



Summit for Recycling  
&  
Rocky Mountain Composting Symposium



**SOIL CARBON  
SOLUTIONS CENTER**  
COLORADO STATE UNIVERSITY

# Soils, organics, and climate resilience

Dr. Jane Zelikova  
Soil Carbon Solutions Center  
Colorado State University

**August 23 - 24, 2022 Aurora, Colorado**



# UN climate report: Carbon removal is now “essential”

Removing the greenhouse gas from the air will likely be necessary, along with radical emissions cuts, to keep temperatures from rising 2 ° C.

By James Temple & Casey Crownhart

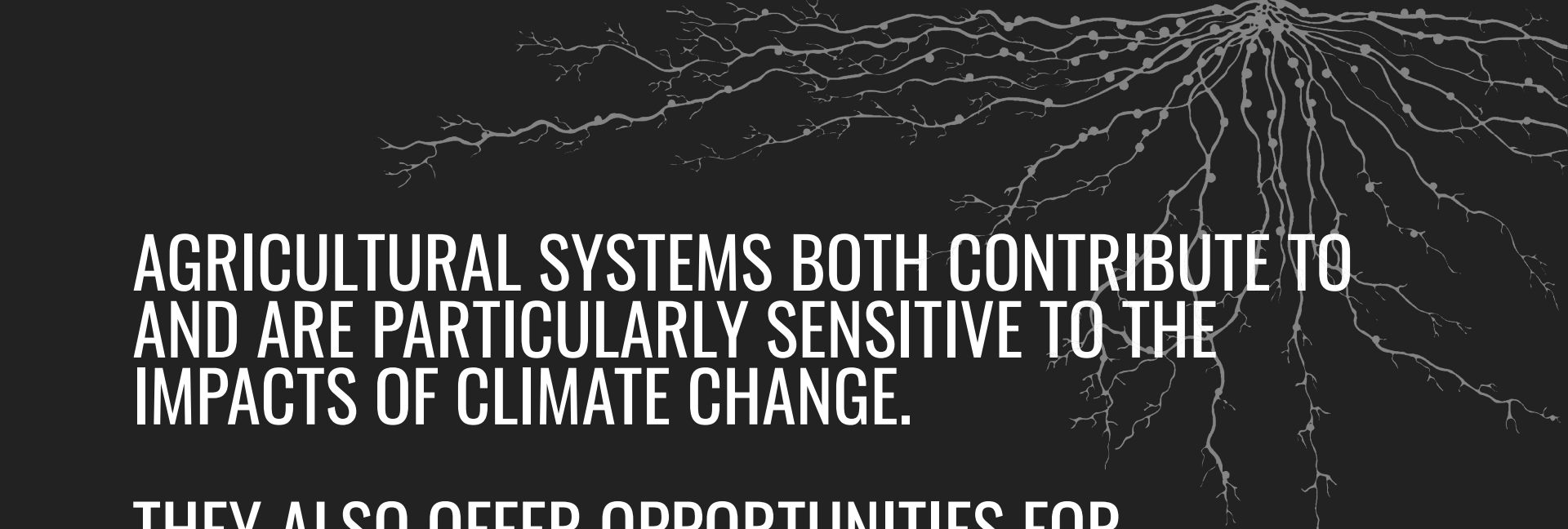
April 4, 2022



Removal of residual emissions from hard-to-decarbonize sectors (heavy industry, transportation, agriculture)



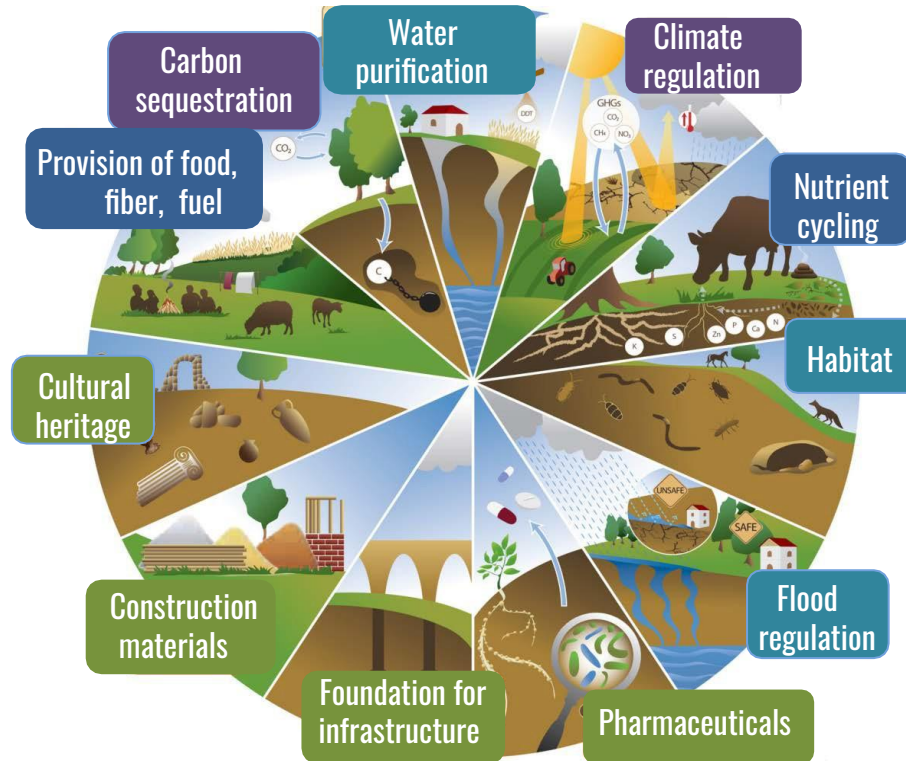
Draw down “legacy” emissions



**AGRICULTURAL SYSTEMS BOTH CONTRIBUTE TO  
AND ARE PARTICULARLY SENSITIVE TO THE  
IMPACTS OF CLIMATE CHANGE.**

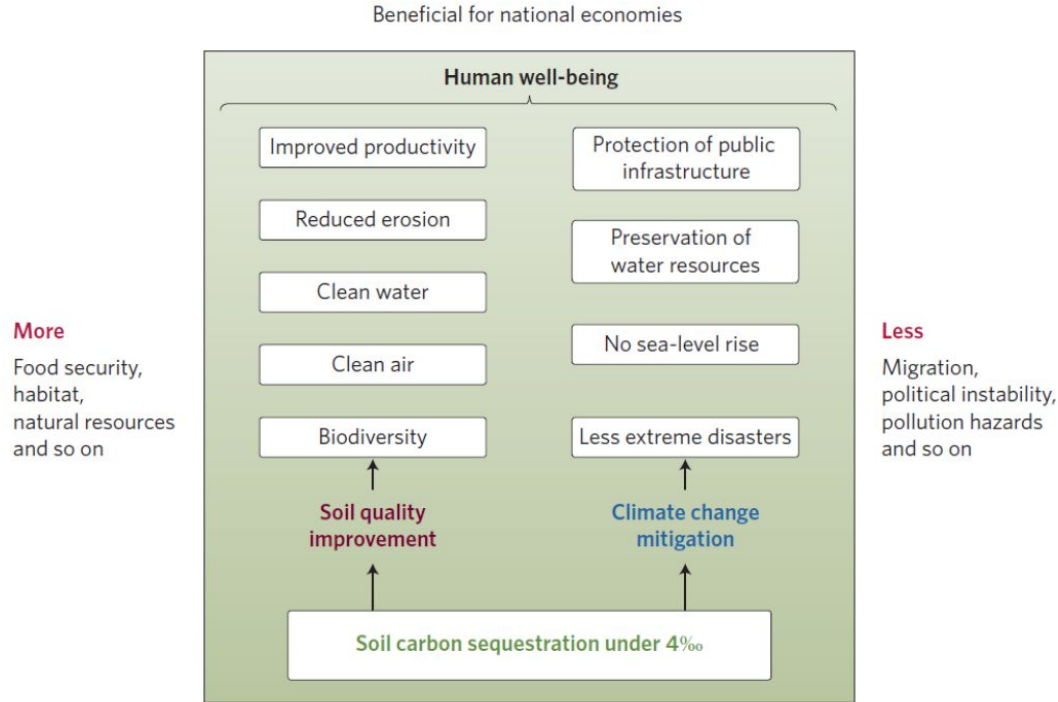
**THEY ALSO OFFER OPPORTUNITIES FOR  
MITIGATION.**

# Soils are at the nexus of many concurrent and reinforcing challenges





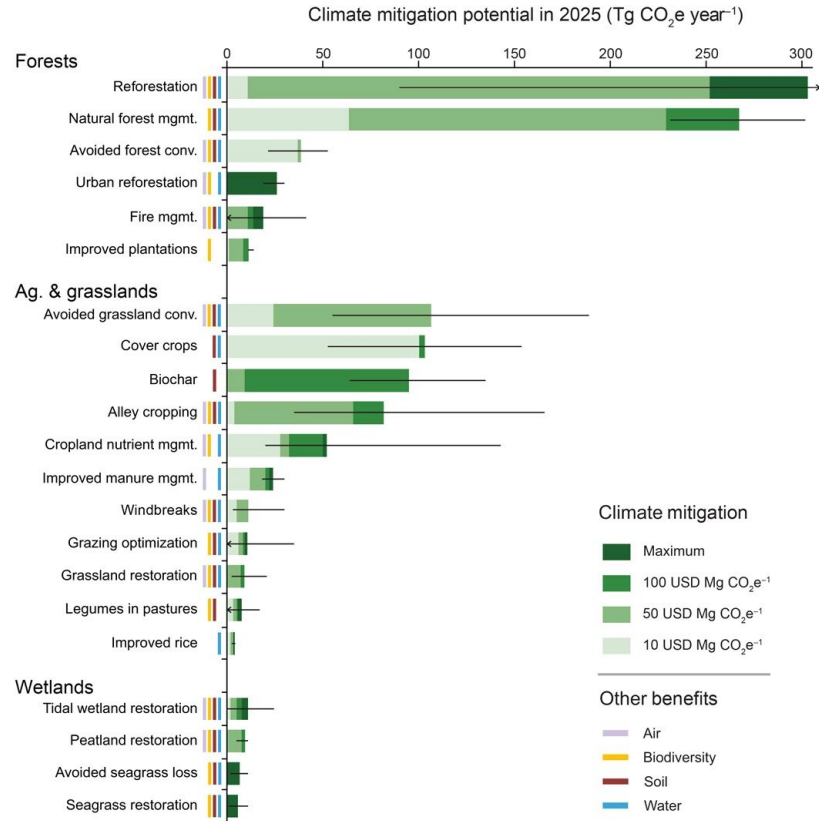
# Soils can help meet multiple challenges



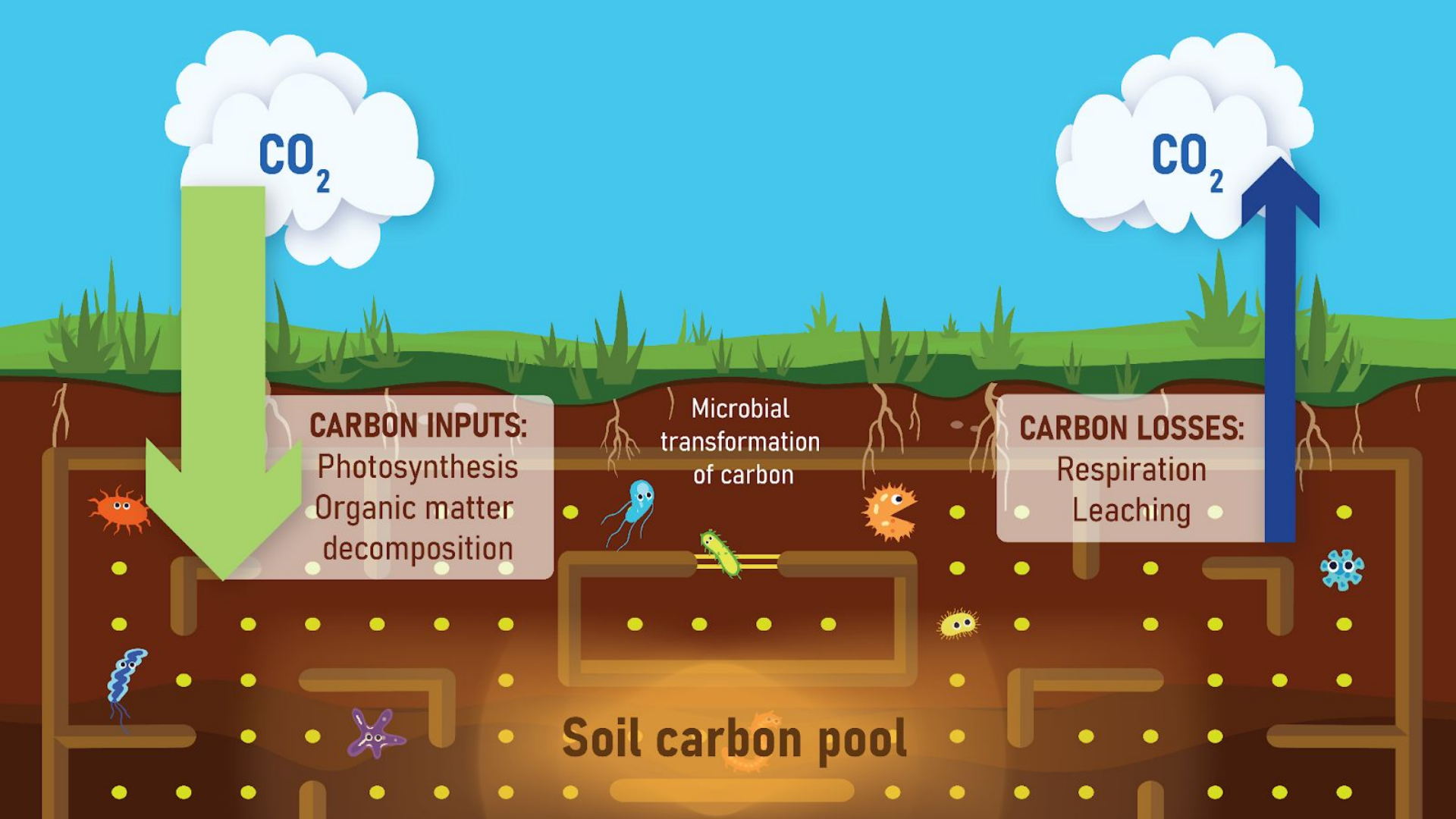
Chabbi, Lehmann, Ciais, Loescher, Cotrufo et al., 2017

Paustian et al., 2019

# A “win win” solution under our feet



fargone et al 2018



$\text{CO}_2$

$\text{CO}_2$

**CARBON INPUTS:**  
Photosynthesis  
Organic matter  
decomposition

Microbial  
transformation  
of carbon

**CARBON LOSSES:**  
Respiration  
Leaching

**Soil carbon pool**

# Principles of regenerative agriculture



Minimize soil disturbance



Plants in the ground year round



Diversified crops in time and space



Optimized application of biological and chemical inputs



Integrated livestock when possible



# Benefits of regenerative agriculture

Mitigation of climate impacts

Increased food security

Avoided deforestation and land degradation

Enhanced nutrient management, reduced GHG emissions and water pollution

Improved biodiversity

Enhanced profitability



Image: Dan Meyers, Unsplash



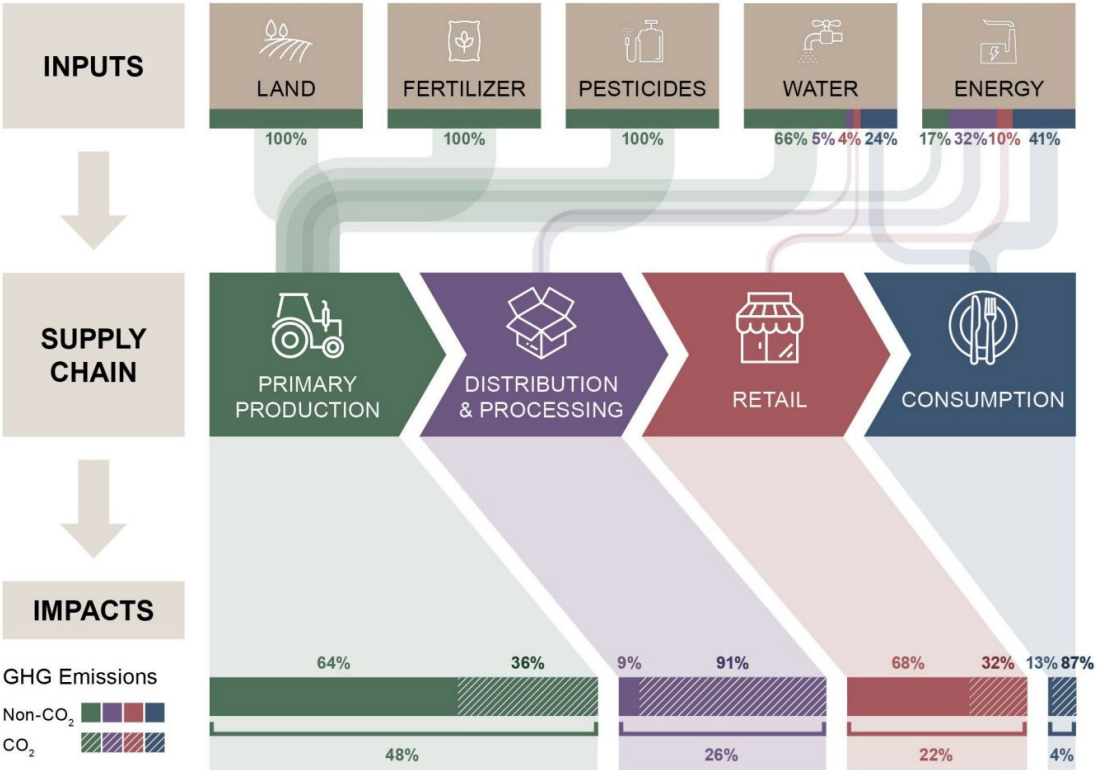
Management practice	Increased C inputs	Reduced C losses
Improved crop rotations and increased crop residues	✓	
Cover crops	✓	
Conversion to perennial grasses and legumes	✓	✓
<b>Manure and compost addition</b>	✓	
No-tillage and other conservation tillage		✓
Rewetting organic (i.e., peat and muck) soils		✓
Improved grazing land management	✓	

Faustman et al. 2019



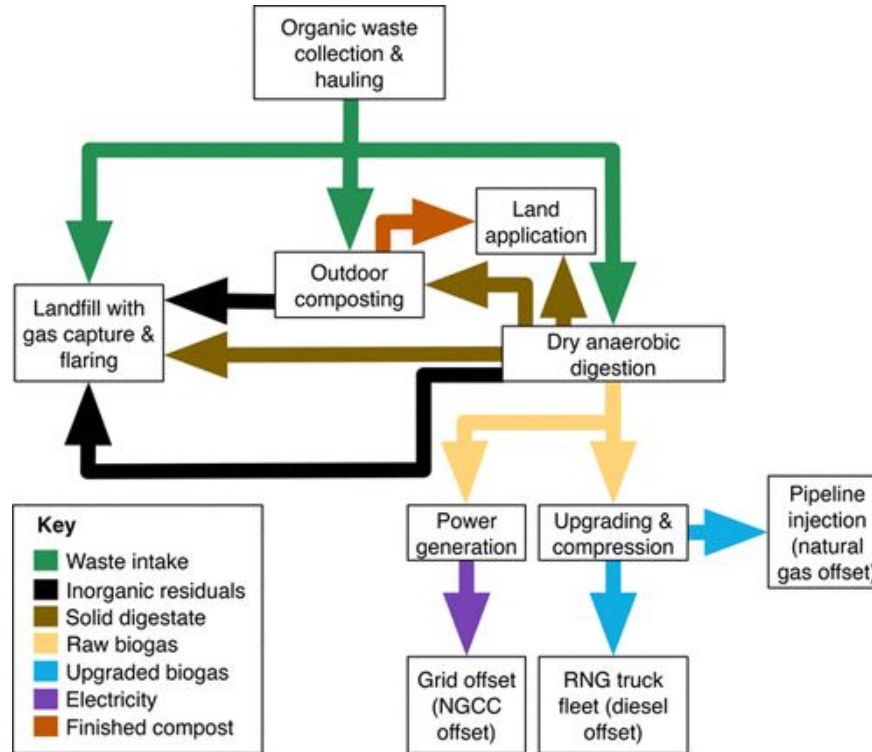
Photo credit: Phil Taylor

# ORGANICS DIVERSION AND APPLICATION



EPA 2021: From Farm to Kitchen: The Environmental Impacts of U.S. Food Waste; Data Source: Canning et al. (2020); Crippa et al. (2021)

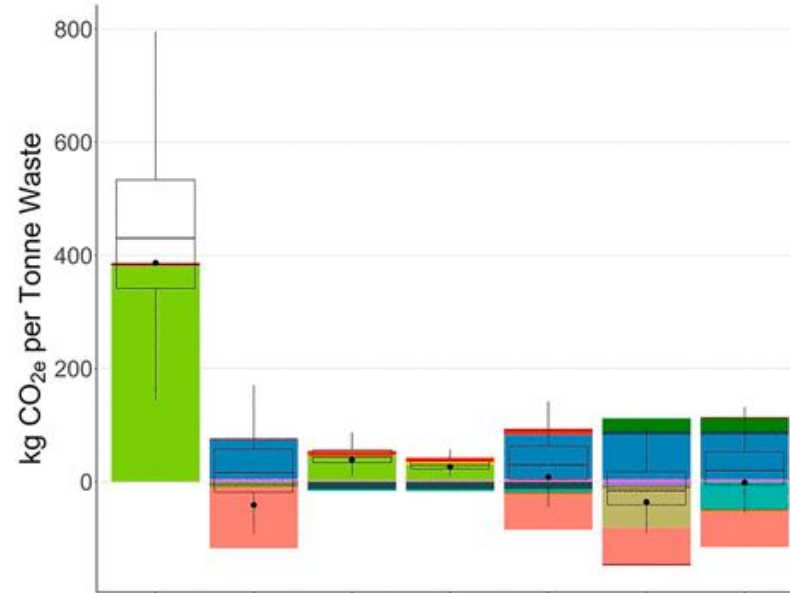
# ORGANICS DIVERSION AND APPLICATION



Nordahl et al. 2020



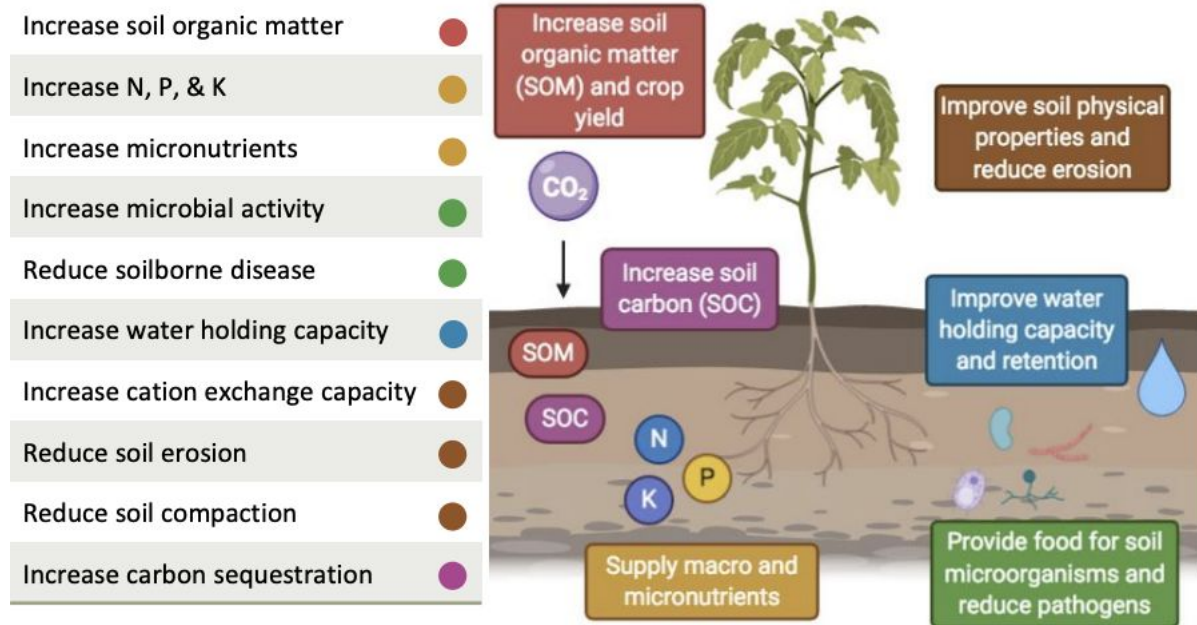
# ORGANICS DIVERSION AND APPLICATION



Organics Fate	Landfill	Compost	Dry AD	Dry AD	Dry AD	Dry AD	Dry AD					
Energy Output	N/A	N/A	Electricity to Grid	Electricity to Grid	Electricity to Grid	RNG to Trucks	RNG to Pipeline					
Digestate Fate	N/A	N/A	Landfill	Land Applied	Compost	Compost	Compost					
Offset Credit(s)	N/A	Fertilizer	NGCC	NGCC, Fertilizer	NGCC, Fertilizer	Diesel, Fertilizer	Natural Gas, Fertilizer					
	Transportation	Organics Composting	NGCC Electricity	Natural Gas	Methane Loss	Landfill	Fertilizer Use	Digestate Application	Diesel	Compost Application	CHP	Other

Nordahl et al. 2020

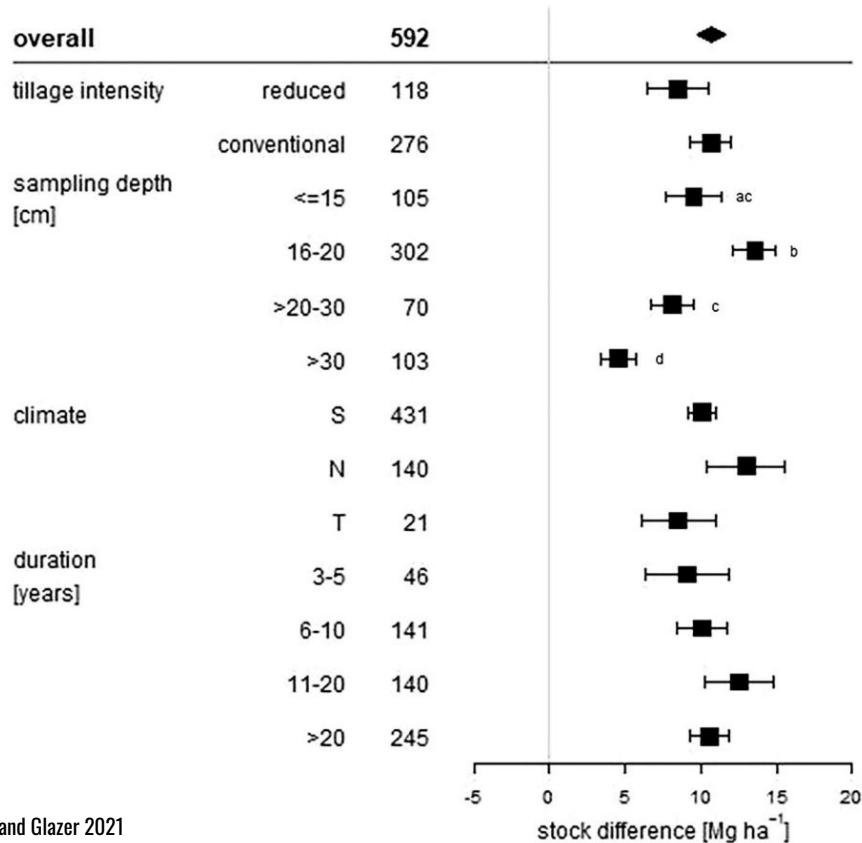
# COMPOST APPLICATION TO AG LANDS



Adapted from Martinez-Blanco, J., Lazcano, C., Christensen, T.H., Munoz, P., Rieradevall, J., Møller, J., & Boldrin, A. (2013). Compost benefits for agriculture evaluated by life cycle assessment. A review. *Agronomy for sustainable development*, 33(4), 721-732.

Created in BioRender.com

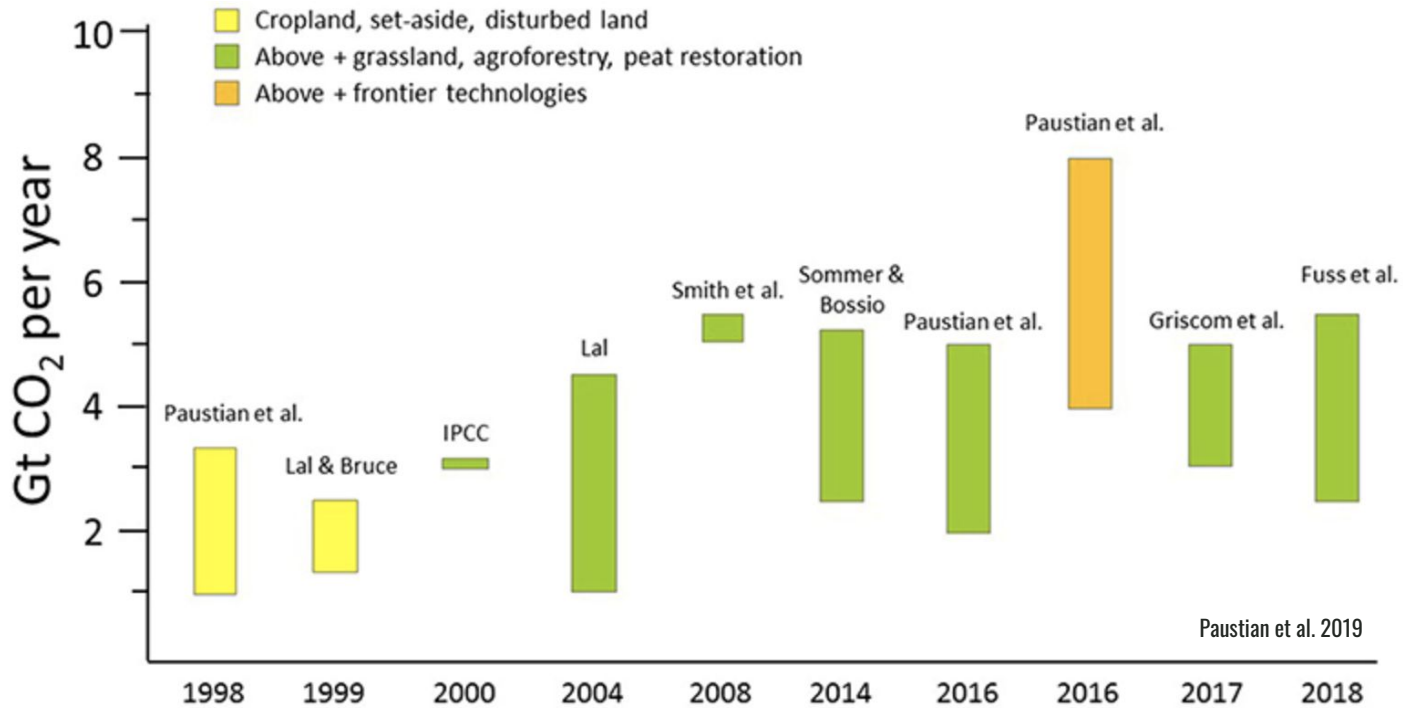
# MANURE APPLICATION



> SOC stocks by 35% (10.7 Mg ha<sup>-1</sup>)

- Less effective in reduced tillage systems
- More effective in cooler climates
- Most effective in less C rich soils
- Animal manure more effective than green

# WHAT IS THE SOIL C DRAWDOWN POTENTIAL?



~10% OF GLOBAL ANNUAL EMISSIONS





NORTH AMERICA

EUROPE

ASIA

AFRICA

SOUTH AMERICA

AUSTRALIA

WHERE WE CAN GROW CROPS

PASTURE

# WHERE IS THE POTENTIAL?



# WHERE IS THE POTENTIAL?

WHERE WE HAVE LOST A LOT OF CARBON

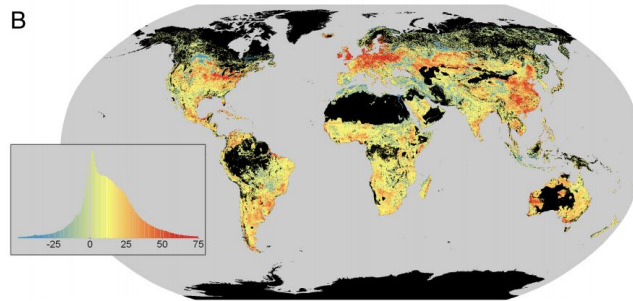
RESEARCH

## MIDWESTERN US HAS LOST 57.6 BILLION METRIC TONS OF SOIL DUE TO AGRICULTURAL PRACTICES

New research, led by UMass Amherst, shows that human-caused erosion in America's Breadbasket is far greater than previously thought

<https://www.umass.edu/news/article/midwestern-us-has-lost-57-6-billion-metric-tons-soil-due-agricultural-practices>

B



Sanderman et al. 2017

Agricultural land uses have resulted in the loss of **133 Pg C** from the soil. Maps indicate hotspots of soil carbon loss, often associated with major cropping regions and degraded grazing lands, suggesting that there are identifiable regions that should be targets for soil carbon restoration efforts.

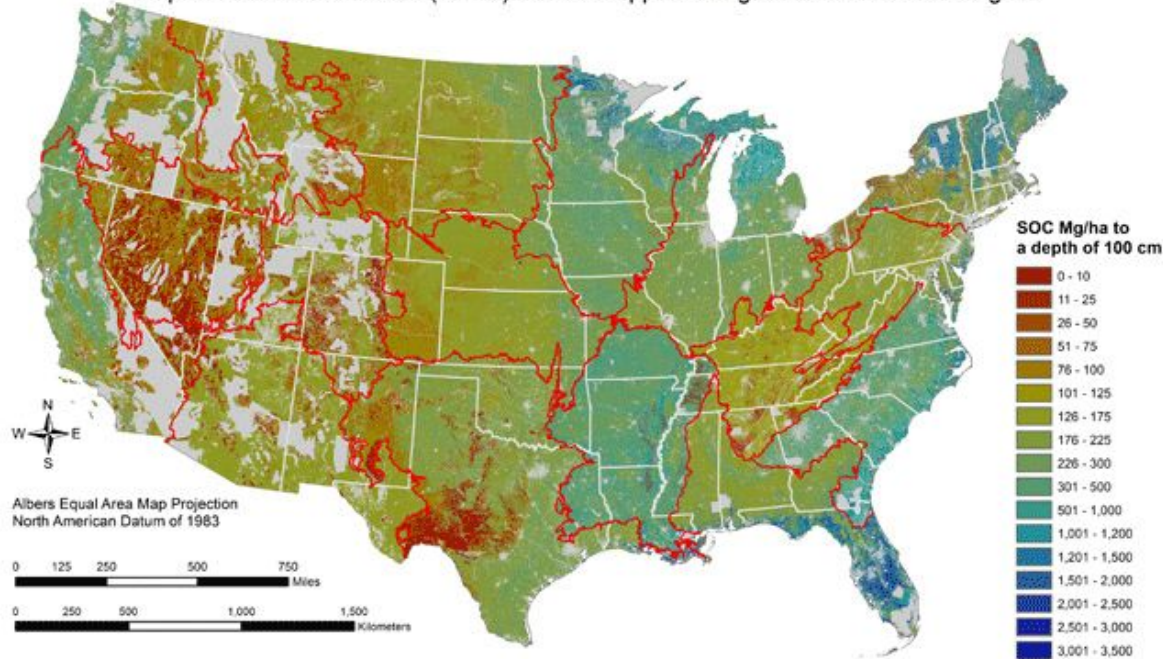


# WHERE IS THE POTENTIAL?

WHERE SEQUESTRATION RATES ARE HIGH

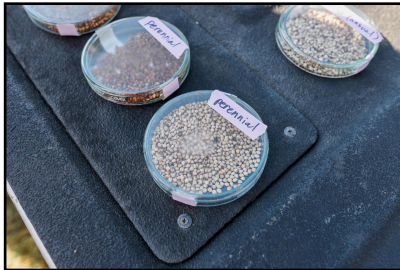
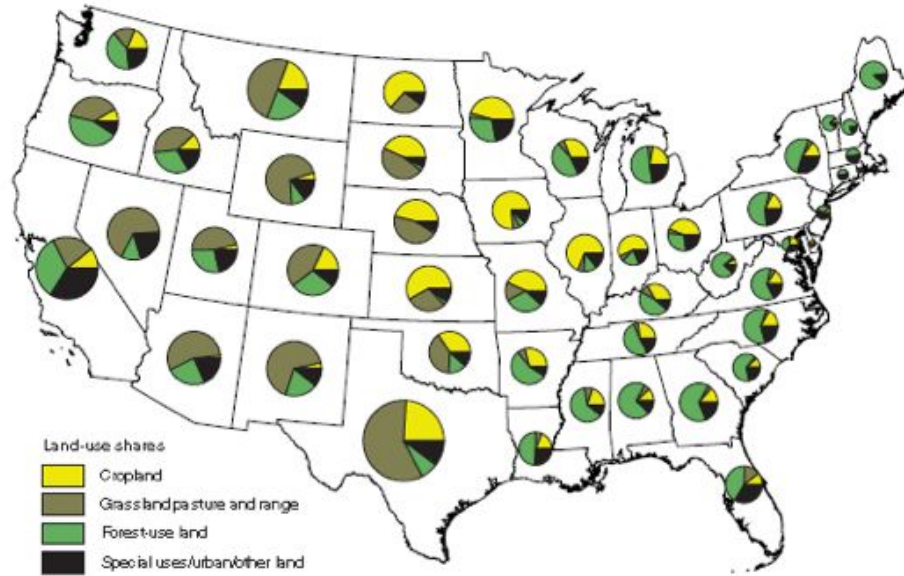
## Soil Organic Carbon Stocks

Rapid Carbon Assessment (RaCA) Values Mapped Using SSURGO and NLCD grids



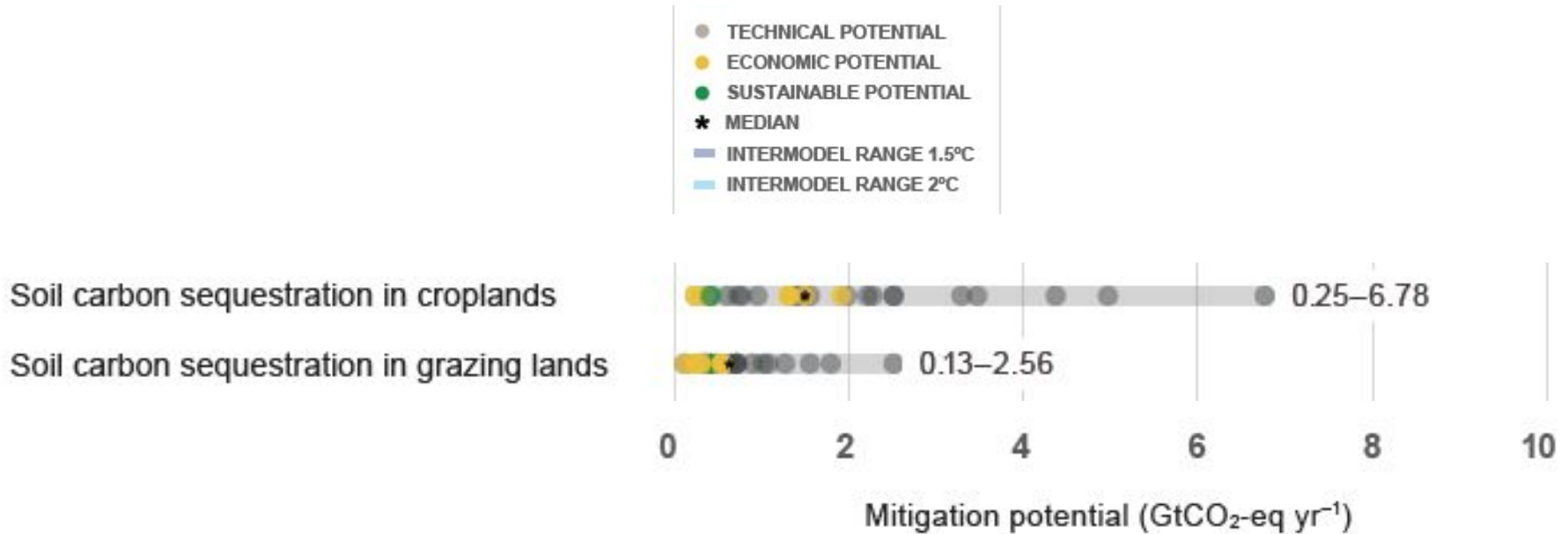
# WHERE IS THE POTENTIAL?

WHERE WE CAN SHIFT MANAGEMENT PRACTICES





# ECONOMIC << TECHNICAL POTENTIAL



# RAPIDLY EXPANDING SPACE

Climate Solutions

The Washington Post  
*Democracy Dies in Darkness*

## Planting crops — and carbon, too

President Biden says farmers can adopt agricultural methods that help fight climate change. Maryland farmer Trey Hill has been trying.

January 2021

GreenBiz

## How carbon-smart farming is catalyzing the big bucks needed to transform the way America eats

By [CJ Clouse](#)

December 21, 2020

The New York Times Magazine

## Can Dirt Save the Earth?

Agriculture could pull carbon out of the air and into the soil — but it would mean a whole new way of thinking about how to tend the land.

FOOD & AGRICULTURE

## Startups aim to pay farmers to bury carbon pollution in soil

January 2020



# CRITICISMS



## Regenerative Agriculture: Good for Soil Health, but Limited Potential to Mitigate Climate Change

May 12, 2020 By Janet Ranganathan, Richard Waite, Tim Searchinger and Jessica Zions

### Environmental Groups Call Biden's Carbon Bank Plan a 'Scam'

APR 22, 2021

Dan Nosowitz **modern farmer**

**WIRED**

ROBERT PAARLBERG IDEAS JAN 22, 2021 8:00 AM

### INSIDER: Further Explanation on the Potential Contribution of Soil Carbon Sequestration on Working Agricultural Lands to Climate Change Mitigation

August 24, 2020 By Tim Searchinger and Janet Ranganathan

CLIMATE CHANGE

### Why we can't count on carbon-sucking farms to slow climate change

Even though lots of politicians, environmentalists, and companies are eager to try.

By James Temple

June 3, 2020

MIT  
Technology  
Review

## President Biden, Please Don't Get Into Carbon Farming

This is not the solution to our climate problems; it's a sweetheart deal for Big Ag.



# CRITICISMS



**US scheme used by Australian farmers reveals the dangers of trading soil carbon to tackle climate change**

June 24, 2021 4:12pm EDT

## Crediting agricultural soil carbon sequestration

EMILY E. OLDFIELD, ALISON J. EAGLE, RACHEL L. RUBIN, JOSEPH RUDEK, JONATHAN SANDERMAN, AND, DORIA R. GORDON [Authors Info & Affiliations](#)

*SCIENCE* · 17 Mar 2022 · Vol 375, Issue 6586 · pp. 1222-1225 · DOI: [10.1126/science.abc7991](https://doi.org/10.1126/science.abc7991)

Synthesis Article

## Caught in between: credibility and feasibility of the voluntary carbon market post-2020

Nicolas Kreibich & Lukas Hermwille  

Received 19 Nov 2020, Accepted 22 Jun 2021, Published online: 07 Jul 2021

 Download citation  <https://doi.org/10.1080/14693062.2021.1948384>

 Check for updates

<https://www.tandfonline.com/doi/full/10.1080/14693062.2021.1948384>

CLIMATE SCIENCE

## A Soil-Science Revolution Upends Plans to Fight Climate Change

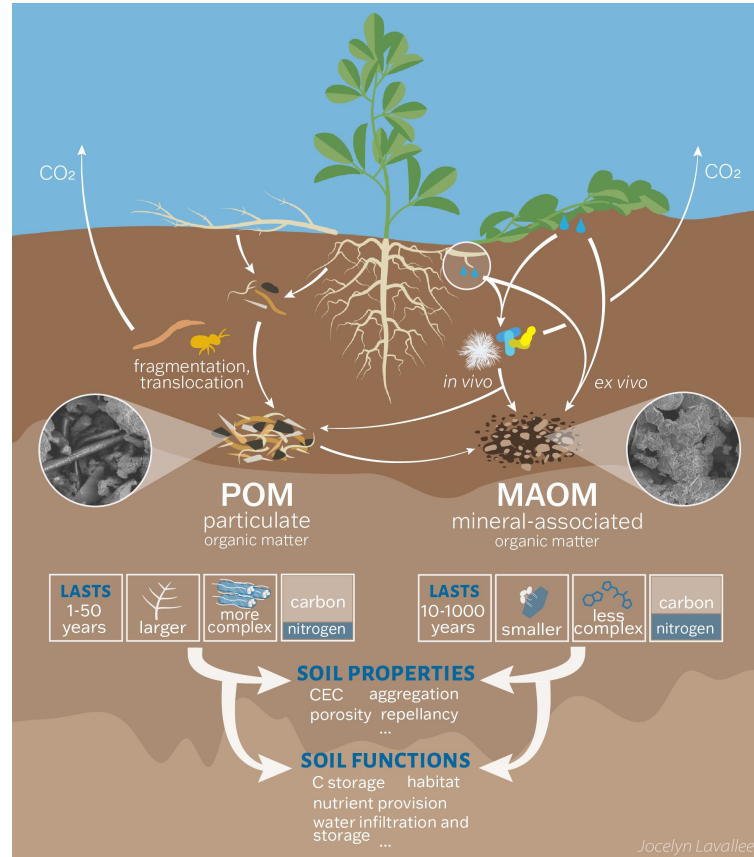
<https://www.quantamagazine.org/a-soil-science-revolution-upends-plans-to-fight-climate-change-20210727/>

July 2021

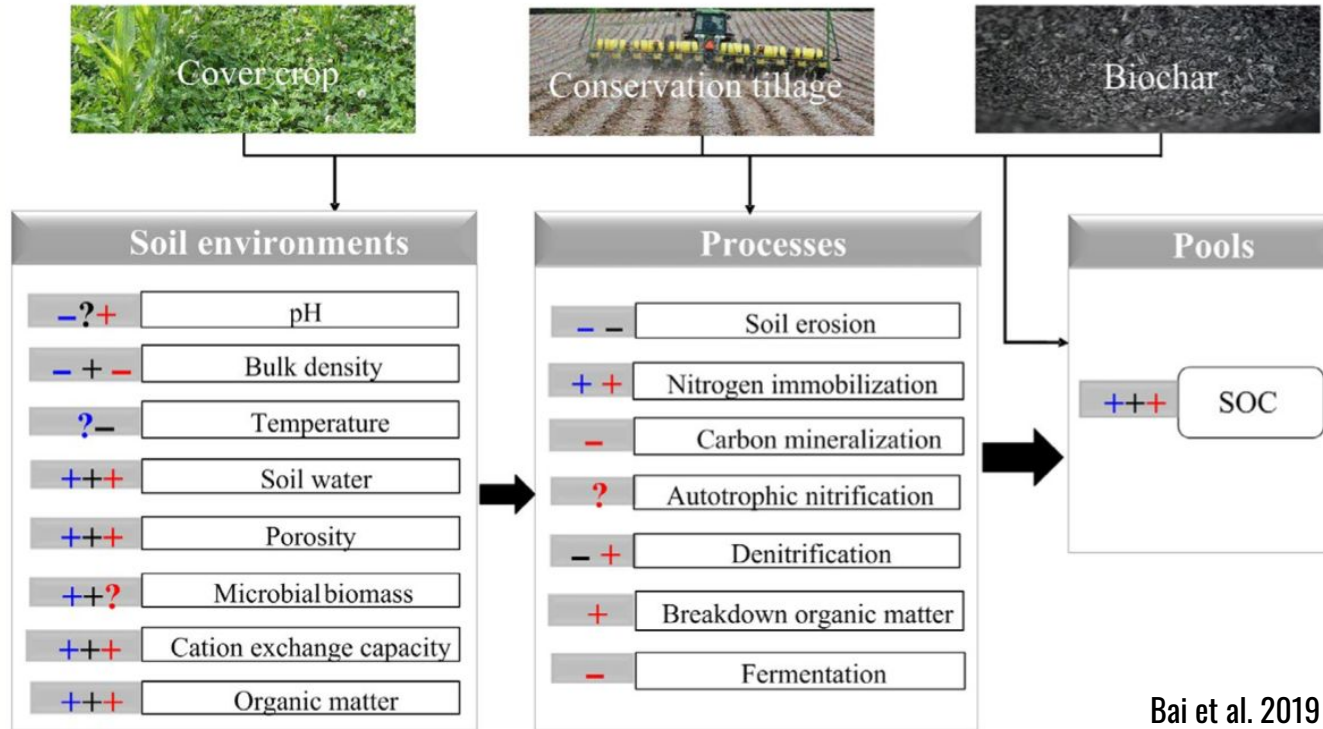


# WHAT DOES SCIENCE SAY?

NOT ALL CARBON IS CREATED EQUAL

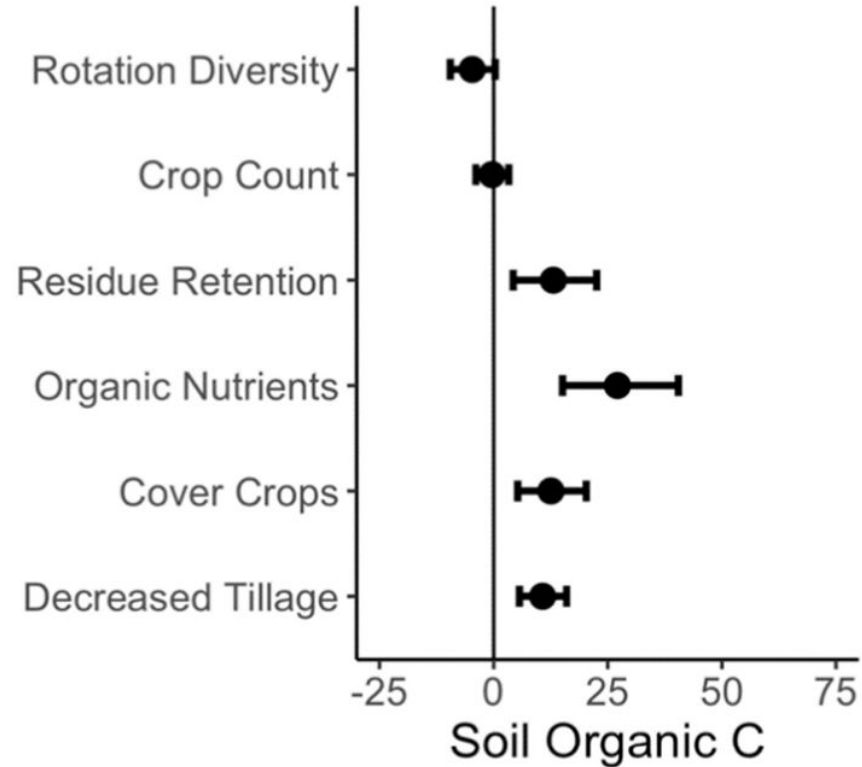


# WHAT DOES SCIENCE SAY?



Bai et al. 2019

# WHAT DOES SCIENCE SAY?



Lipzin et al SBB, 2022



# CHALLENGES



## 1 Education

...

Technical assistance and education resources are critical for farmers and ranchers to implement new practices and capitalize on the value of soil health.



## 2 Science

...

Soil health and carbon sequestering practices need to be linked with outcomes in an accessible way.



## 3 Incentives

...

Policies should help derisk soil health practices, reduce market barriers, and streamline access to incentives that are congruent with soil health objectives.



# CHALLENGES



## PRODUCERS:

Need incentives to implement climate-smart practices



## FUNDERS:

Now is the time! Capital for carbon drawdown seeks soil solutions

## CURRENT ROADBLOCKS TO SOIL CARBON MARKET INTEGRATION

Carbon valuation, co-benefits and policies must evolve

The science is not accessible

Soil science is misunderstood



## CARBON FINANCE & POLICY:

Currently lacking cost-effective, verifiable accounting tools



Research advancements need scaling

Soil Carbon Solutions Center  
Colorado State University

# SOIL CARBON MARKETS - THE WILD WILD WEST

**ESMC & ESRC Funders**

FFAR MCKNIGHT FOUNDATION The Nature Conservancy USDA NRCS USDA The Ida and Robert Gordon Family Foundation General Mills UNITED SOYBEAN BOARD WALTON FAMILY FOUNDATION arpa e NOBLE RESEARCH INSTITUTE

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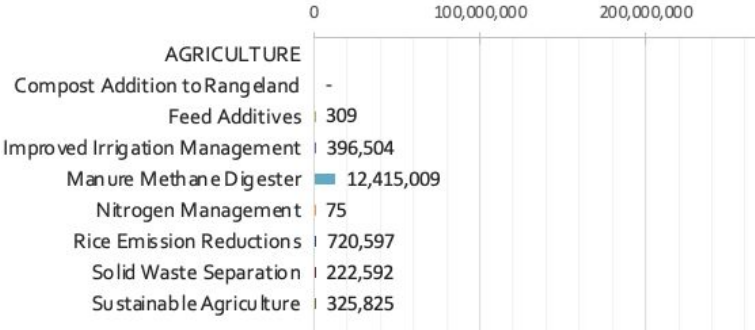
**Founding Circle Members**

SOIL HEALTH INSTITUTE Enriching Soil. Enhancing Life. Nestlé CORTEVA agriscience NOBLE RESEARCH INSTITUTE The Nature Conservancy Protecting nature. Preserving life. General Mills Cargill Helping the world thrive. NFWF INNOVATION CENTER FOR U.S. DAIRY. HEALTHY PEOPLE • HEALTHY PRODUCTS • HEALTHY PLANET. syngenta. National Indian Carbon Coalition ADM

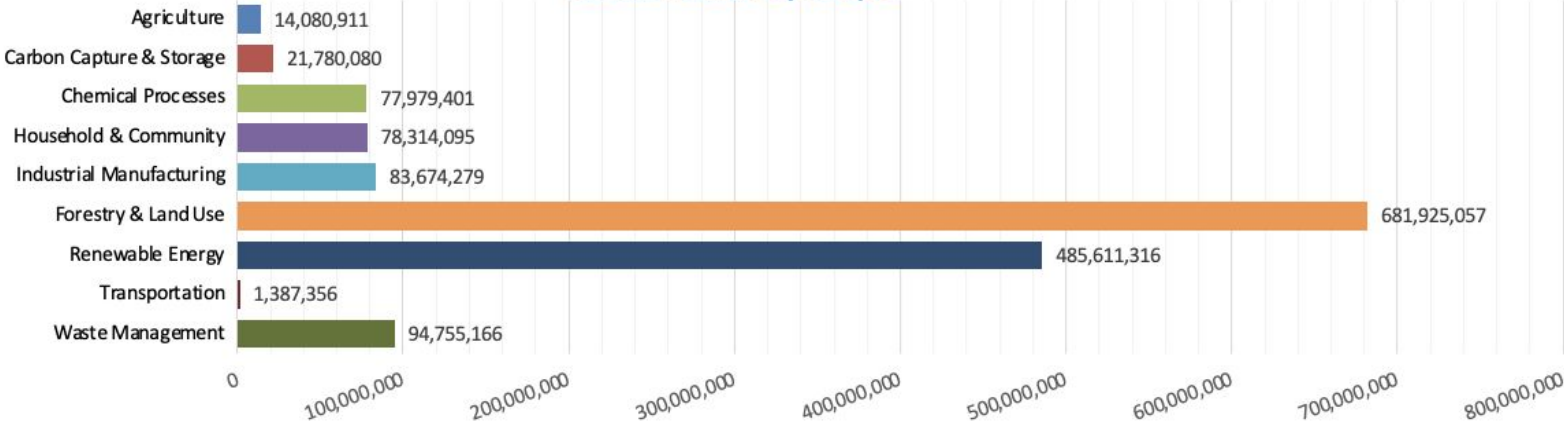
**Legacy Partner Members**

california almonds Almond Board of California BUSHEL PORT MISSOURI SOYBEANS MissouriCorn The MOONSHOT FACTORY NATIONAL CORN GROWERS ASSOCIATION FARMERS BUSINESS NETWORK TRACE GENOMICS GROWMARK PILOT BIO THE CAMPBELL FOUNDATION BENSON HILL Nourishing Innovation Field to Market MFA INCORPORATED IL Corn icorn.org National Farmers Union PEPSICO Farm Foundation Cornell Atkinson Center for Sustainability HEARTLAND Science & Technology Group TRUST IN FOOD A FARM JOURNAL INITIATIVE ASU Arizona State University DANONE NORTH AMERICA JOYN BIO K-COE ISOM regrow TYSON ASA NCBA National Cattlemen's Beef Association CTC National Association of Conservation Districts Sustainable Northwest Low Carbon Prosperity Institute SILICON RANCH MARS FARMOBILE VENCE ARVA THE FERTILIZER INSTITUTE ANUVIA native energy WWF Agronomy Crop Science SOCIETY OF AMERICA AMERICAN FARM BUREAU FEDERATION NEWTRIENT American Farmland Trust SAVING THE LAND THAT SUSTAINS US STEWARDSHIP INDEX FOR SPECIALTY CROPS American Sugarbeet Growers Association PATTERN

### Credits Issued by Type



### Credits Issued by Scope



<https://gspp.berkeley.edu/faculty-and-impact/centers/cepp/projects/berkeley-carbon-trading-project/offsets-database>



# CARBON CREDIT QUALITY CRITERIA



## Additionality & Baselines

Credited activities would not have occurred without carbon payments, activities are not common practice. Baselines should be set conservatively to minimize risk of over-crediting.



## Carbon Accounting

Quantification and monitoring uses credible, repeatable and verifiable methods, and project-specific uncertainty is estimated in a conservative manner.



## Do No Harm

Low risk of any material negative impacts on the surrounding ecosystems and local communities.



## Durability

Low risk of stored carbon being re-released into the atmosphere through voluntary or involuntary reversal events. Projects should have measures in place to minimize and account for such risk.



## Leakage

Minimal risk of displacing activities that cause emissions from the project site to another site and account for any displacement.

# Soil carbon crediting protocols are inconsistent and lack rigor

	Rigor	Additionality	Durability	Safeguards	Rating
ACR C	1/3	1/3	2/3	1/3	✓✓✓✓
ACR G	1/3	1/3	2/3	1/3	✓✓✓✓
Alb Cr*	1/3	1/3	2/3	2/3	✓✓✓✓
Aus Est*	1/3	1/3	2/3	3/3	✓✓✓✓
Aus Meas*	3/3	2/3	2/3	3/3	✓✓✓✓
BCarbon	3/3	1/3	2/3	1/3	✓✓✓✓
CAR Soil	2/3	1/3	2/3	1/3	✓✓✓✓
FAO	3/3	1/3	2/3	1/3	✓✓✓✓
Gold Std	1/3	1/3	2/3	3/3	✓✓✓✓
Nori	1/3	1/3	2/3	1/3	✓✓✓✓
Plan Vivo	1/3	1/3	2/3	3/3	✓✓✓✓
Regen	1/3	1/3	2/3	1/3	✓✓✓✓
Verra FG	2/3	1/3	2/3	1/3	✓✓✓✓
Verra IA	1/3	2/3	2/3	1/3	✓✓✓✓
Verra Soil	3/3	1/3	2/3	1/3	✓✓✓✓
Verra SA	1/3	1/3	2/3	1/3	✓✓✓✓
Verra SG	1/3	1/3	2/3	1/3	✓✓✓✓

<https://carbonplan.org/research/soil-protocols-explainer>

# WHAT DO FARMERS SAY?



**90%** are aware of C markets



**3%** currently participating

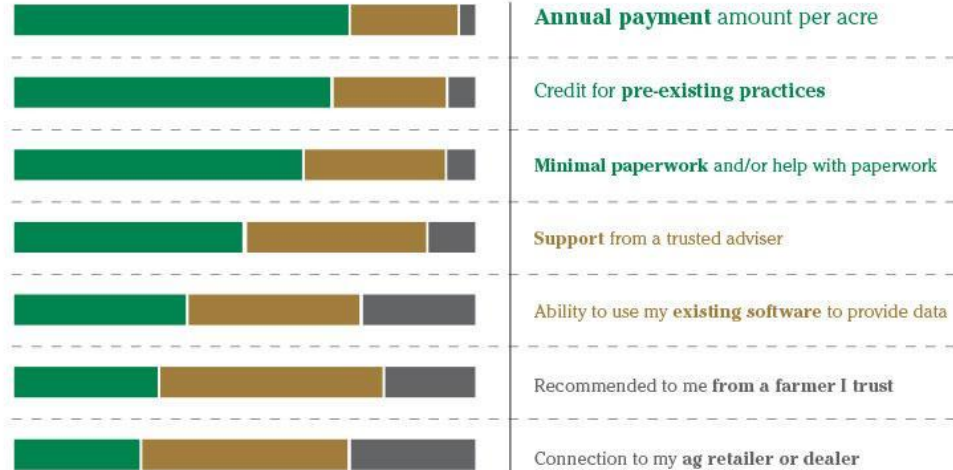


**59%** won't participate without changes

## 500 FARMER INSIGHTS

How important are the following criteria to you in evaluating what carbon market you might choose to participate in?

VERY IMPORTANT    SOMEWHAT IMPORTANT    NOT IMPORTANT



SOURCE: TRUST IN FOOD

Anything that makes regenerative practices more **profitable**, **easier**, and **socially acceptable** will lead to **climate positive outcomes**.



The background is a watercolor-style illustration. The top half is a blue sky with various shades of blue and white, suggesting clouds. The bottom half is a bright yellow ground, representing a field or soil. The two colors meet at a slightly wavy horizontal line.

# THANK YOU

QUESTIONS? GET IN TOUCH!

[HELLO@SOILCARBONSOLUTIONSCENTER.COM](mailto:HELLO@SOILCARBONSOLUTIONSCENTER.COM)