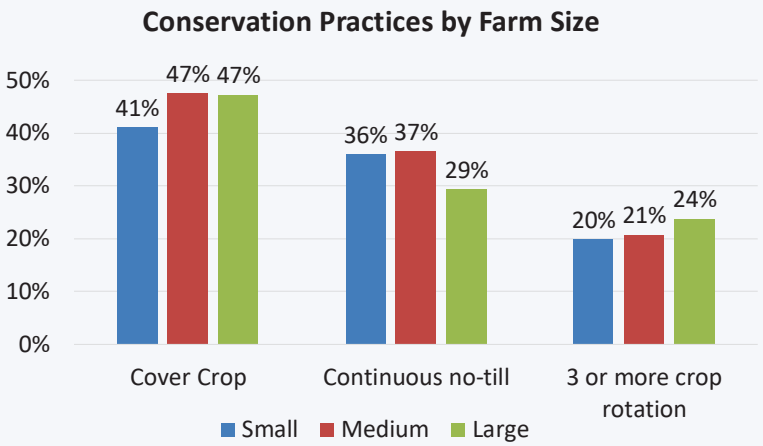


Age	Conservation Practices		
	Cover Crop	Continuous no-till	3 or more Crop Rotation
Under 45 years old	76%	53%	31%
45 to 65 years old	59%	44%	23%
Over 65 years old	27%	26%	22%

Summary of Part 1

Survey Details





Farm size based on Gross Revenue according to the USDA:

- **Small**: Gross Revenue < $350,000
- **Midsize**: Gross Revenue between $350,000 and < $1,000,000
- **Large**: Gross Revenue >= $1,000,000

Takeaways from part 1

- Conservation practice adoption rates tend to be higher than the national averages, especially for cover crops, but with substantial variation.
- The survey was effective at finding key differences in conservation practices.
- Younger producers have higher levels of conservation practice adoption, and farm size adoption rates are similar

Chapter IV

Part 2: What's New?

Part 2: What's New?

Total farms for Analysis: 438
Additional data: Weather data to predict yield

Going from Practices to Soil Health Investment:

- Quantify soil health investment based on reported practices
- Explore how soil health investment relates to farm financial performance
- Explore mechanisms: expense ratio, yield

Questions to be answered:

- How can soil health investments be quantified for Kansas commercial crop farming?
- What is the connection between these soil health investments and farm financial performance?

Part 2: What's New?

Quantifying Soil Health Investment (3 approaches)

1. Agronomic Scoring

Principles:

- Minimize soil disturbance
- Keep the soil covered
- Maintain living roots in the soil
- Maximize plant diversity
- Integrate livestock into the system

Practices and Score:

- Tillage practices: 0 – 3 points
- Crop rotation: 0 – 4 points
- Cover crop: 0 – 2 points
- Grazing Practices: 0 – 3 points
- Soil Testing: 0 – 3 points

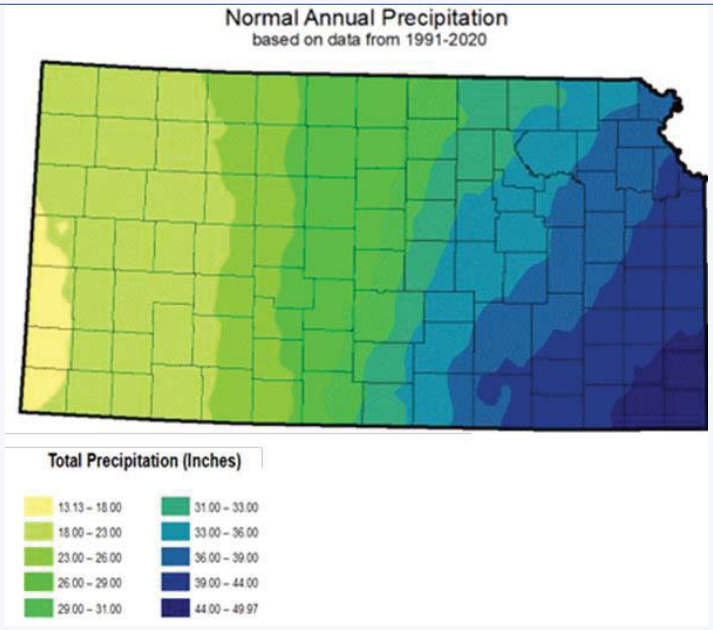
Part 2: What's New?

Each practice is scored based on intensity and regional adaptation

The amount of precipitation received across the different regions may dictate how intensive (number of crops in the rotations) the production systems are.

Crop rotations (ranging from 0 to 4 points)

- **Higher precipitation regions (NE and SE)**
  4 points: Rotation with 4 or more crops, including perennials
- **Moderate precipitation regions (NC and SC)**
  4 points: Rotation with 3 or more crops
- **Lower precipitation regions (NW and SW)**
  4 points: Rotation with 2 or more crops, including the use of low water-demanding crops, and supplemental irrigation.



Source: https://eupdate.agronomy.ksu.edu/article/average-precipitation-distribution-a-kansas-climate-primer-594-3

Part 2: What's New?

Total score and qualitative interpretation of the results

Score Range	Classification	Interpretation
0 – 6 points	Low	Farmer shows limited, no adoption, or demonstrate some adoption of key regenerative agriculture, improvement needed
7 – 10 points	Moderate	Moderate adoption of key soil health practices
11 – 15 points	High	Strong and consistent commitment to soil health practices

Part 2: What's New?

Quantifying Soil Health Investment (3 approaches)

2. Cluster-Based Classification: K-means Clustering

Farms coded with binary values (1= yes, 0= no)
Farms with similar combinations of practices are grouped.

Farm ID	No-Till	Cover Crops	Rotation	Grazing	Soil Testing
Farm 1	1	1	1	0	1
Farm 2	1	0	1	0	1
Farm 3	0	0	0	0	1
Farm 4	1	1	1	1	1
Farm 5	0	0	1	0	0
Farm 6	1	1	1	1	0
Farm 7	0	0	0	0	0
Farm 8	0	0	0	0	0
Farm 9	1	1	1	0	1
Farm 10	1	0	1	0	1

Part 2: What's New?

Quantifying Soil Health Investment (3 approaches)

2. Cluster-Based Classification: K-means clustering

Groups are labeled High, Medium, or Low based on weighted average adoption levels across practices.

Farm Group	What They Tend to Do	How Common
Group 1: Low	Use fewer or no soil health practices	44% of farms
Group 2: Medium	Use a few (e.g., cover crop + reduced till)	32% of farms
Group 3: High	Use many (e.g., no-till, cover, crop rotation, grazing)	24% of farms

III

Part 2: What's New?

Quantifying Soil Health Investment (3 approaches)

3. Threshold-Based Categorization

Soil health investment levels are based on how many criteria a farm meets:

- **High**: Meets 5 criteria, or 4 including continuous no-till
- **Medium**: Meets 3 criteria, or 4 including reduced tillage
- **Low:** All other cases

Practice	Criteria
Tillage	Continuous no-till Reduced Tillage
Crop Rotations	2 or 3; 2 or 3 or 4; 3; 3 or 4; 4
Cover Crops	Winter or summer or both
Grazing	Graze cover crops or residue or annual forage crop or rotational grazing
Management	Test for biological matter or attend soil health workshop or soil health important 4 or 5

III

Part 2: What's New?

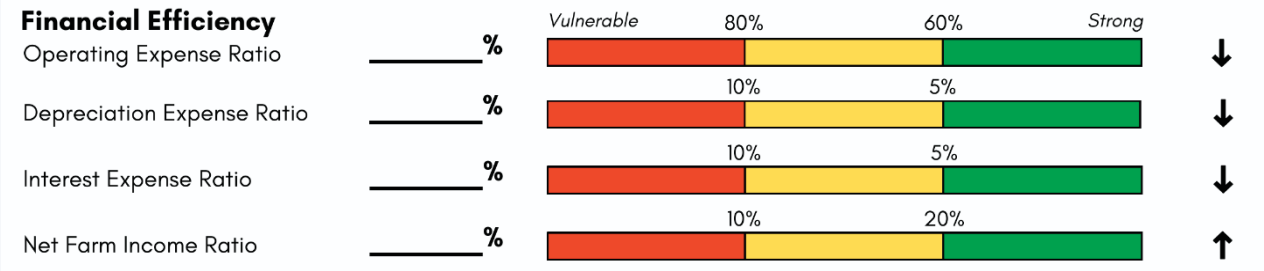
Financial Metric Used

OER: Operating Expense Ratio

Shows the proportion of farm income that is used to pay operating expenses, excluding depreciation and interest expense

NFIR: Net Farm Income Ratio

Compare profit to gross revenue. It shows how much is left after all farm expense, except unpaid labor and management, are apaid.

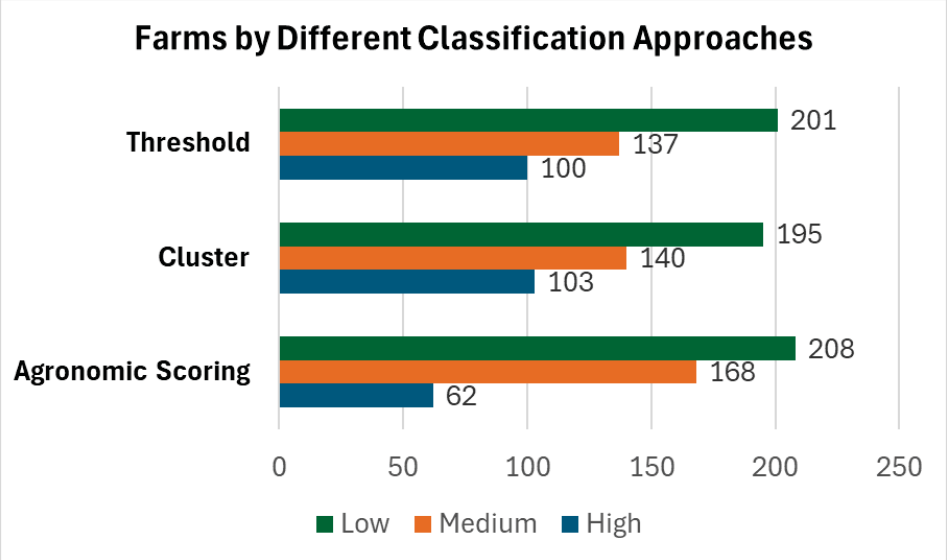


According to Farm Financial Standards Council (FFSC): available at https://www.ffsc.org/guidelines.php

Chapter V

Results & Discussions

Results of Soil Health Measures



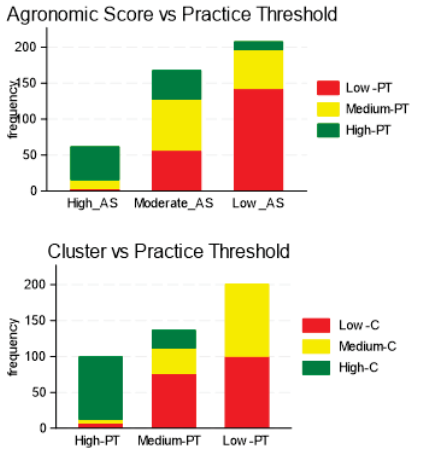
Different ways of measuring soil health investment don't always agree. A farm classified as "High" by one method might be "Medium" or "Low" in another.

IV

Results & Discussions

Results of Soil Health Measures

Overlap Between Soil Health Investment Measures



Pairwise comparison:

Agronomic vs Threshold: 11% high, 16% medium, 32% low

Agronomic vs Cluster: 11% high, 12% medium, 26% low

Threshold vs Cluster: 8% high, 8% medium, 23% low.

Takeaway: 10% of farms were consistently classified as high, 4% as medium, and 17% as low across all three methods.

IV

Results & Discussions

Raw NFIR Results are Misleading, Why?

Agronomic Score	Average Net Farm Income Ratio	Farms
Low	0.11	208
Medium	0.09	168
High	0.12	62

Threshold-Based	Average Net Farm Income Ratio	Farms
Low	0.11	208
Medium	0.09	168
High	0.10	62

Cluster-Based	Average Net Farm Income Ratio	Farms
Low	0.09	208
Medium	0.10	168
High	0.11	62

Why does this happen?

Younger farmers — who tend to adopt more soil health practices — are still building capital, land base, and efficiency. This can mask the true relationship in simple correlations.

Regression fixes this:

Regression controls for confounders: operator age, land ownership, irrigation, and weather (yield/income)

IV

Results & Discussions

High-Scoring Farms Performed Better Financially

Under Agronomic Score Classification

- **High-score farms earned 5.6 percentage points more in Net Farm Income Ratio (NFIR)**
  - Magnitude is substantial: On a $500,000 gross income farm → ~$28,000 more in net income

- **Positive Association under the Cluster classification, but not statistically significant**
  - High group shows 1.4 percentage points more in NFIR
- **Negative association under the Threshold also not statistically significant**
  - High group show 0.6 percentage points less in NFIR

Raw patterns can mislead. Regression shows that when controlling for key farm characteristics, high soil health investment is positively associated with profitability under the agronomic scoring classification.

IV

Results & Discussions

Raw OER Results are Also Misleading, Why?

Agronomic Score	Average Operating Expense Ratio	Farms
Low	0.76	208
Medium	0.79	168
High	0.76	62

Threshold-Based	Average Operating Expense Ratio	Farms
Low	0.77	208
Medium	0.80	168
High	0.79	62

Cluster-Based	**Average Operating Expense Ratio**	**Farms**
Low	0.79	208
Medium	0.77	168
High	0.78	62

Why does this happen?

Same reason as mentioned for NFIR

Regression fixes this:

Regression controls for confounders: operator age, land ownership, irrigation, and weather (yield/income)

IV

Results & Discussions

High-Scoring Farms Performed Better Cost Wise

- **High-score farms spent 4.7 percentage points less on Operating Expense Ratio (OER)**
  - Magnitude is substantial: On a $500,000 gross revenue → that is ~$23,500 less in operating cost

Raw patterns can mislead. Regression shows that when controlling for key farm characteristics, high soil health investment is positively associated with improving cost efficiency.

IV

Results & Discussions

Is This Just Correlation?

- We controlled for farm size, weather, and operator age.
- The score reflects agronomic principles.
- We don't see this pattern with raw practice counts or clusters→ which strengthens the case

This supports what many in the field already know: the effectiveness of conservation practices depends heavily on how they're applied, not merely whether they're used.

IV

Results & Discussions

What We Still Need to Understand

- Longer-term impacts (only one year of data)
- Self-reported practices vs. actual implementation
- Biophysical indicators (e.g. SOC, microbial activity)
- Why the measurement method matters so much

IV

Results & Discussions

Takeaways for Producer

- ✅ Farms with high soil health scores tend to be more profitable
  Practices alone are not related to higher profits -- doing what is most effective for your area matters
- ✅ It's not just about using practices — it's about using what works best for your farm and region
  – Local context and tailoring matter
- ✅ Observed benefit came from cost efficiency, not necessarily more yield
  - There may be yield benefits, most likely in the long term
- ✅ Adopting new practices is within a farmer's control, but it can be demanding

IV

Results & Discussions

Takeaways for Producer

Resources

Many resources available:

No Till On the Plains: https://www.notill.org/

Kansas Soil Health Alliance: https://kssoilhealth.org/

USDA – NRCS such as EQIP: https://www.nrcs.usda.gov/programs-initiatives/eqip-environmental-quality-incentives

Green Cover Seed Podcast: https://greencover.com/green-cover-podcast/

Advancing Eco Agriculture: https://advancingecoag.com/

K-State has county agents for soil health purposes

Kansas State University regenerative Agriculture: https://www.kstateregenag.org/

K-State Extension website: https://www.ksre.k-state.edu/

K-State Agronomy Extension website: https://www.agronomy.k-state.edu/extension/

K-State Agricultural Economics Extension website: https://agmanager.info/

IV

Results & Discussions

Takeaways for Producer

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K-State Agronomy Extension website: https://www.agronomy.k-state.edu/extension/

K-State Agricultural Economics Extension website: https://agmanager.info/

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Ag Economics, Kansas State University

Thank you for your attention!

Authors:

Delide Joseph
Jennifer Ifft
Cesar Guareschi
Matthew Sanderson
Megan Hughes
Charles Rice

IV

Results & Discussions

Soil Health Investment and Operational Mechanisms

Agronomic Score and 2023 Operational Outcomes

	OER	Corn	Sorghum	Soybeans
Moderate_AS	-0.004	1.473	-6.097	2.886*
	(0.016)	(5.146)	(7.803)	(1.545)
High_AS	-0.047*	10.874	4.875	2.511
	(0.025)	(8.477)	(10.017)	(2.418)
R-squared	0.130	0.743	0.381	0.717
Observations	438	354	128	395

Cluster-based Classification and 2023 Operational Outcomes

	OER	Corn	Wheat	Sorghum	Soybeans
Medium-C	0.018	-7.698	-4.624	-6.040	-1.245
	(0.017)	(7.834)	(3.536)	(8.843)	(1.974)
High-C	-0.000	-0.627	-9.255***	6.704	-1.638
	(0.018)	(7.651)	(3.198)	(7.486)	(1.750)
R-squared	0.125	0.744	0.386	0.385	0.715
Farms	438	354	339	128	395

Practice Threshold and 2023 Operational Outcomes

	OER	Corn	Wheat	Sorghum	Soybeans
Medium-PT	0.040**	8.623	-1.805	12.655*	1.597
	(0.018)	(6.925)	(2.638)	(6.344)	(1.552)
High-PT	0.022	5.588	-8.614***	10.456	0.638
	(0.018)	(7.509)	(3.073)	(10.189)	(1.933)
R-squared	0.134	0.744	0.384	0.389	0.715
Farms	438	354	339	128	395

Some pathways linking soil health practices to farm profitability appear to operate through changes in expense ratio, while others are associated with variations in crop yield.

IV

Results & Discussions

Soil Health Investment and 2023 Farm Financial Performance (Ordered Logit and OLS Models)

	Agronomic Score (AS)		Practice Threshold (PT)		Cluster (C)	
	Financial Rank	NFIR	Financial Rank	NFIR	Financial Rank	NFIR
Moderate_AS	-0.041	0.009				
	(0.207)	(0.016)				
High_AS	0.675**	0.056**				
	(0.326)	(0.026)				
Medium-PT			0.060	-0.029		
			(0.272)	(0.021)		
High-PT			0.037	-0.006		
			(0.240)	(0.018)		
Medium-C					-0.145	-0.004
					(0.258)	(0.021)
High-C					0.085	0.014
					(0.284)	(0.019)
R-squared		0.115		0.111		0.107
Farms	438	438	438	438	438	438

IV

Results & Discussions

Descriptive Statistics

Rank	Variable	Obs.	Mean	Std. dev.	Min	Max
			Agronomic Scoring			
Low	Net Farm Income Ratio	208	0.102	0.153	-0.397	0.611
	Operating Expense Ratio	208	0.775	0.158	0.342	1.195
Medium	Net Farm Income Ratio	168	0.091	0.158	-0.524	0.552
	Operating Expense Ratio	168	0.792	0.142	0.270	1.175
High	Net Farm Income Ratio	62	0.124	0.141	-0.286	0.412
	Operating Expense Ratio	62	0.760	0.143	0.467	1.189
			Threshold-Based Categorization			
Low	Net Farm Income Ratio	201	0.109	0.158	-0.397	0.611
	Operating Expense Ratio	201	0.765	0.155	0.342	1.144
Medium	Net Farm Income Ratio	137	0.087	0.158	-0.524	0.489
	Operating Expense Ratio	137	0.796	0.150	0.270	1.195
High	Net Farm Income Ratio	100	0.104	0.138	-0.286	0.552
	Operating Expense Ratio	100	0.785	0.138	0.467	1.071
			Cluster-Based Classification			
Low	Net Farm Income Ratio	195	0.096	0.160	-0.346	0.611
	Operating Expense Ratio	195	0.788	0.159	0.342	1.189
Medium	Net Farm Income Ratio	140	0.099	0.158	-0.524	0.552
	Operating Expense Ratio	140	0.773	0.151	0.270	1.195
High	Net Farm Income Ratio	103	0.112	0.137	-0.297	0.448
	Operating Expense Ratio	103	0.777	0.135	0.467	1.071