



**Alyssa DeVincentis**

PhD Candidate

Hydrologic Sciences

September 11, 2019

# Cover Crops: Watching the Grass Grow



*Take away:*

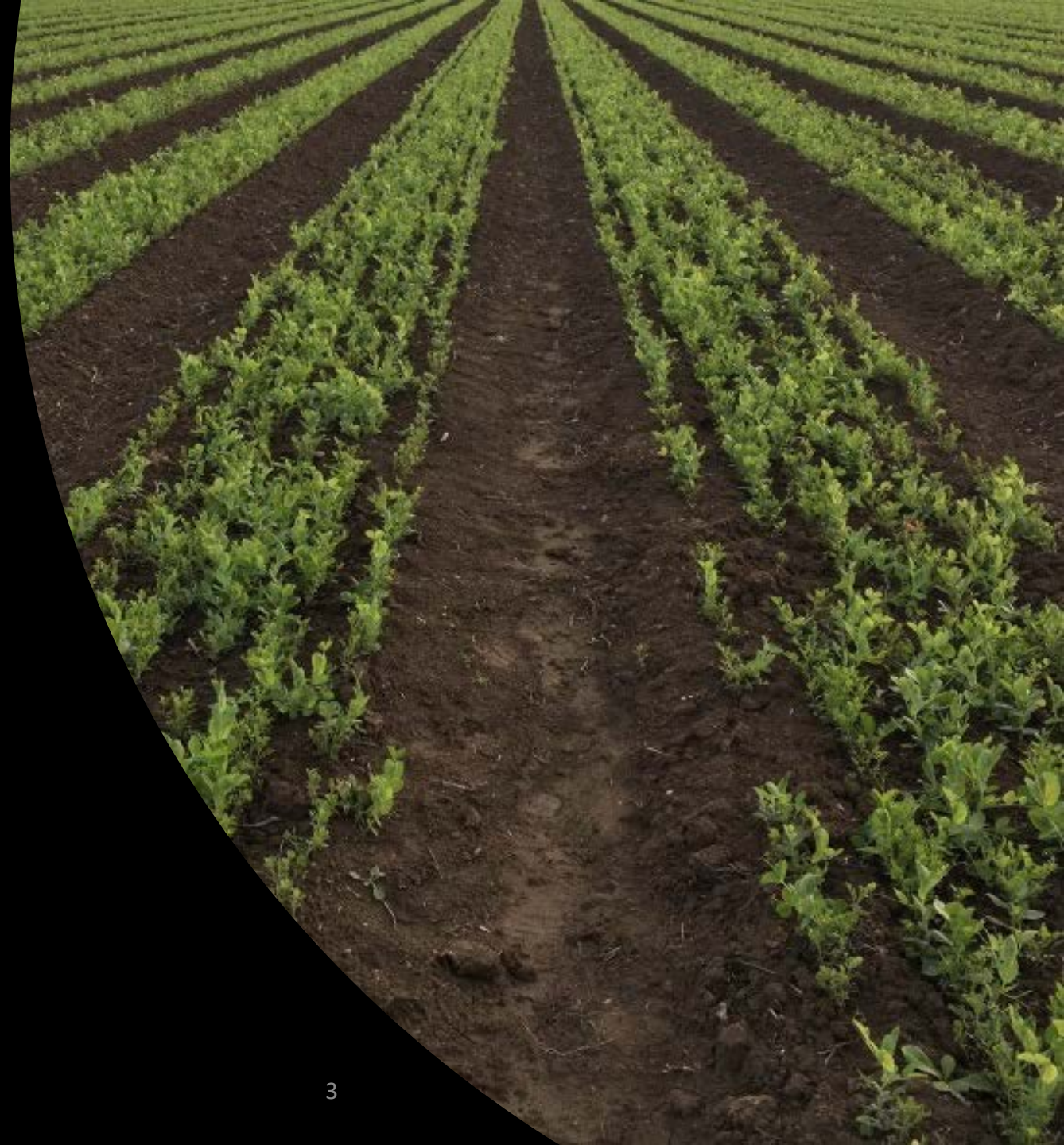
**Cover cropping is profitable... sometimes!**



*Take away:*

**Cover cropping is profitable... sometimes!**

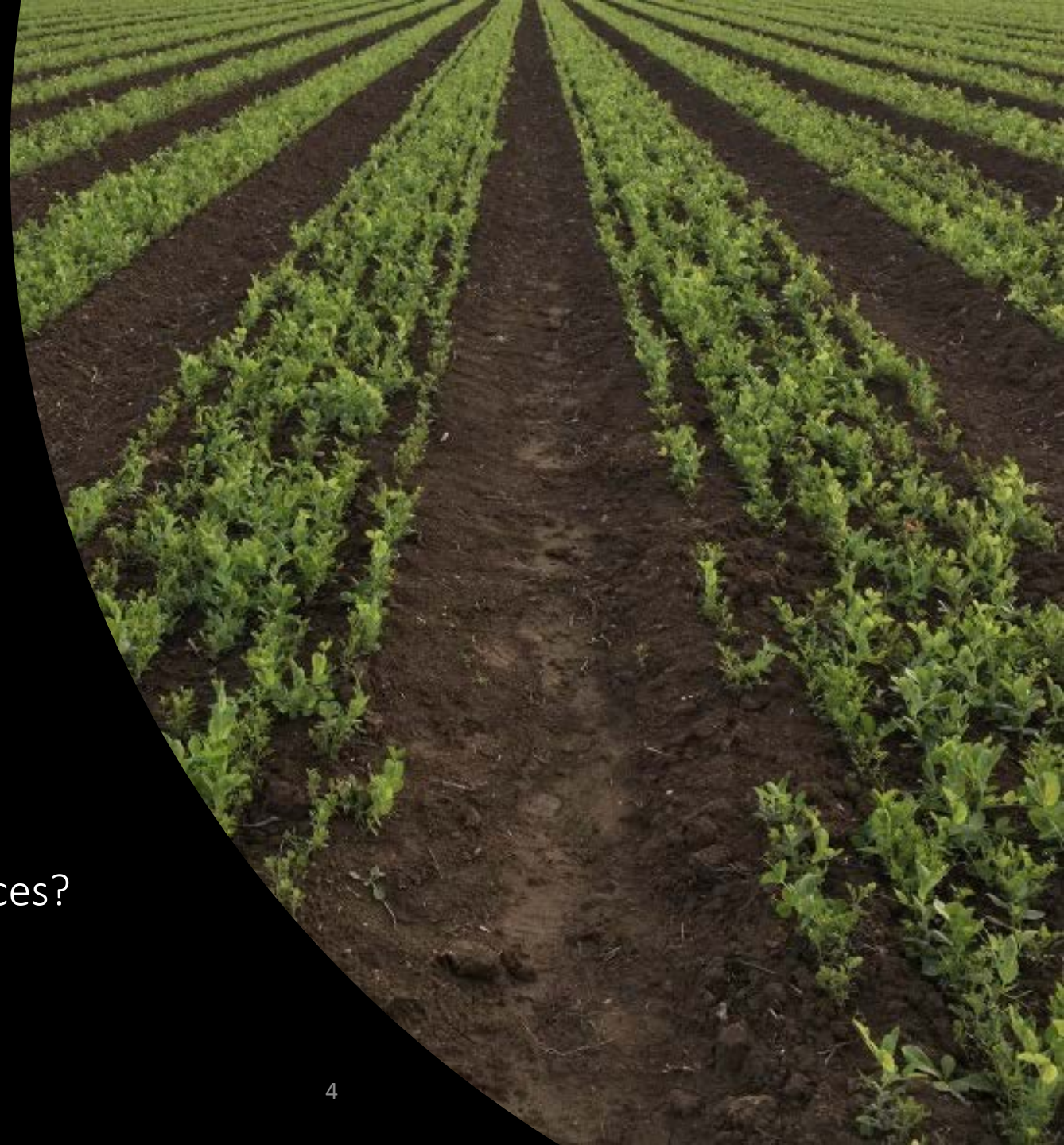
- Growing almonds
- Flexible harvest contracts
- Receive subsidies over \$175/year
- Society values carbon over \$600/ton
- Growers can irrigate 1/3 less
- Without climate change



*Take away:*

**Cover cropping is profitable... sometimes!**

- Why care about cover crops?
- Why aren't farmers growing them?
- How can policy encourage adoption?
- How to value sustainable agriculture practices?





*Cover crops:* Plants grown on agricultural fields when they would otherwise be left fallow.



# *Cover crops:* Plants grown on agricultural fields when they would otherwise be left fallow.

*Prevent erosion*

*Reduce nutrient losses*

*Penetrate compacted soils*

*Aid in weed management*

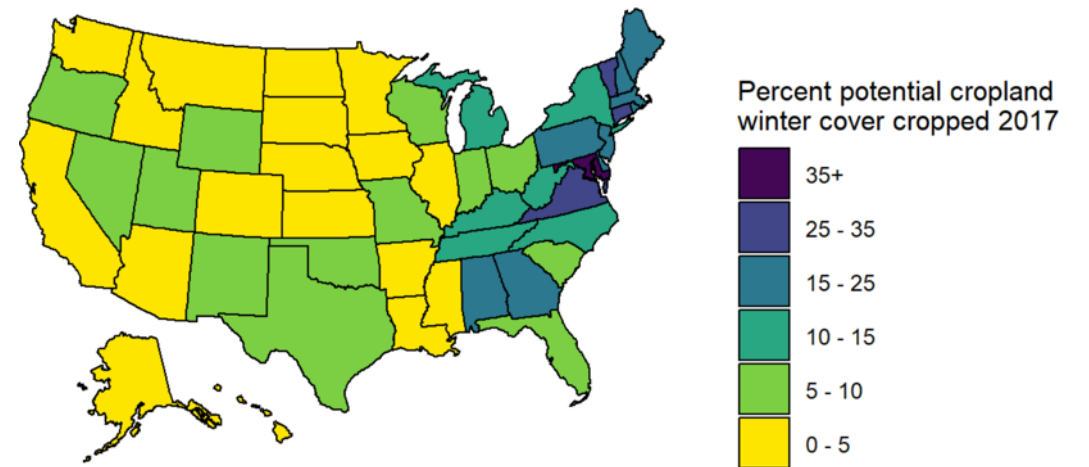
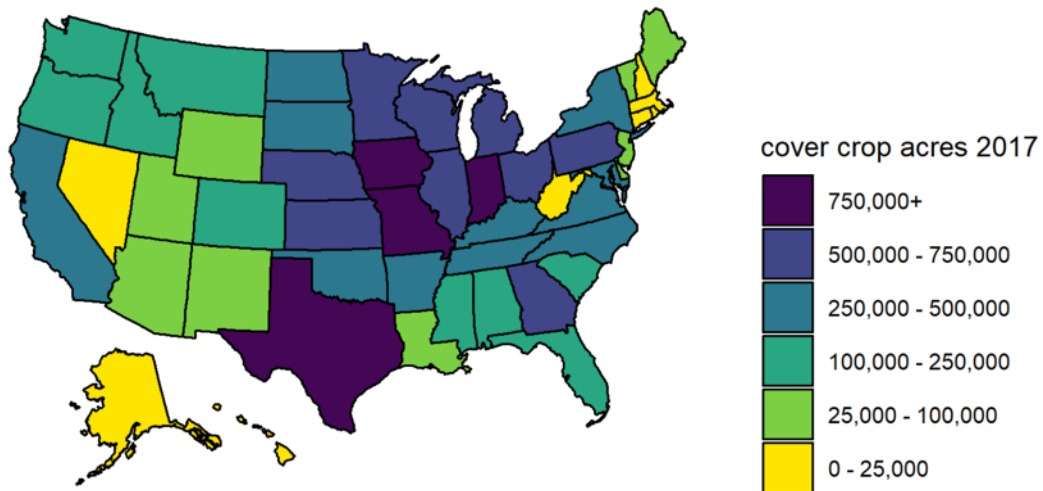
*Promote soil life*

*Sequester carbon*

*Form soil aggregates*

*Fix nitrogen*

*Add organic matter*

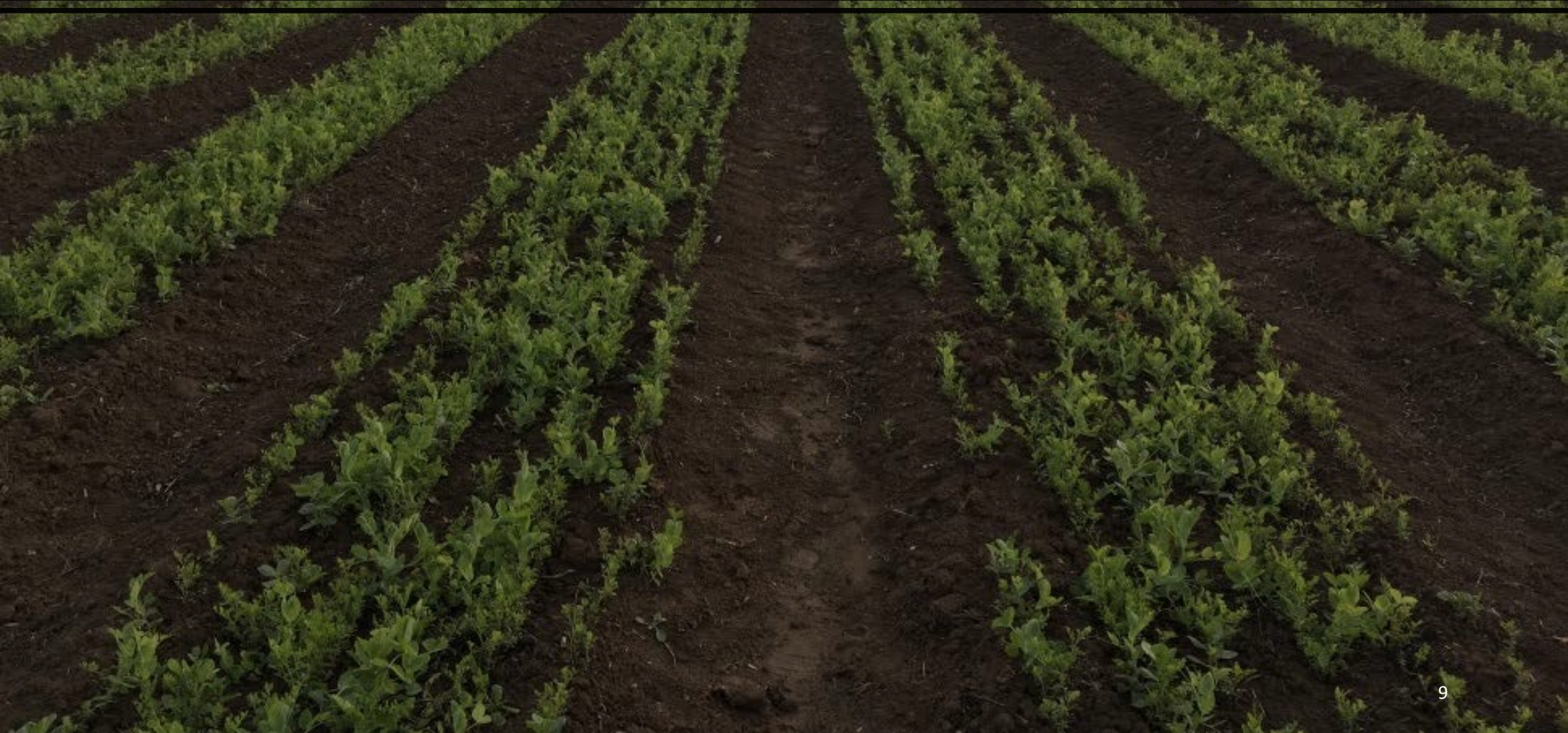


Less than 5% of available crop land is cover cropped in California (Soil Health Institute, 2019)

# Possible explanations for low adoption rates

- Not cost effective
- Cost effective far in the future
- Cost effective but benefits are not experienced by the grower
- Information barriers, risk and uncertainty exist

# California agriculture



# California agriculture

## Over 400 commodities!

Dairy	\$6 billion
Grapes	\$5.6 billion
Almonds	\$5.2 billion
Cattle	\$2.5 billion
Lettuce	\$2 billion
Strawberries	\$1.8 billion
Pistachios	\$1.5 billion
Tomatoes	\$1.3 billion

(CDFA, 2017)

# California agriculture

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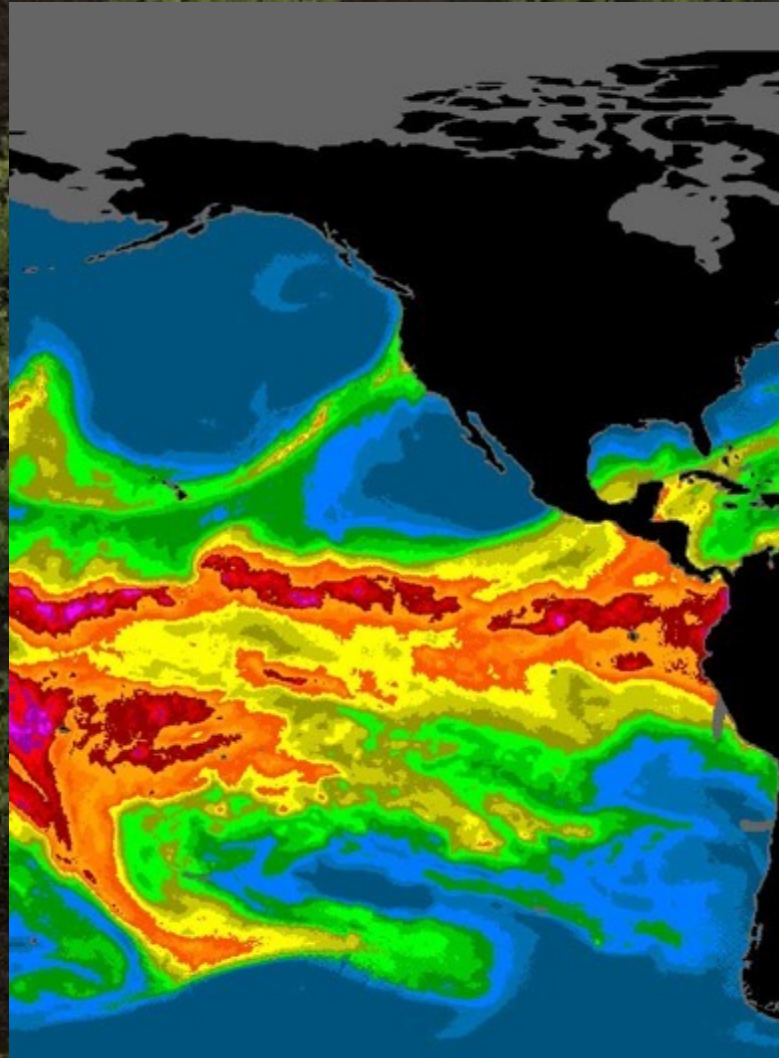


Image: NOAA ESRL

# California agriculture

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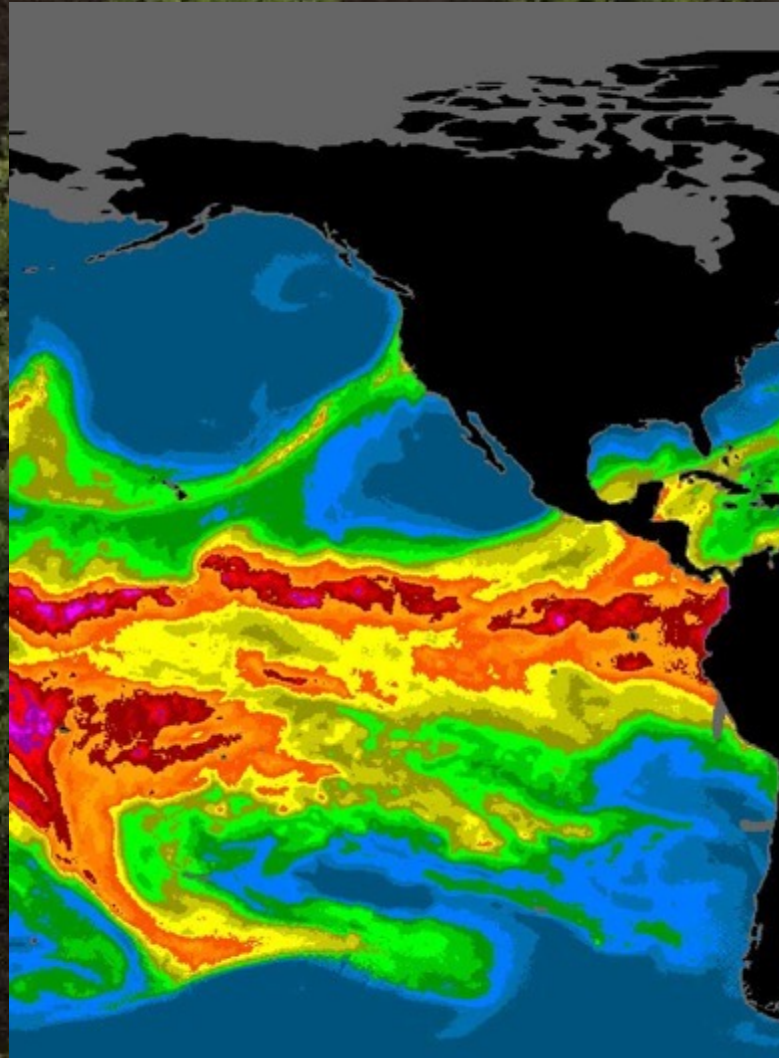


Image: NOAA ESRL

**REGULATION**

# How do benefits and costs of cover crops change with each operation? Geography, cropping system, management choices, etc...

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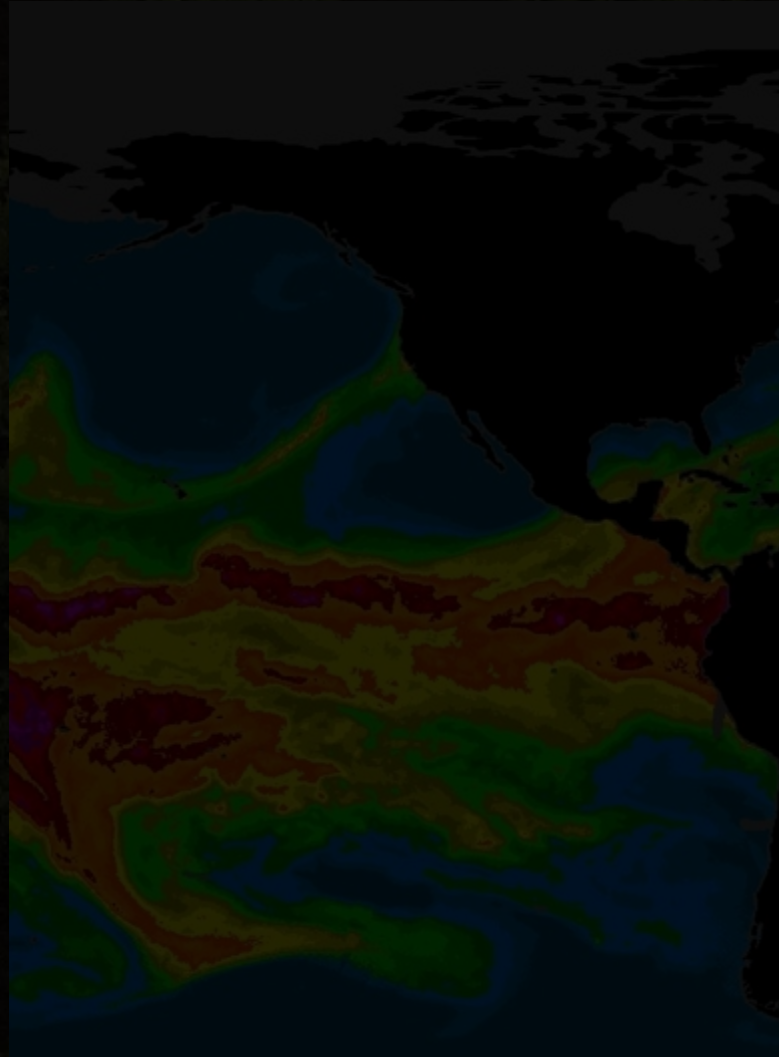
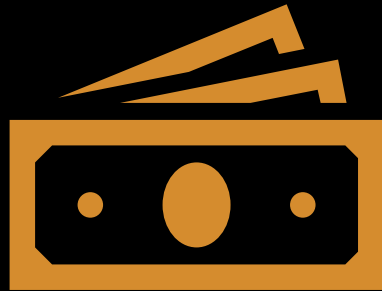


Image: NOAA ESRL

**REGULATION**

# Research questions



At what pace do the benefits and costs of winter cover cropping accumulate?



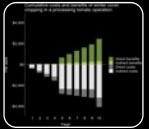
Do climate, water, and policy changes affect the profitability of winter cover cropping?

# Processing tomatoes and almonds are leading commodities in California

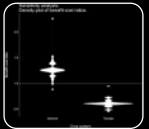




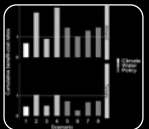
Data collection



Model construction



Model evaluation



Model simulations

# Unique, interdisciplinary field data collection

Goal: Monetize costs  
and benefits

Literature

Farmer  
interviews

Field data

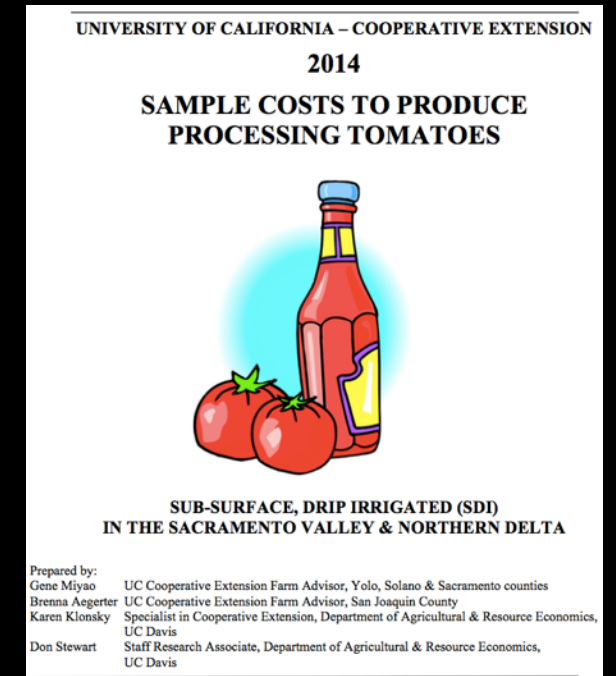
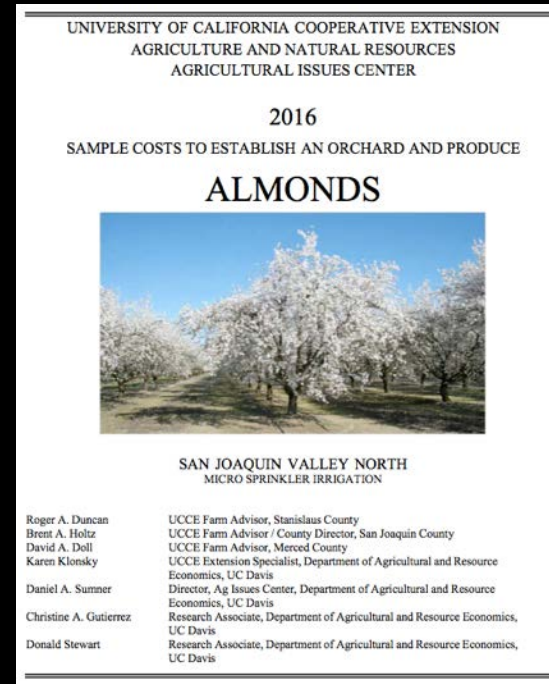
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Farmer interviews

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# Unique, interdisciplinary field data collection

Goal: Monetize costs and benefits

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Farmer interviews

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*"I do think over time cover crops will make an operation more profitable. You'll incur less costs and water. Better fertility, yield, and disease resistance."*

*"There's a tradeoff between efficiency and flexibility - we are too big to be inefficient and you need to be flexible to cover crop."*

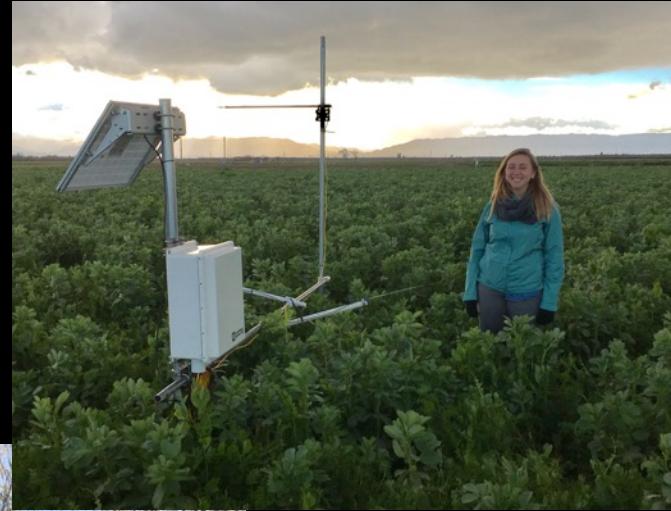
# Unique, interdisciplinary field data collection

Goal: Monetize costs and benefits

Literature

Farmer interviews

Field data



## Costs

Seed

Planting (labor)

Termination (labor)

Cash crop harvest complications

Depreciation of machinery

Opportunity cost of time spent  
learning to grow cover crops

## Benefits

Increased yield

Soil erosion control

Nutrient cycling

Weed control

Reduced tillage / discounted beehives\*

Increased soil organic matter

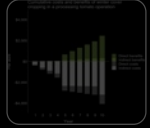
Reduced surface water runoff

Soil-carbon storage

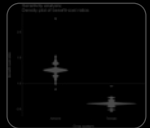
\* Differ between tomato and almond



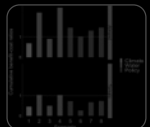
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Budget components	Monetary value		Years of occurrence
	Low	High	

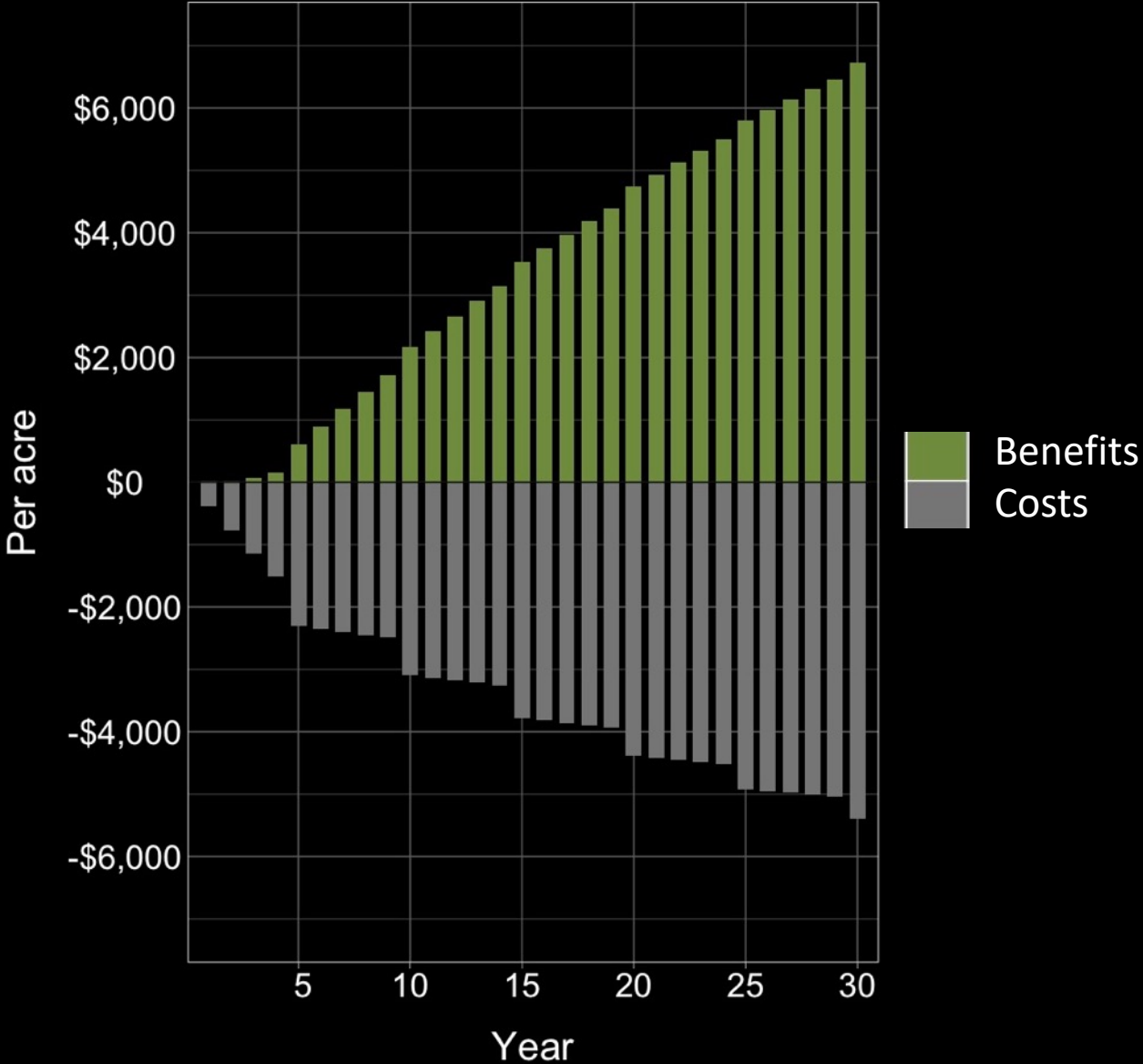
Processing tomatoes growing an annual cover crop

Seed	\$24.00	\$90.00	1 - 10
Planting (labor)	\$9.61	\$19.21	1 - 10
Termination (labor)	\$19.21	\$38.42	1 - 10

Almonds growing an annual cover crop for 3 years, then re-seeding

Seed	\$15.00	\$64.50	1 - 4
Planting (labor)	\$7.69	\$15.38	1 - 4
Termination (labor)	\$15.38	\$30.76	1 - 3
	\$22.50	\$75.00	4 - 30

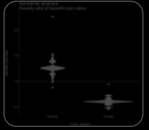
# Cumulative costs and benefits of winter cover cropping in an almond orchard



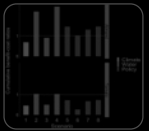
Data collection



Model construction



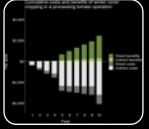
Model evaluation



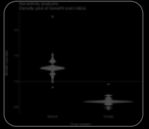
Model simulations



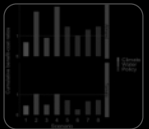
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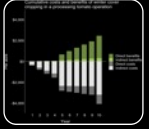
Model simulations

*Benefit cost ratio =*

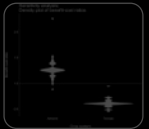
$$\frac{\sum_{t=0}^{t=T} \frac{Benefits_t}{(1+r)^t}}{\sum_{t=0}^{t=T} \frac{Costs_t}{(1+r)^t}}$$



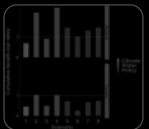
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Model simulations

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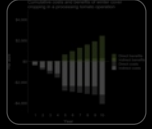
$$\frac{\sum_{t=0}^{t=T} \frac{Benefits_t}{(1+r)^t}}{\sum_{t=0}^{t=T} \frac{Costs_t}{(1+r)^t}}$$

$BCR > 1 =$  *profitable*

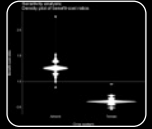
$BCR < 1 =$  not *profitable*



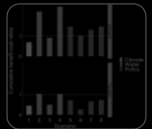
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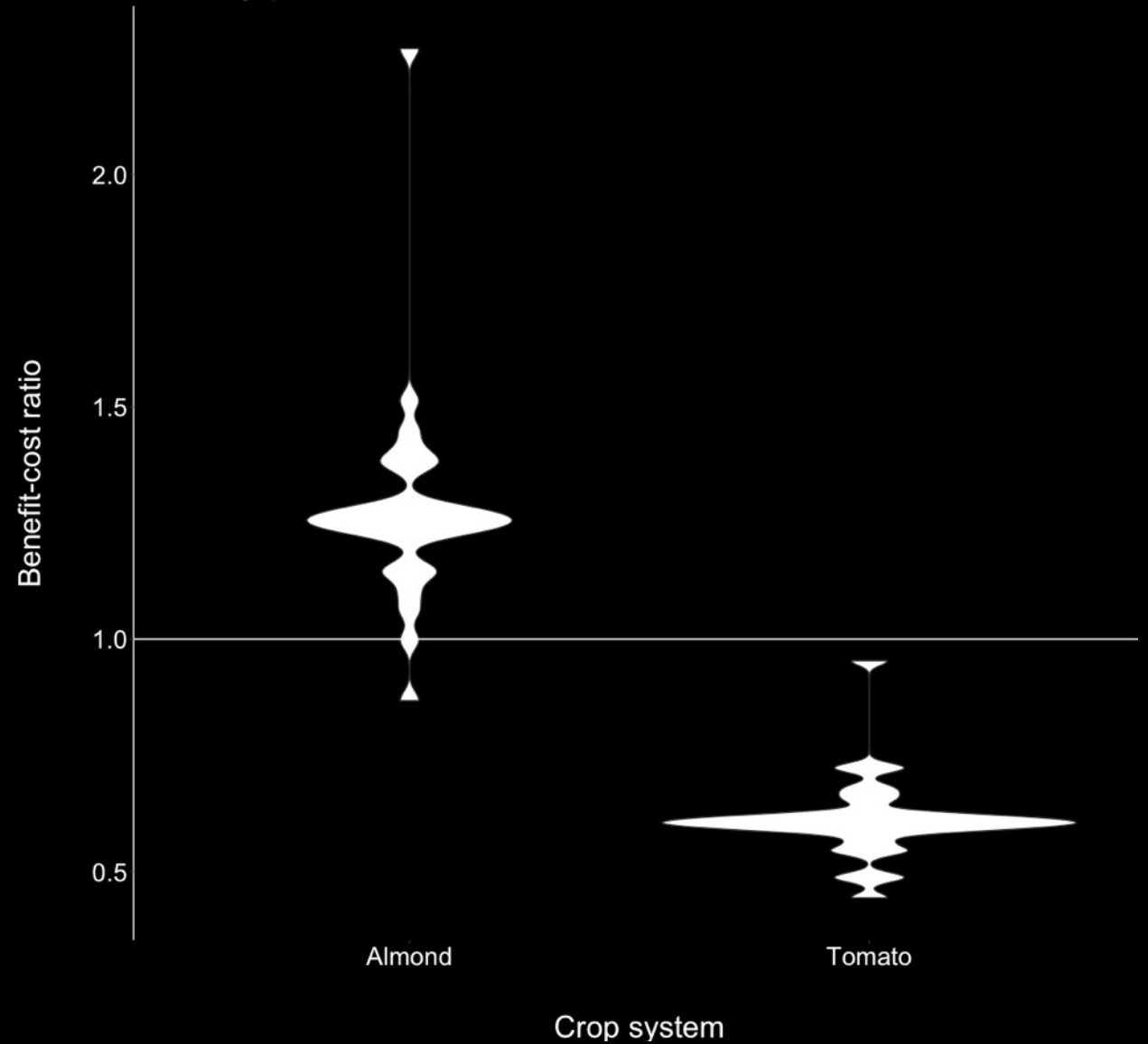


Model evaluation



Model simulations

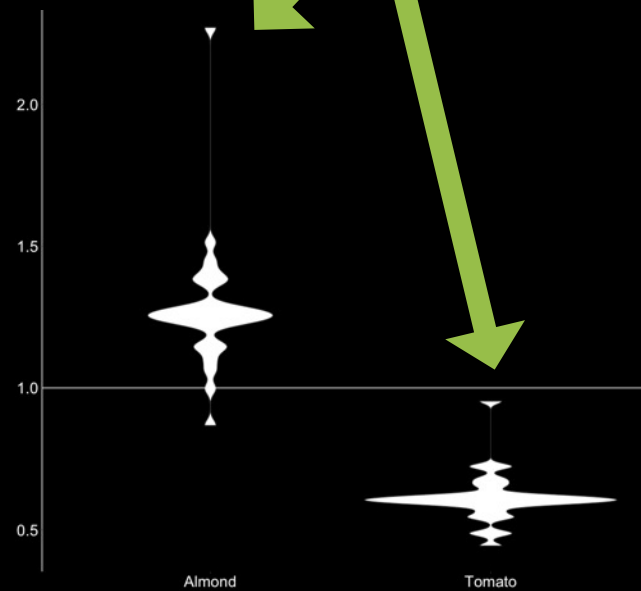
Sensitivity analysis:  
Density plot of benefit-cost ratios



# Which variable matters most?

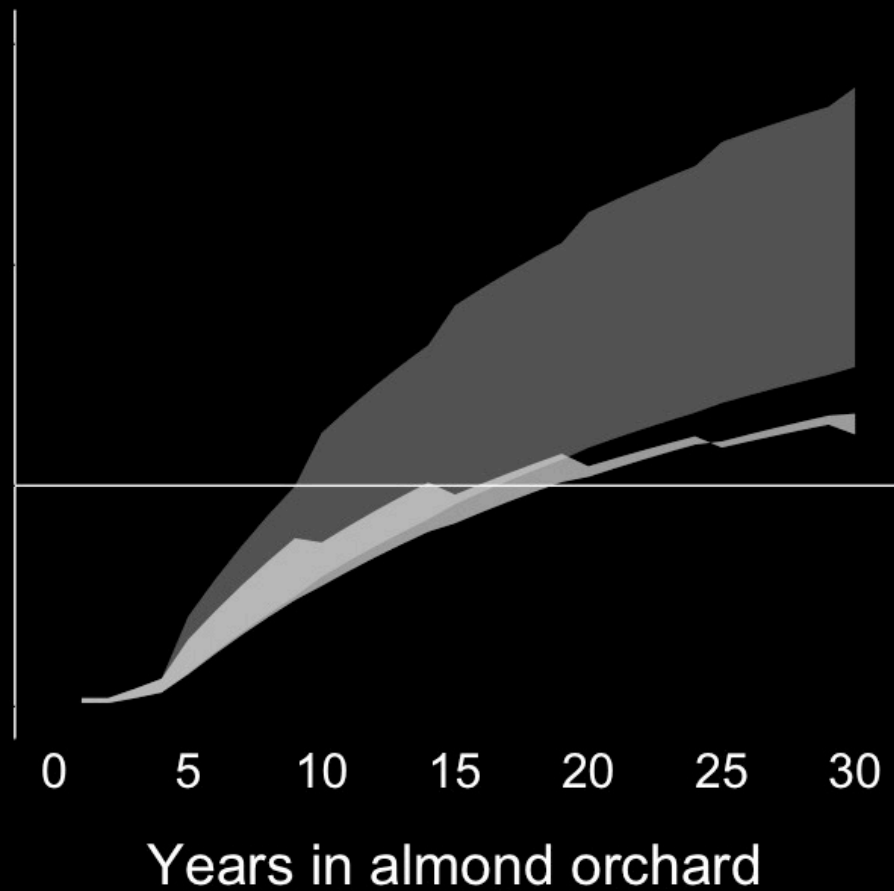
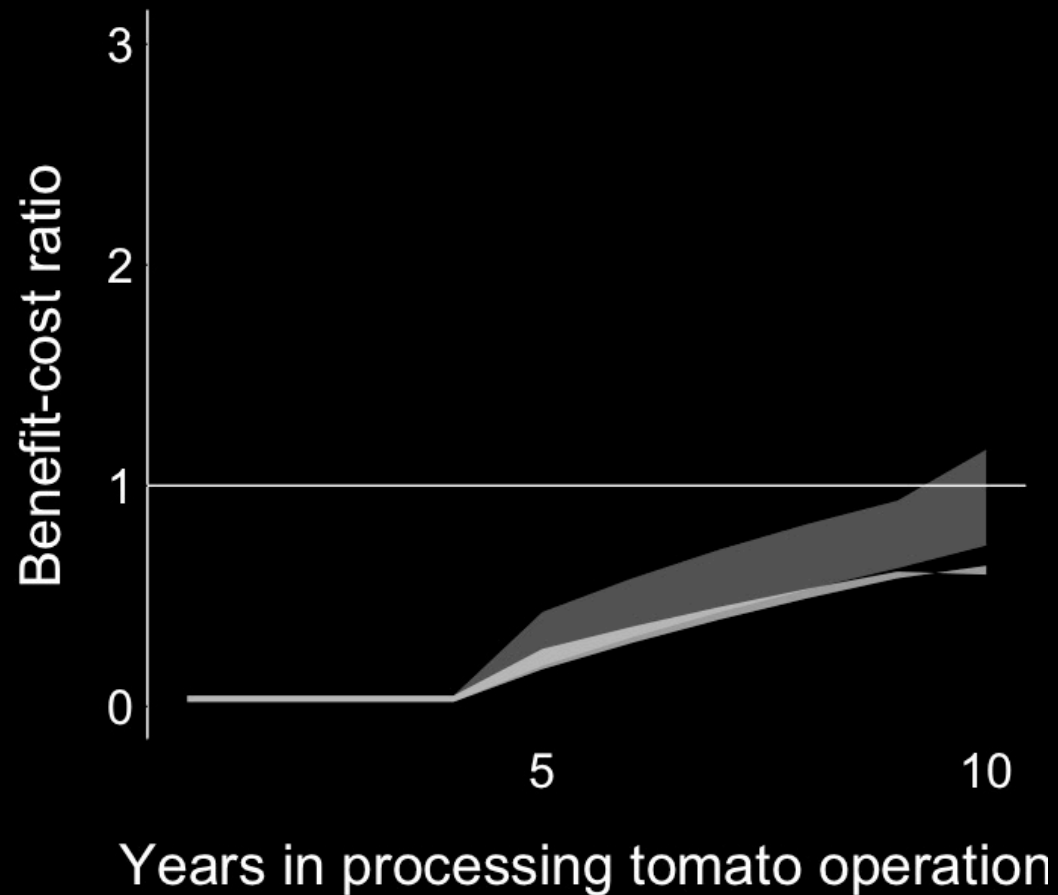


Lower yields due to harvest complications from winter cover cropping



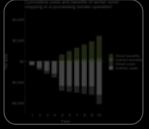
# Range of benefit-cost ratios for winter cover cropping

- Excludes harvest complications
- Includes harvest complications

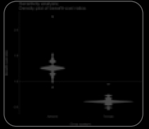




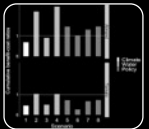
Data collection



Model construction



Model evaluation



Model simulations

*How to reach profitability?*

## Costs

Seed

Planting (labor)

Termination (labor)

Cash crop harvest complications

Depreciation of machinery

Opportunity cost of time spent learning to grow cover crops



## Benefits

Increased yield

Soil erosion control

Nutrient cycling

Weed control

Reduced tillage /  
discounted beehives

Increased soil organic matter

Reduced surface water runoff

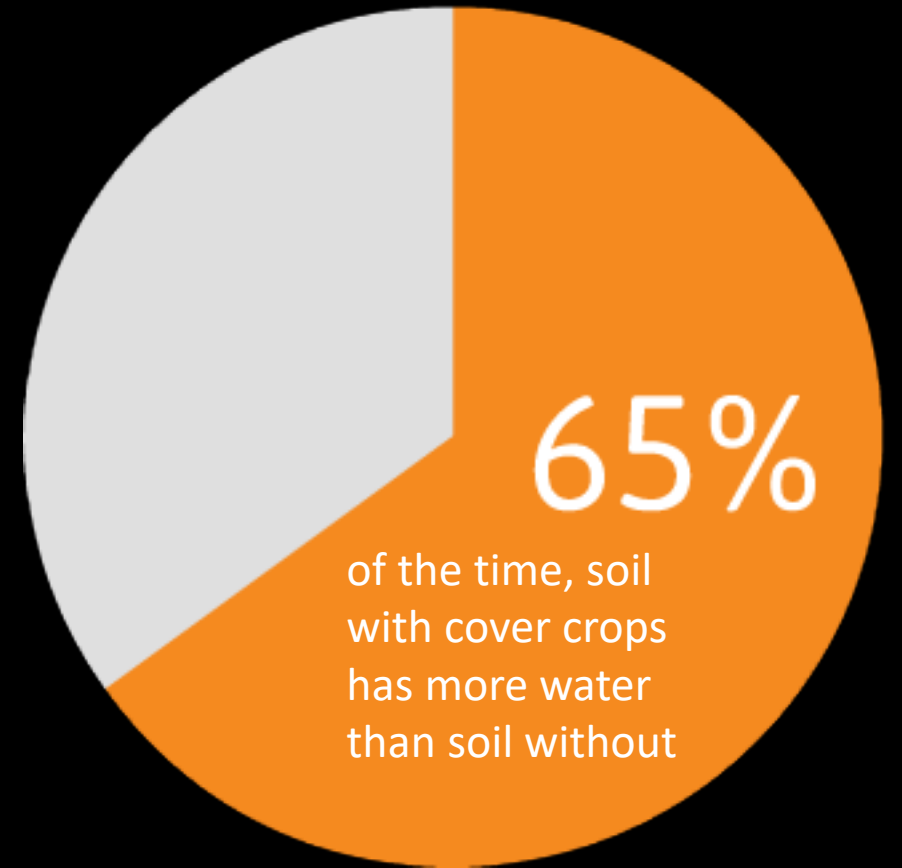
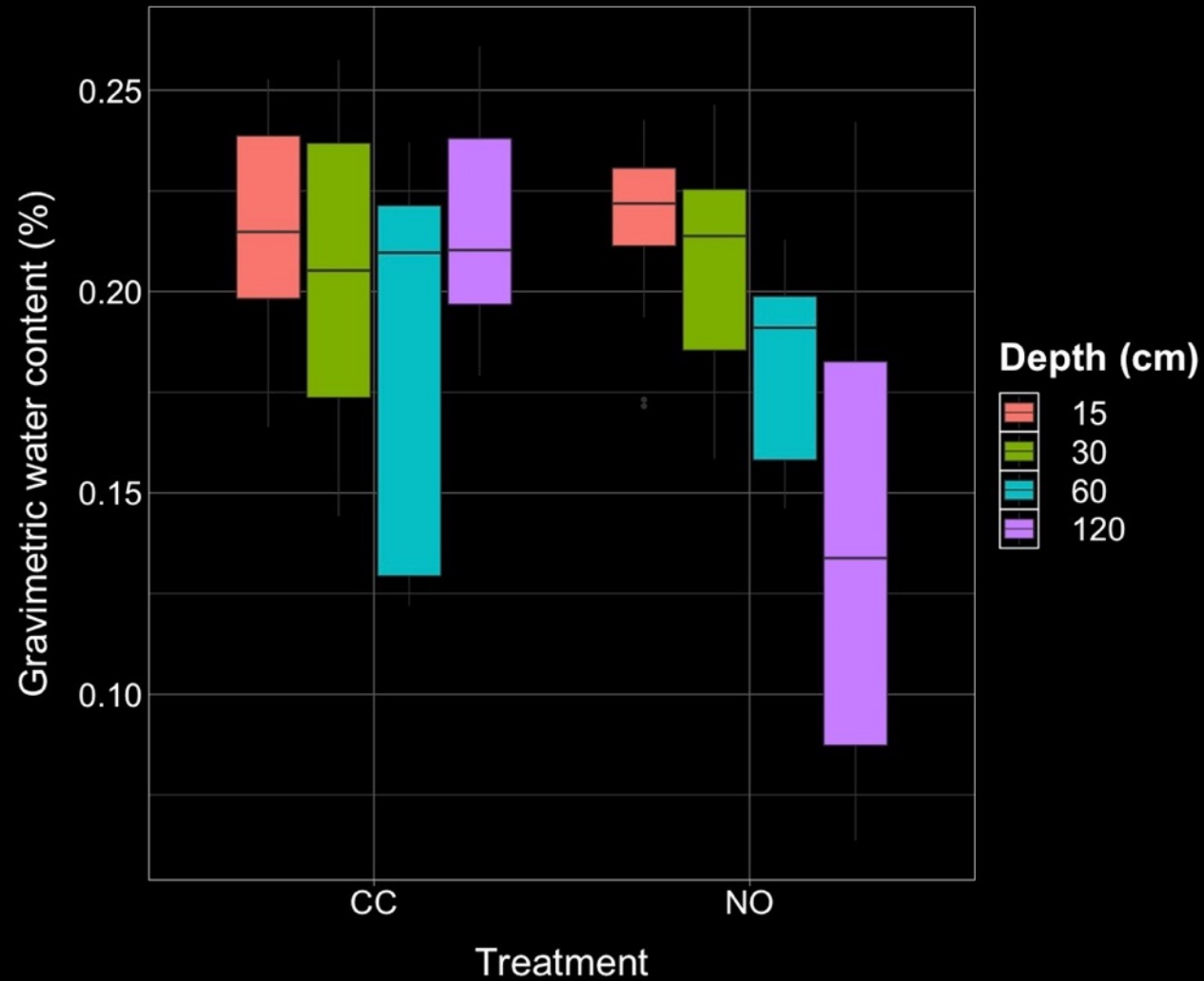
Soil-carbon storage

+ Decreased irrigation by 30%

Benefit-cost ratio	Tomato	Almond
	1.02	2.21

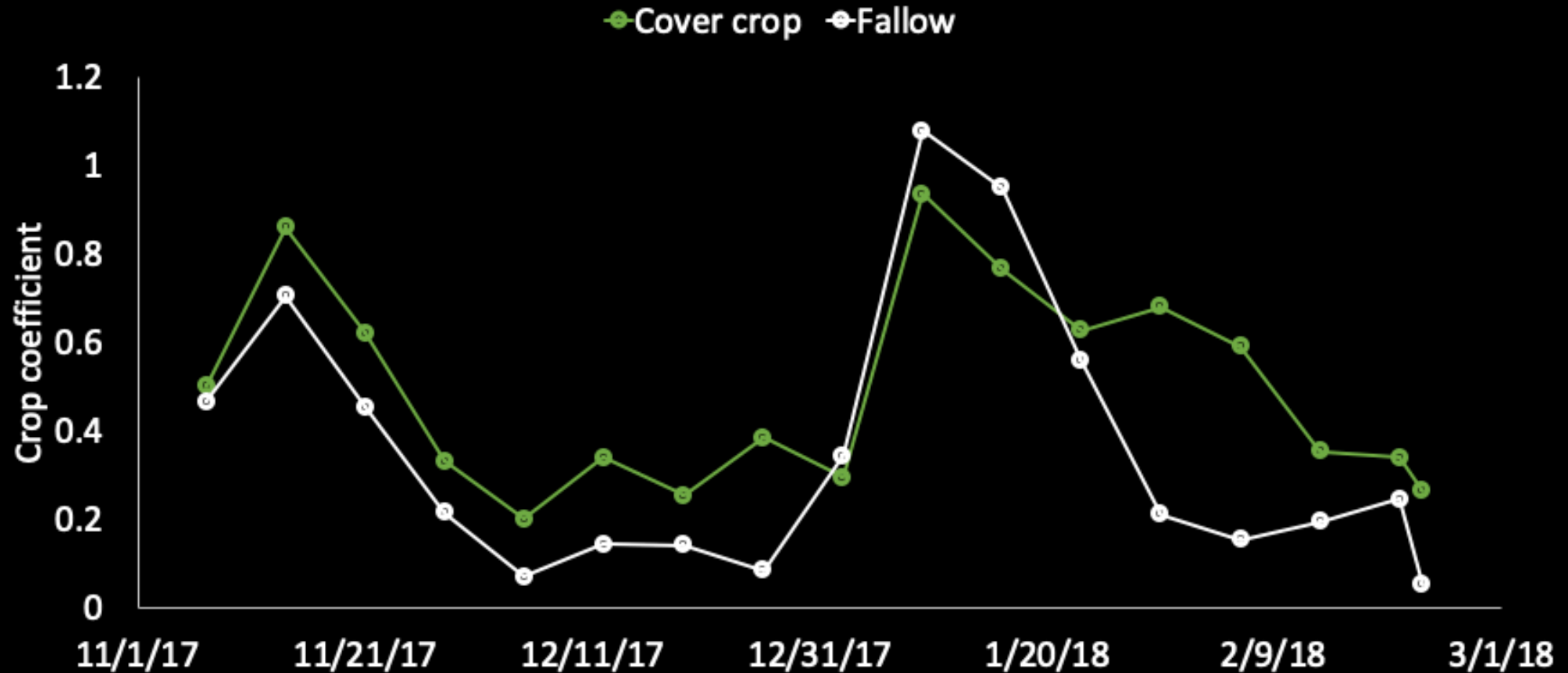
How do cover crops affect the water budget?

# How do cover crops affect the water budget? At *one* farm...



# How do cover crops affect the water budget? *At another farm...*

## Research farm in Northern California



How do cover crops affect the water budget?  
*At another farm...*

Research farm in Northern California



## Costs

Seed  
Planting (labor)  
Termination (labor)  
Cash crop harvest complications  
Depreciation of machinery  
Opportunity cost of time spent learning to grow cover crops

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Increased yield  
Soil erosion control  
Nutrient cycling  
Weed control  
Reduced tillage /  
discounted beehives\*  
Increased soil organic matter  
Reduced surface water runoff  
Soil-carbon storage

**+ Subsidies for ecosystem services**

Benefit-cost ratio	Tomato	Almond
	0.73	1.5

## Costs

Seed  
Planting (labor)  
Termination (labor)  
Cash crop harvest complications  
Depreciation of machinery  
Opportunity cost of time spent learning to grow cover crops

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Increased yield  
Soil erosion control  
Nutrient cycling  
Weed control  
Reduced tillage /  
discounted beehives\*  
Increased soil organic matter  
Reduced surface water runoff  
Soil-carbon storage

**+ Subsidy for carbon at \$40/ton**

Benefit-cost ratio	Tomato	Almond
	0.64	1.28

## Costs

Seed

Planting (labor)

Termination (labor)

Cash crop harvest complications

Depreciation of machinery

Opportunity cost of time spent learning to grow cover crops

- **New groundwater markets**

## Benefits

Increased yield

Soil erosion control

Nutrient cycling

Weed control

Reduced tillage /  
discounted beehives\*

Increased soil organic matter

Reduced surface water runoff

Soil-carbon storage

Benefit-cost ratio	Tomato	Almond
	0.27	1.02

## Costs

Seed

Planting (labor)

Termination (labor)

Cash crop harvest complications

Depreciation of machinery

Opportunity cost of time spent learning to grow cover crops

**- Lower yields for almonds**

**- More irrigation during droughts**

**- Surface water is more expensive**

## Benefits

Increased yield

Soil erosion control

Nutrient cycling

Weed control

Reduced tillage /  
discounted beehives\*

Increased soil organic matter

Reduced surface water runoff

Soil-carbon storage

**+ Higher yields for tomatoes**

**+ Less erosion during floods**

Benefit-cost ratio <i>climate change</i>	Tomato	Almond
	0.45	0.69

# Limitations

## More costs and benefits

- Insect biodiversity
- Improvements to biogeochemistry
- Grazing and forage as termination methods
- Leaching of chemicals
- Complicated carbon trade-off

*For example... greenhouse gasses are emitted when diesel powered equipment is used to plant and terminate but cover crops naturally sequester carbon in soil*

## Rich heterogeneity is not captured

These results are location and crop specific, but this model could be fitted to different systems

# Potential subsidies for processing tomatoes

\$

- Annual subsidy of at least \$175 per acre

\$\$

- 3 year subsidy of \$550 per acre

\$\$\$

- Annual subsidy for carbon sequestration valued at \$600 per ton

# Contribution to sustainable agriculture

- Sheds light on low adoption of an important practice
- Focused on California + high value crops specifically
- Unique methods ensure that results are grounded in reality that farmers experience

# Possible explanations for low adoption rates

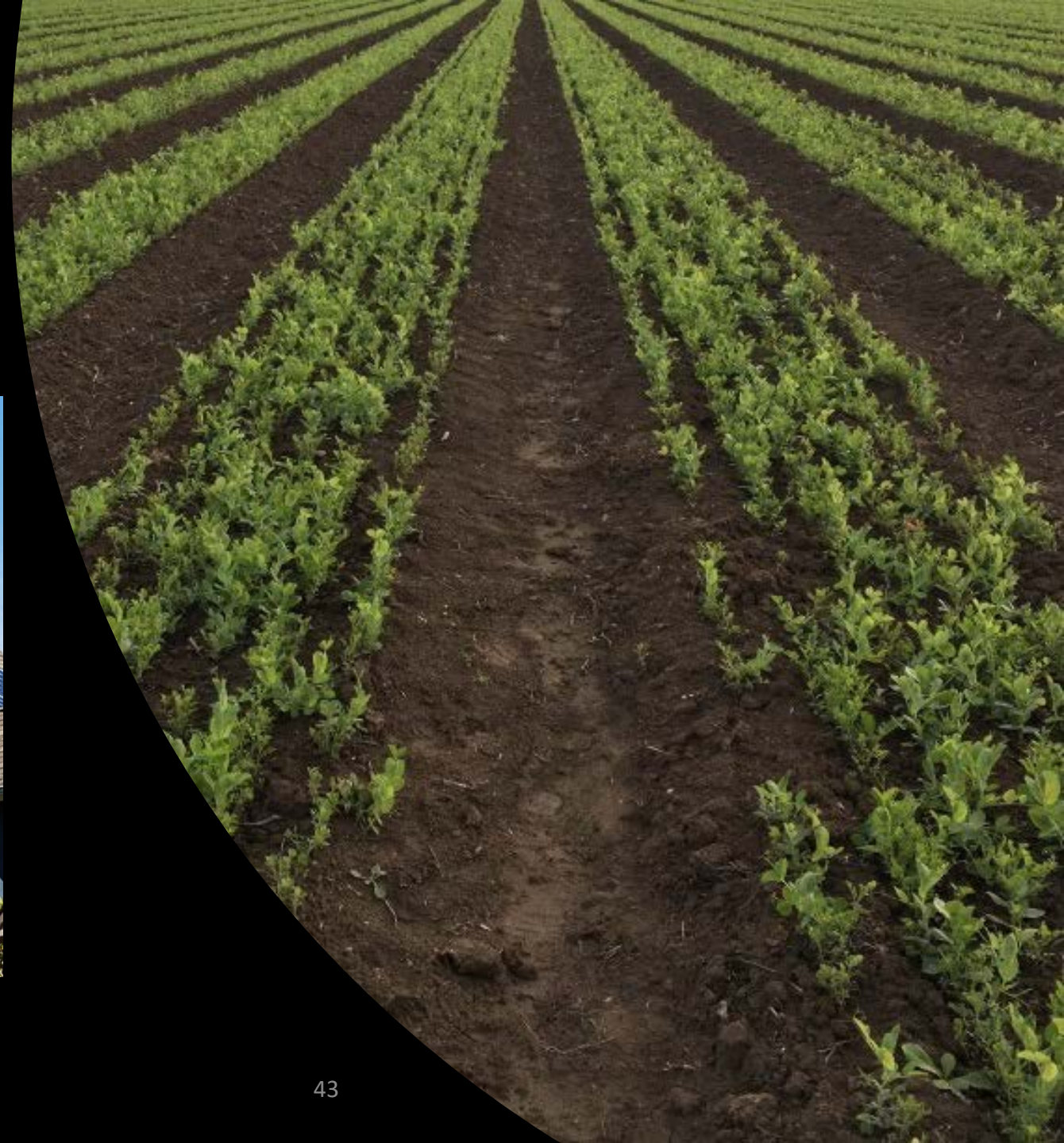
- ✗ Not cost effective
- ✓ Cost effective far in the future
- ✓ Cost effective but benefits are not experienced by the grower
- ✓ Information barriers, risk and uncertainty

*Take away:*

**Cover cropping is profitable... sometimes!**



Photo credit: jhorrocks/iStock



## Thanks to:

Dr. Sam Sandoval

Dr. Ellen Bruno

Dr. Daniele Zaccaria

Dr. Jeffrey Mitchell

Sloane Rice

Amber Leavitt

Anna Gomes

Contact:  
[ajdevincentis@ucdavis.edu](mailto:ajdevincentis@ucdavis.edu)



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