University of Minnesota Extension

Carbon Smart

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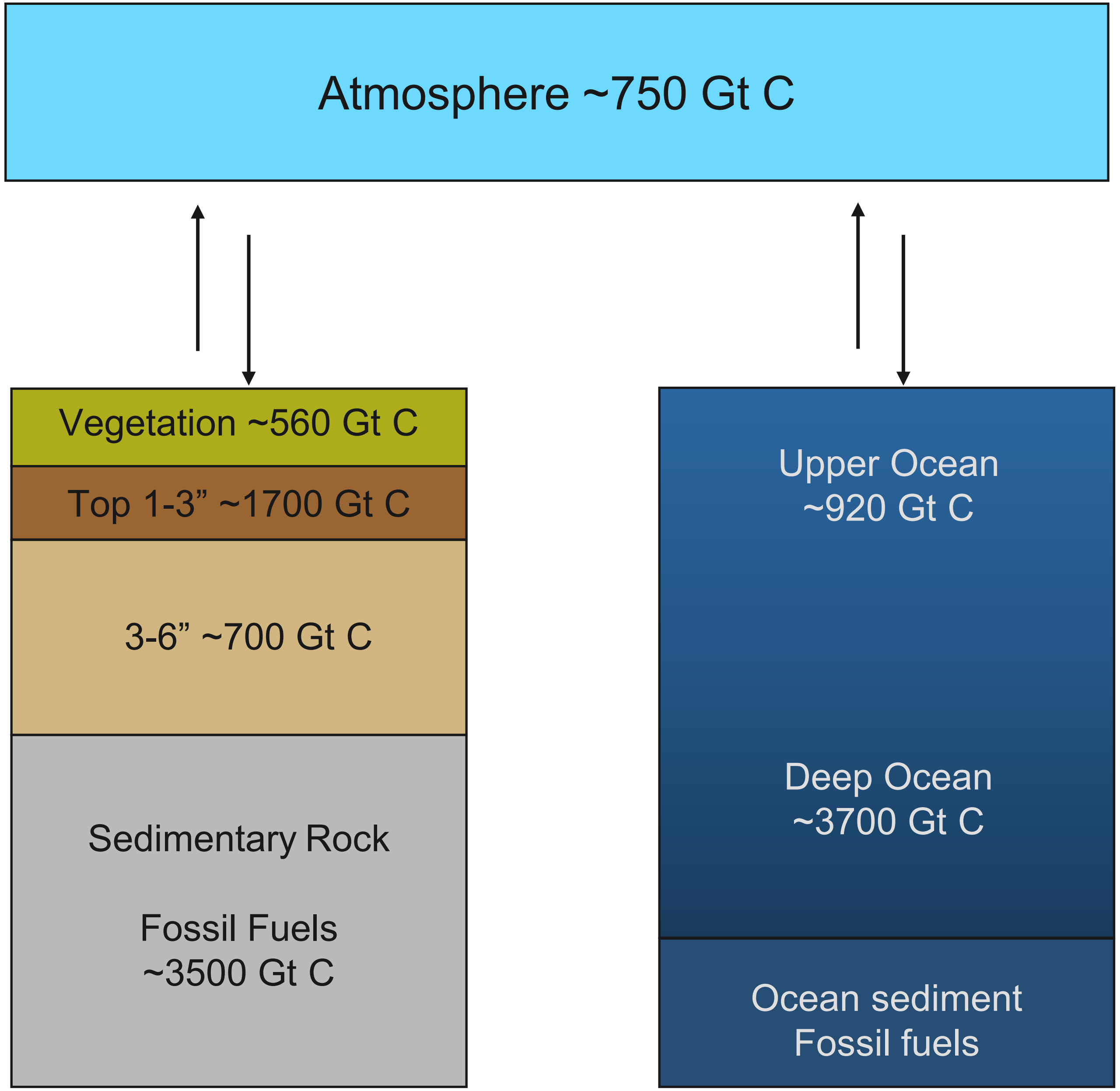
Why is Carbon Important?

- Carbon is the duct tape for **all** life on Earth!
- Carbon as CO_2 is a greenhouse gas; increases climate changes

Where is Carbon Stored Globally?

(GT = *Billion* Metric Ton)

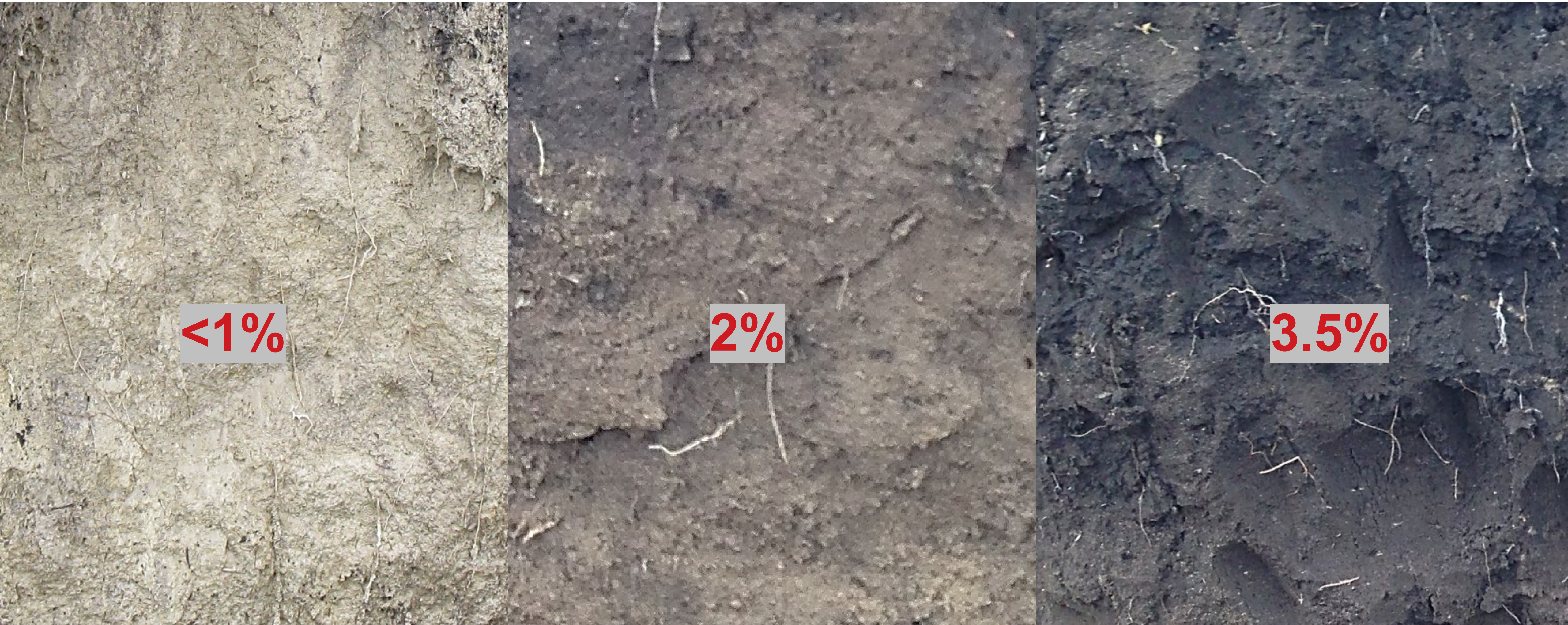


Redrawn from Hillel and Rosenzweig, 2010

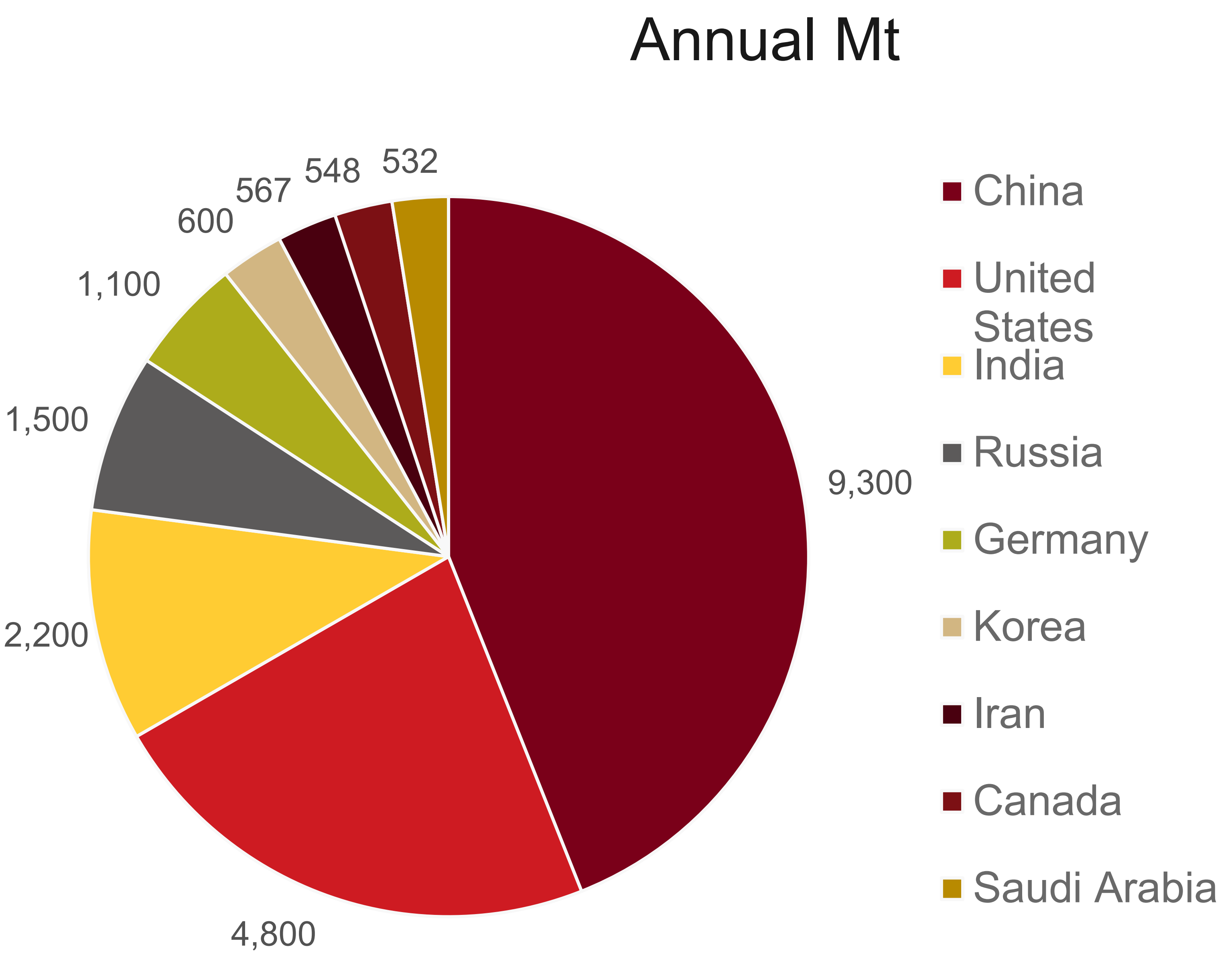
Organic Matter is ~58% Carbon

- May hear soil organic carbon used as soil organic matter.
- 1% OM has 11,600 pounds of C in 6” of topsoil per acre.

You can **see** when carbon is stored in the soil

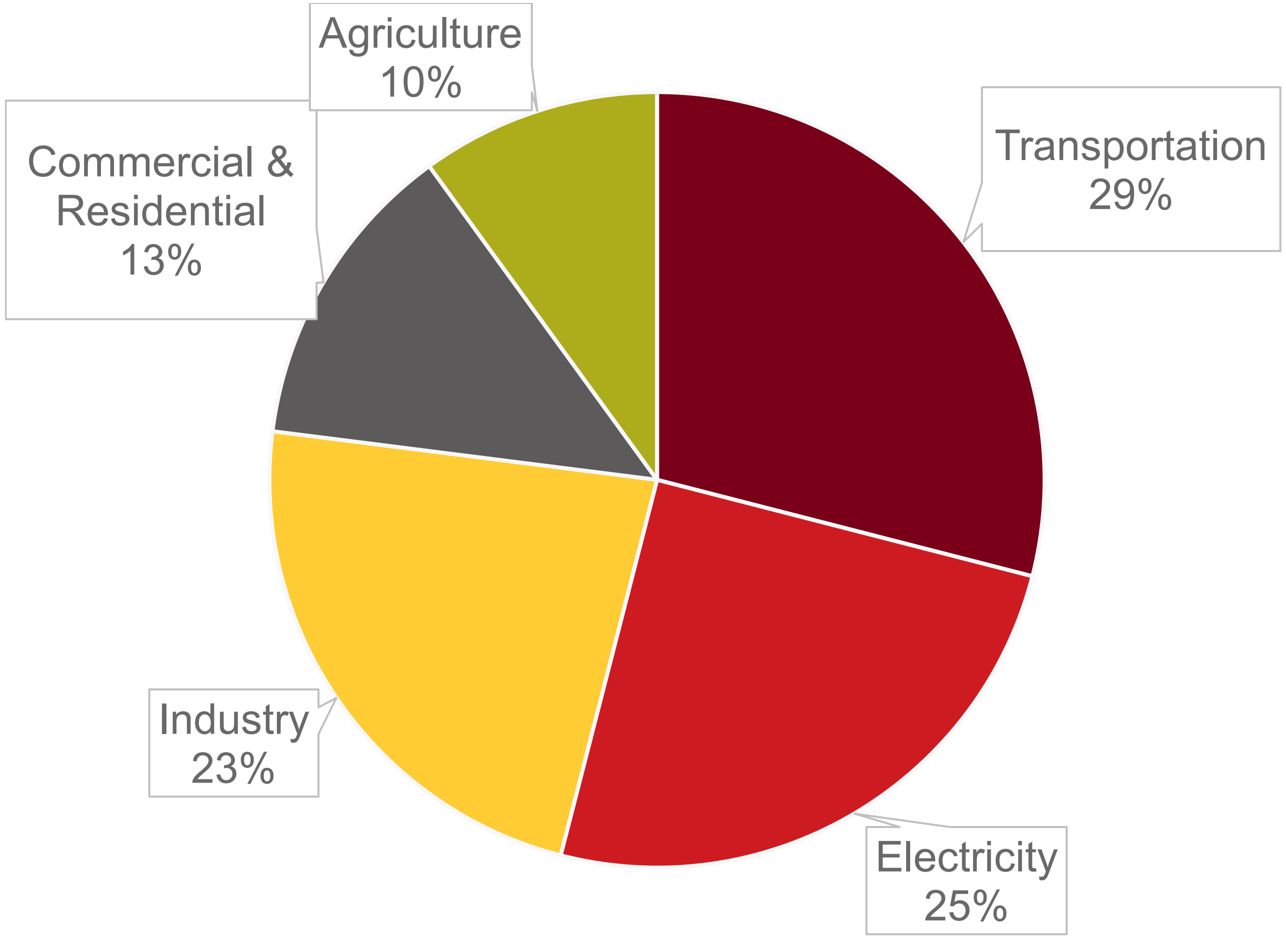


Top Ten CO_2 Emitters in 2017



http://energyatlas.iea.org/

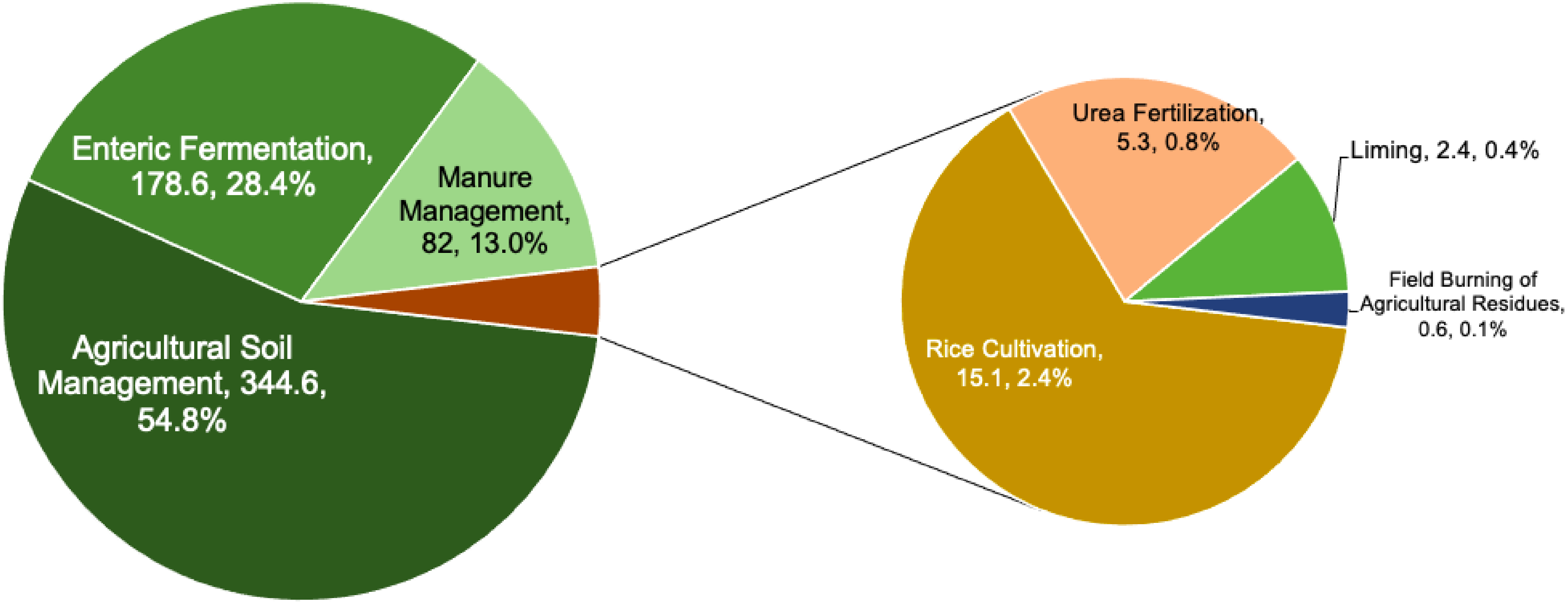
US Emitted Greenhouse Gases by Sectors



EPA - Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2019.

Agricultural Emissions By Source, 2019*

Million Metric Tons CO2 Equivalent

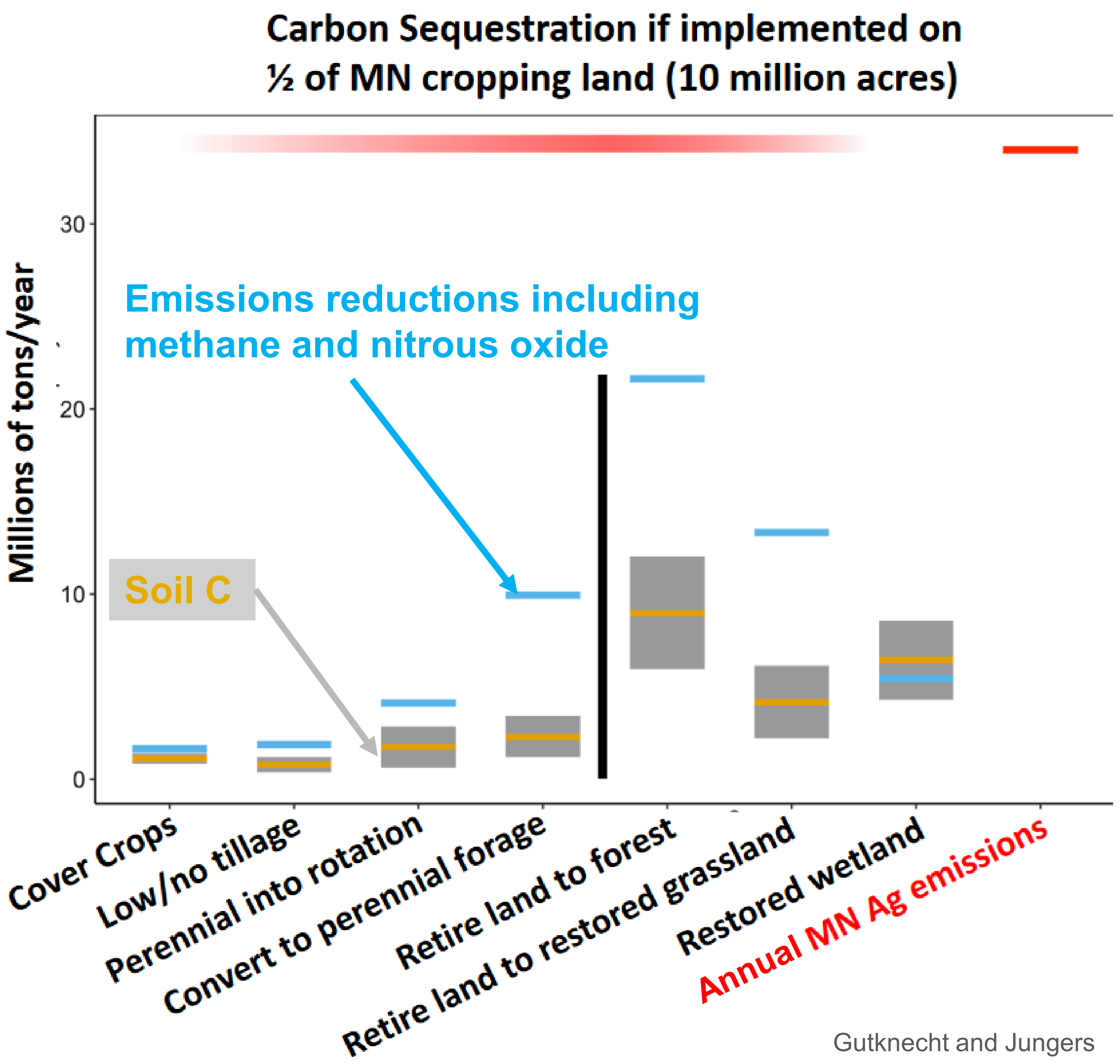


Fertilizer and tillage

Source: EPA, Farm Bureau Calculations
**2019 Is Based On Draft EPA Data*

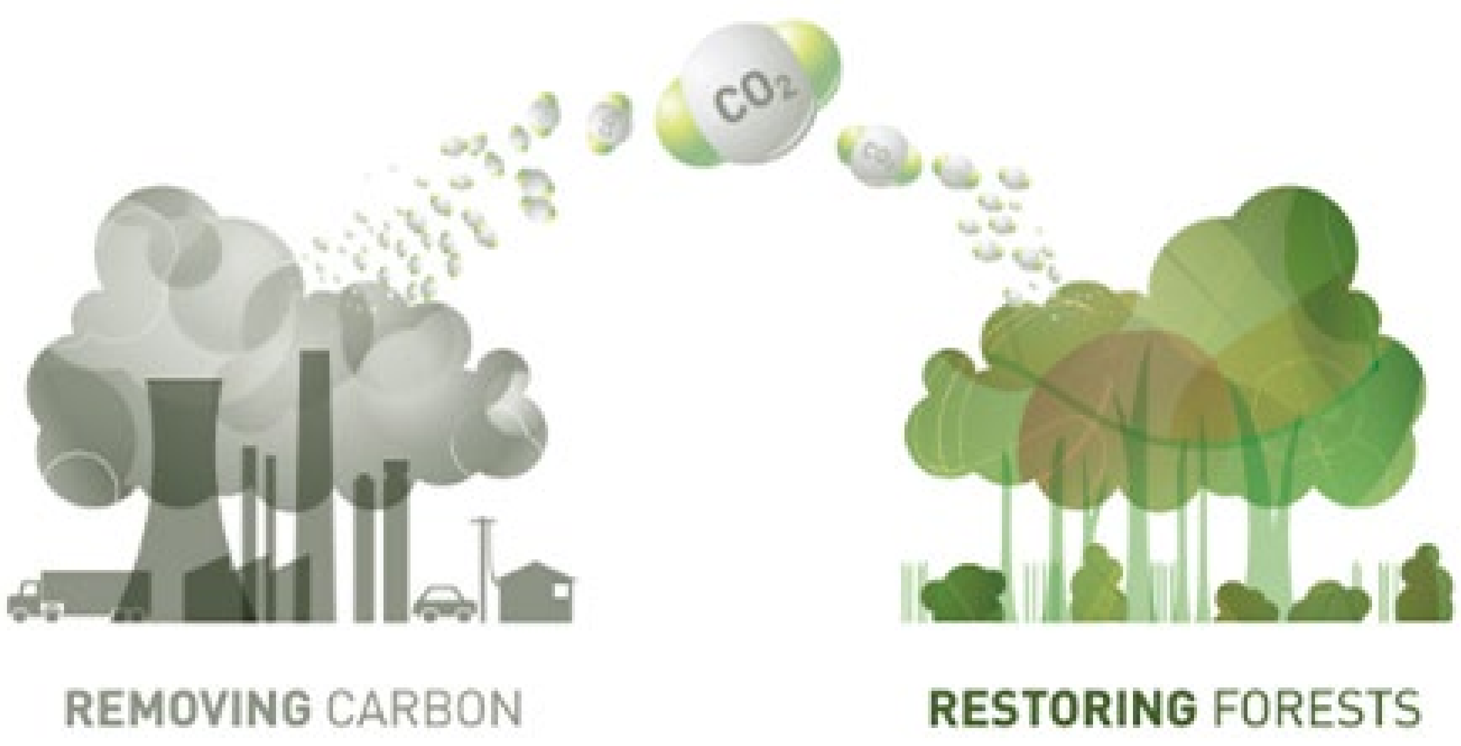
MN's Potential

- Methane (CH_4) and nitrous oxide (N_2O)have greater climate impact than soil C
- Emissions reductions over 10-20 years peak at ½ annual MN Ag emissions



Gutknecht and Jungers

Companies Are Reducing Their Carbon Footprint



- **Inset**- a company reduces its emissions through a carbon offset project within its own value chain.
- **Offset** –a company funds projects in other locations that remove greenhouse gases from the atmosphere or from being released.

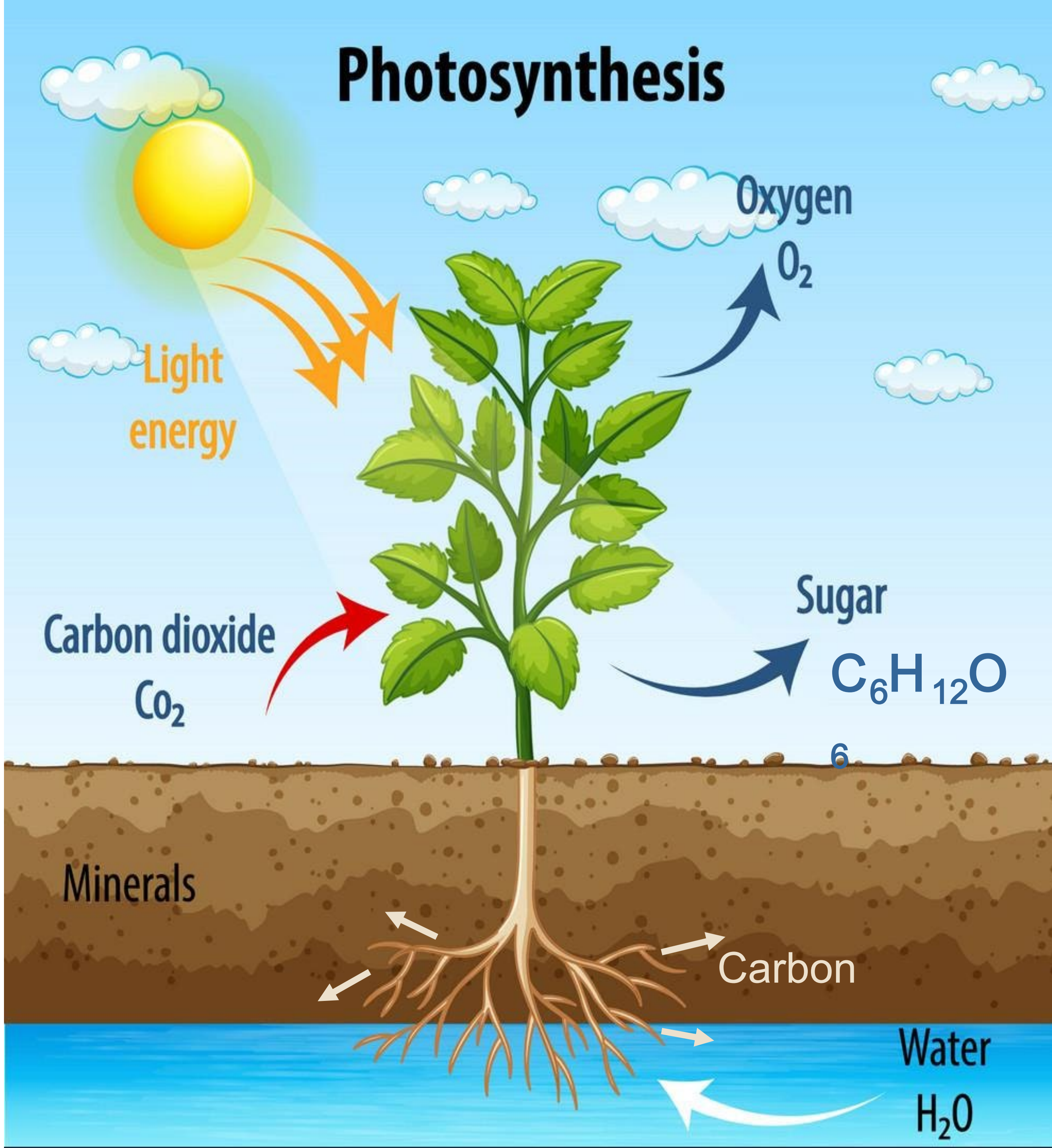
Graphic by www.clear-water-revival.com/

Carbon Cycling -Plants and Soil

Photosynthesis

- Plant takes in CO_2 from atmosphere
- With sunlight and water plant makes sugars ($C_6H_{12}O_6$)
- Carbon is stored in plant tissue and leaked into soil via roots as food for microbes

Vectorstock.com/36658030



Carbon Cycling

- Plants leak up to 30% of its carbon through the roots
- Carbon is a food source for microbes
- Microbes use C and respire it off at CO_2
- <1% make it to a stable form

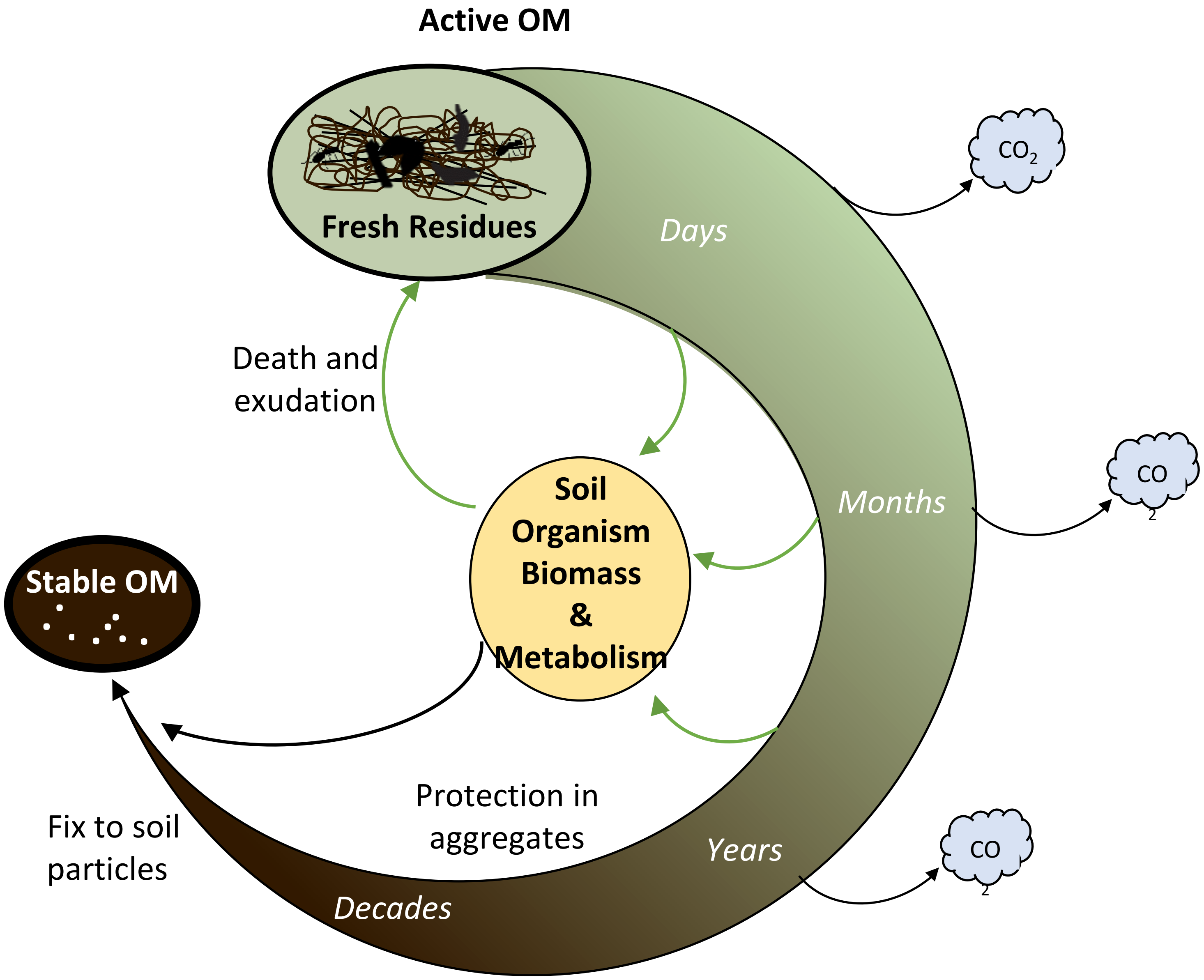
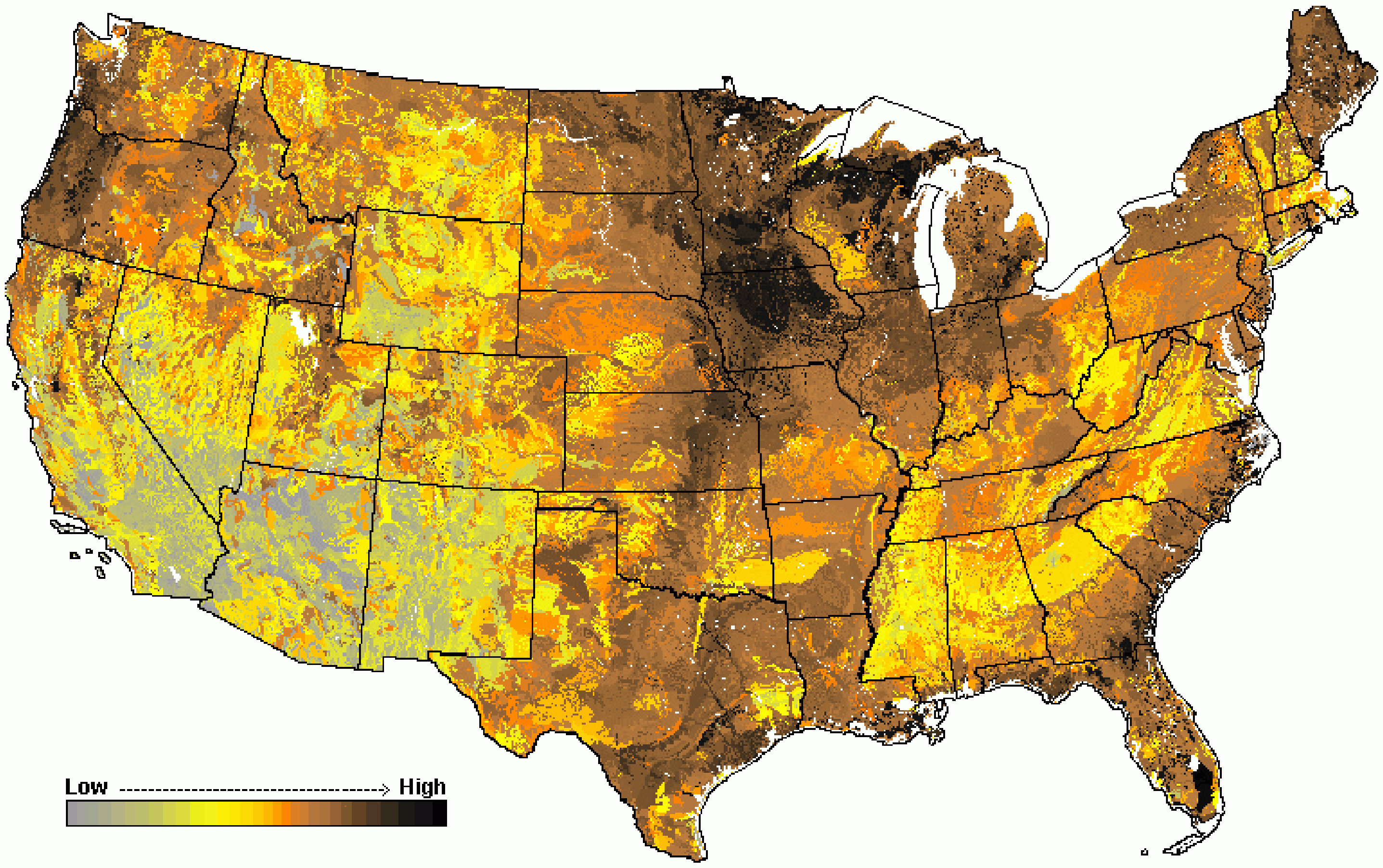


Figure from Soil Organic Matter Does Matter, NDSU and UMN

Soil Organic Matter in the US



Hargrove and Luxmoore

Carbon Concept

Carbon Storage is Like a Bank Account

C Deposits

- Crop biomass
- Crop roots
- Manure
- Cover Crops

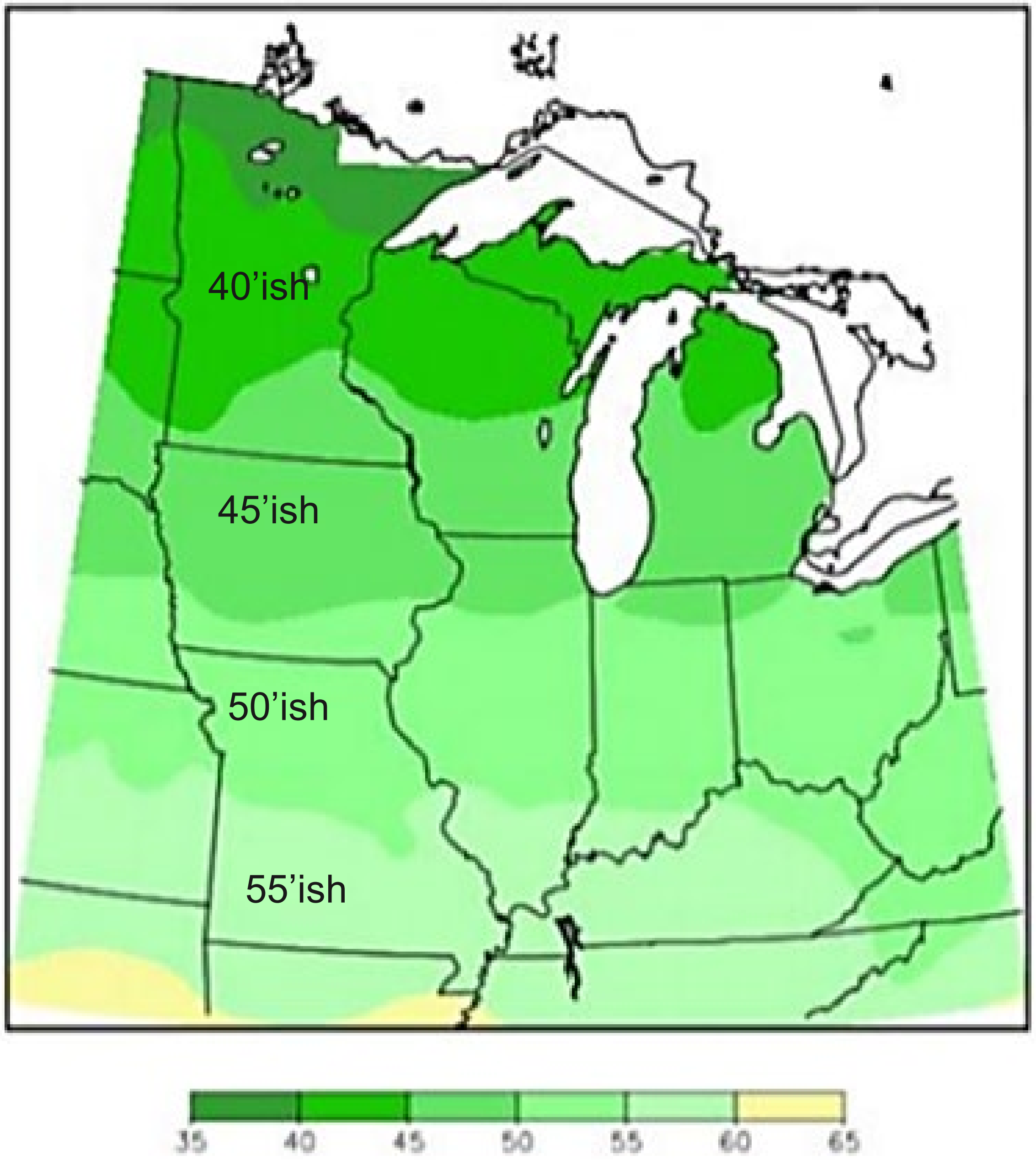
C Withdraws

- Erosion
- Tillage
- Baling/burning
- Harvest

Carbon Markets

one size will not fit all

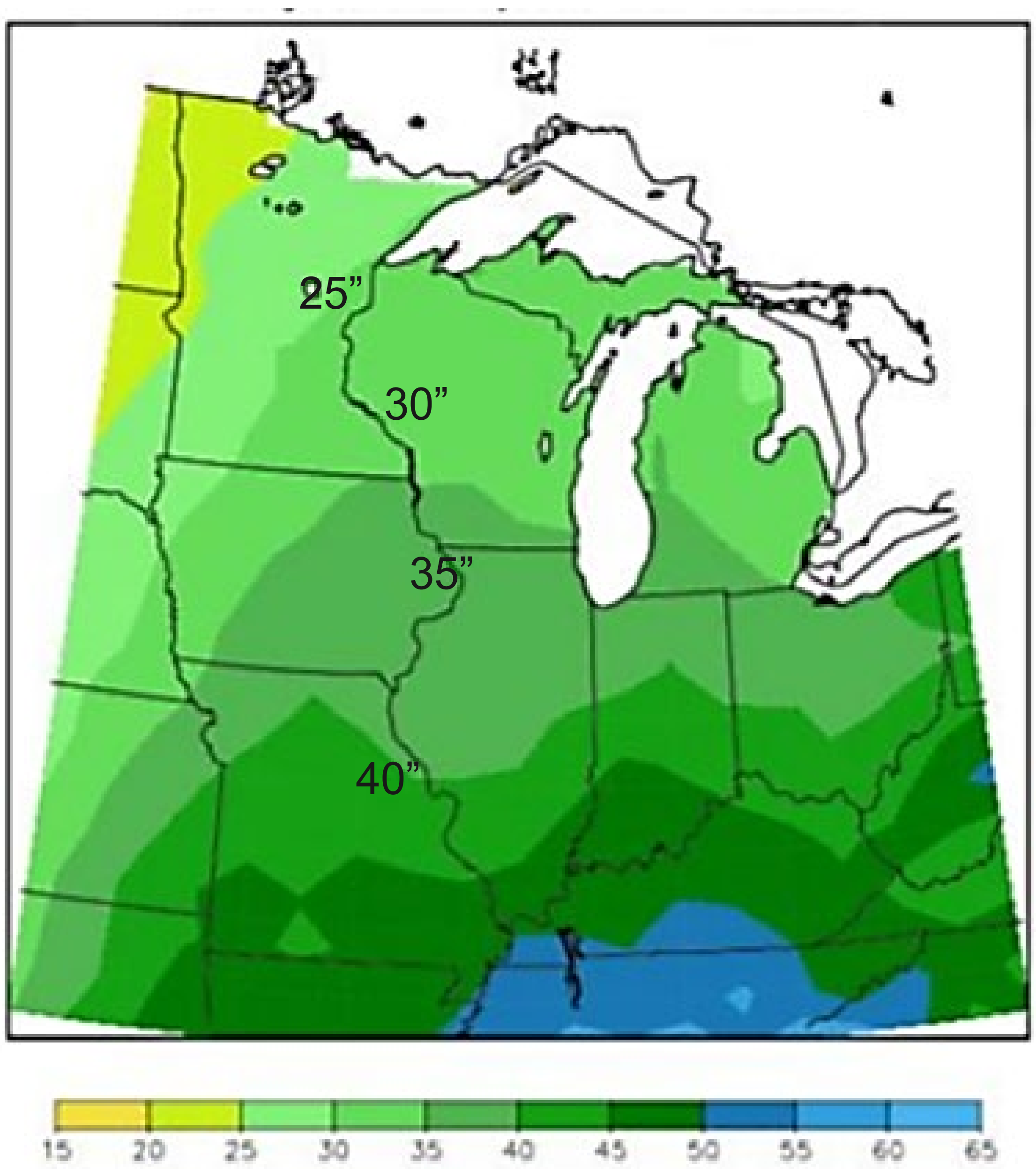
Average Annual Temperature (1981-2010)



http://glisa.umich.edu/

Figure courtesy of Midwestern Regional Climate Center

Total Annual Precipitation (1981-2010)

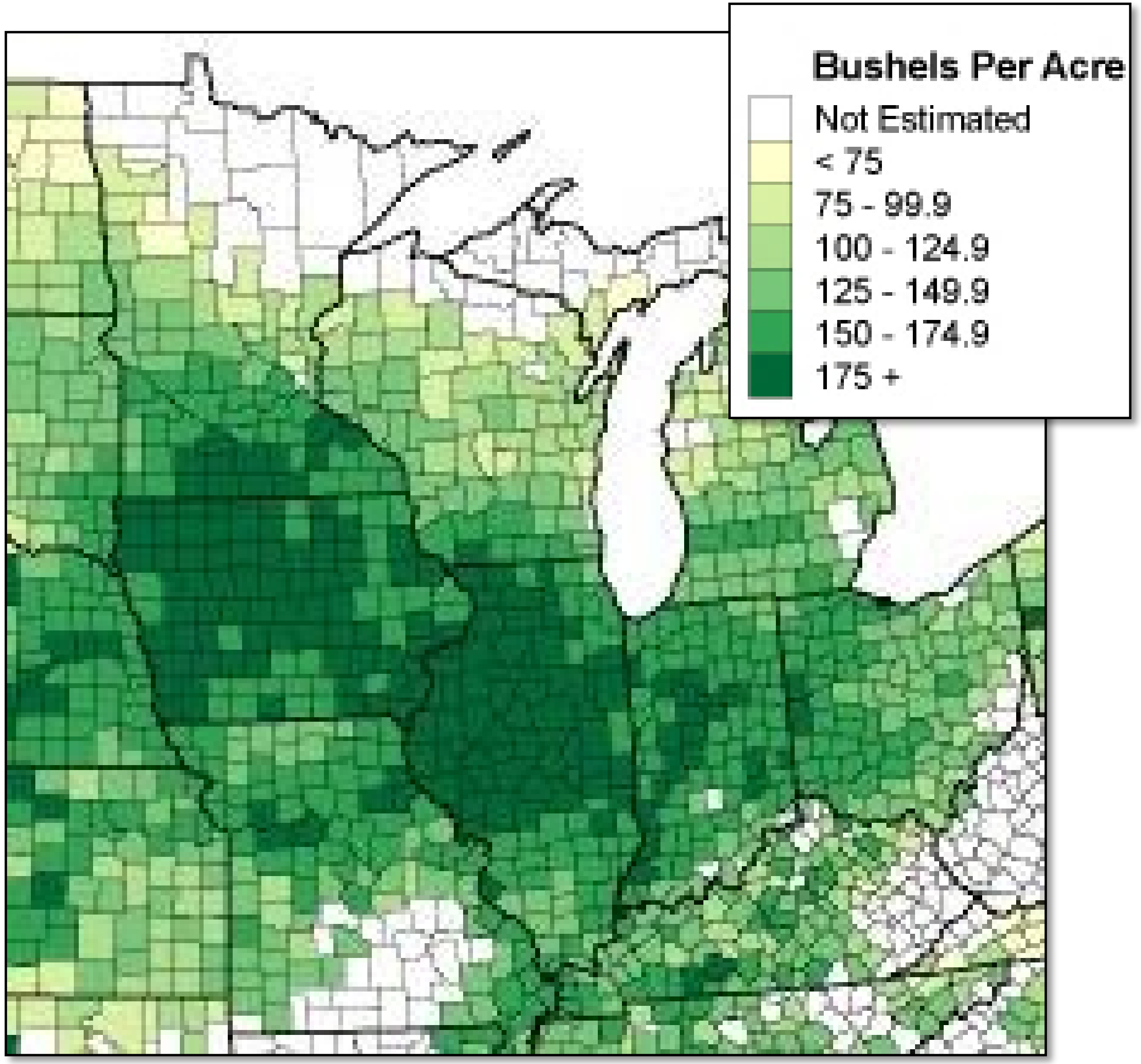


http://glisa.umich.edu/

Figure courtesy of Midwestern Regional Climate Center

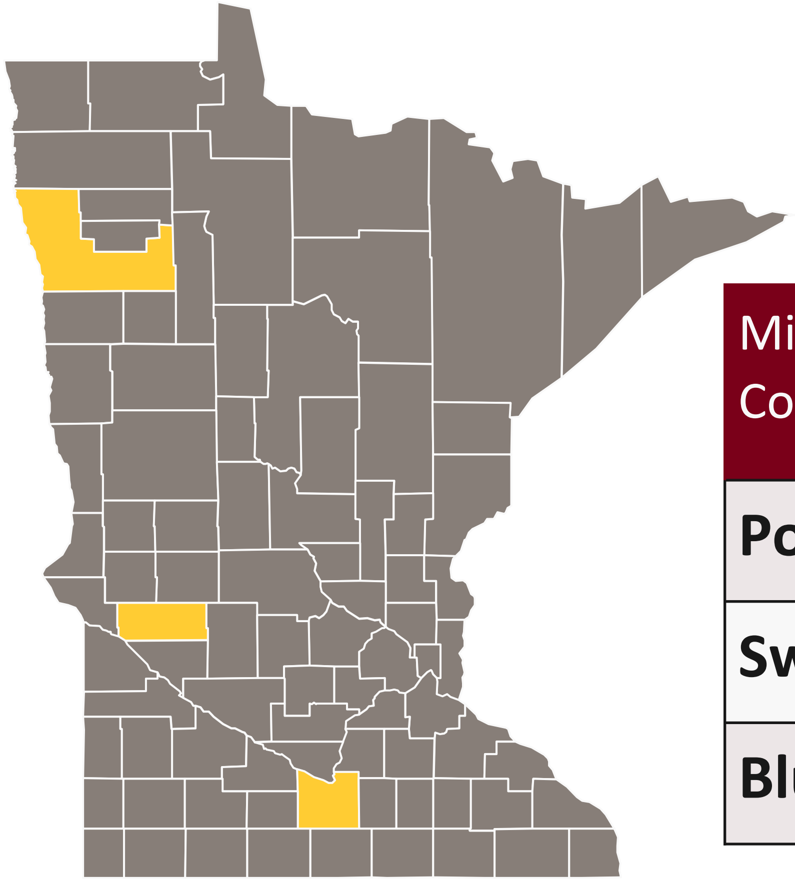
Harvested Corn Yield

Important for pounds of biomass (C)



Carbon Credit by Practice and Location

(as estimated by Indigo Ag, 2020)

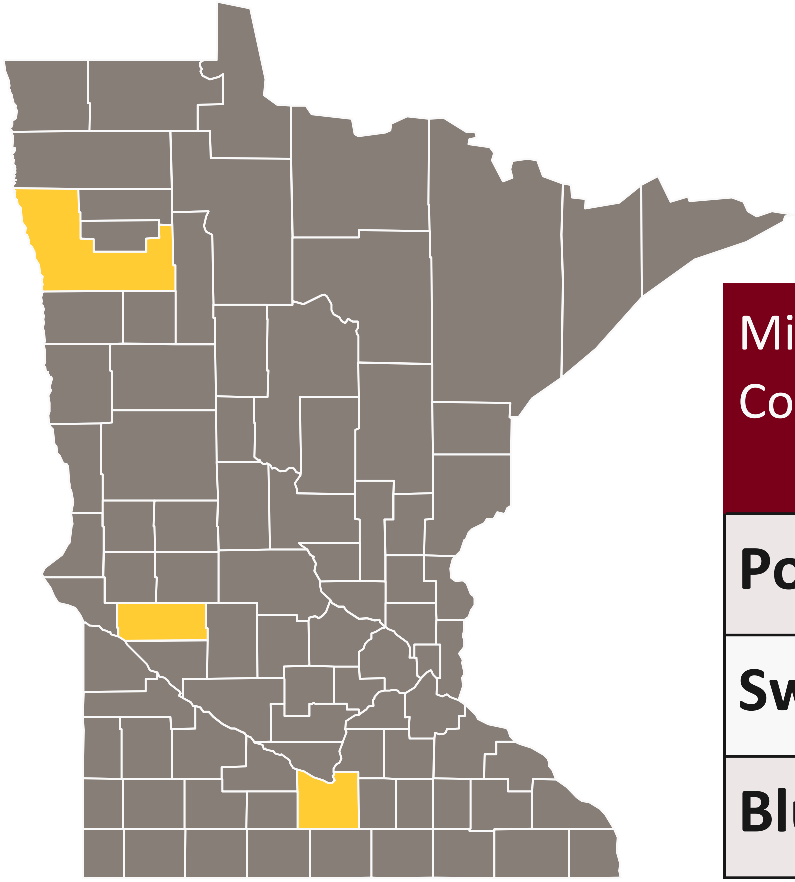


Minnesota County	Conventional to Vertical Till	Conventional to No Till	Add Non-Legume Cover	Add Legume Cover
Polk	0.15 - 0.24	0.43 - 0.70	0.12 - 0.19	0.17 - 0.28
Swift	0.20	0.60 - 0.64	0.16 - 0.17	0.20 - 0.23
Blue Earth	0.22 - 0.25	0.69 - 0.77	0.19 - 0.20	0.21 - 0.23

Range represents non-irrigated vs irrigated

Carbon Credit by Practice and Location

(as estimated by Indigo Ag, 2020)



Minnesota County	Conventional to Vertical Till	Add Non-Legume Cover	Carbon Credit by Ton	Price received before fees
Polk	0.15	0.12	$15	$4.05
Swift	0.20	0.16	$15	$5.40
Blue Earth	0.22	0.19	$15	$6.15

Logistical Considerations

- Who
  - Collects, verifies, and owns management data, soil samples, etc
  - Landlord or renter responsibilities
- What
  - Practices and data specifications and fees
- When
  - Contract length, payment schedule, and exit clause
- Where
  - Start with low productivity lands (more likely to change)
- Why
  - Not enough to pay for practices – Just the gravy

Secondary Considerations

- Plan B
  - What happens if you are not able to implement the new practice?
  - What happens if soil carbon doesn’t increase over the contract time?
- Conflict of interest
  - Does the company sell other services or products?
  - Are any of these services/products required to be purchased in order to participate?

Public Perception

Think about C Management

One size does not fit all

- Climatic differences
- Biomass potential
- Starting point
- Equipment needs
- ROI
- Learning curve

What's the science on C sequestration?

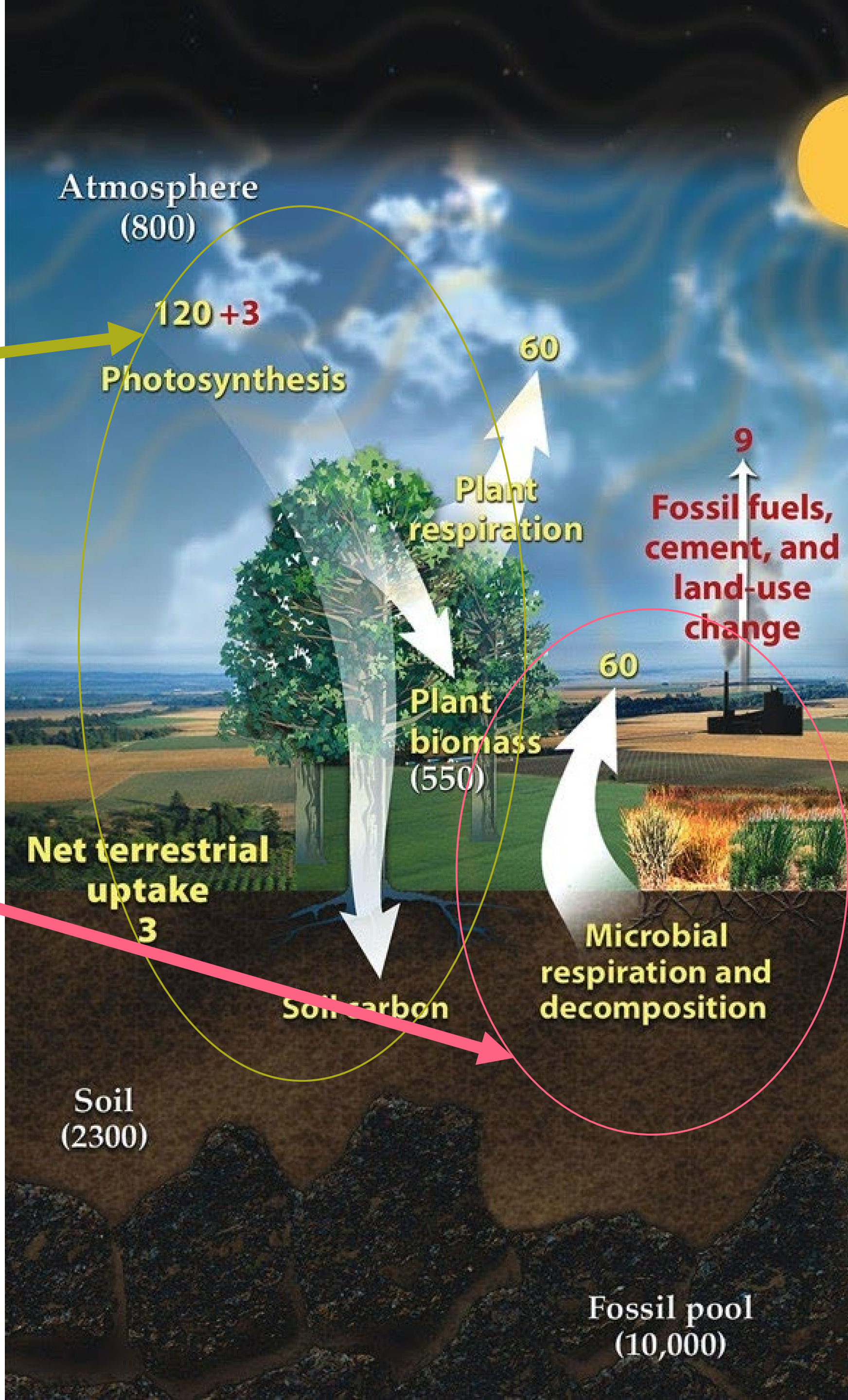
Soil carbon balance =

Inputs: photosynthesis

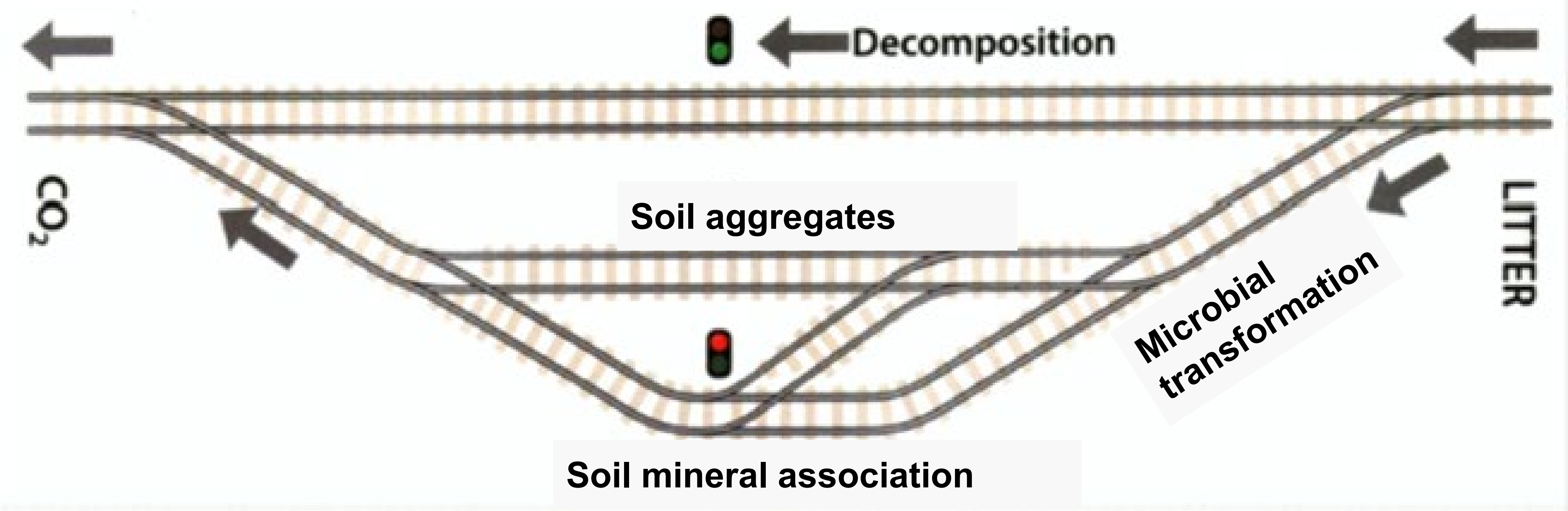
–

Outputs: microbial respiration

*can calculate daily or annually



Soil C is a pause in the cycle

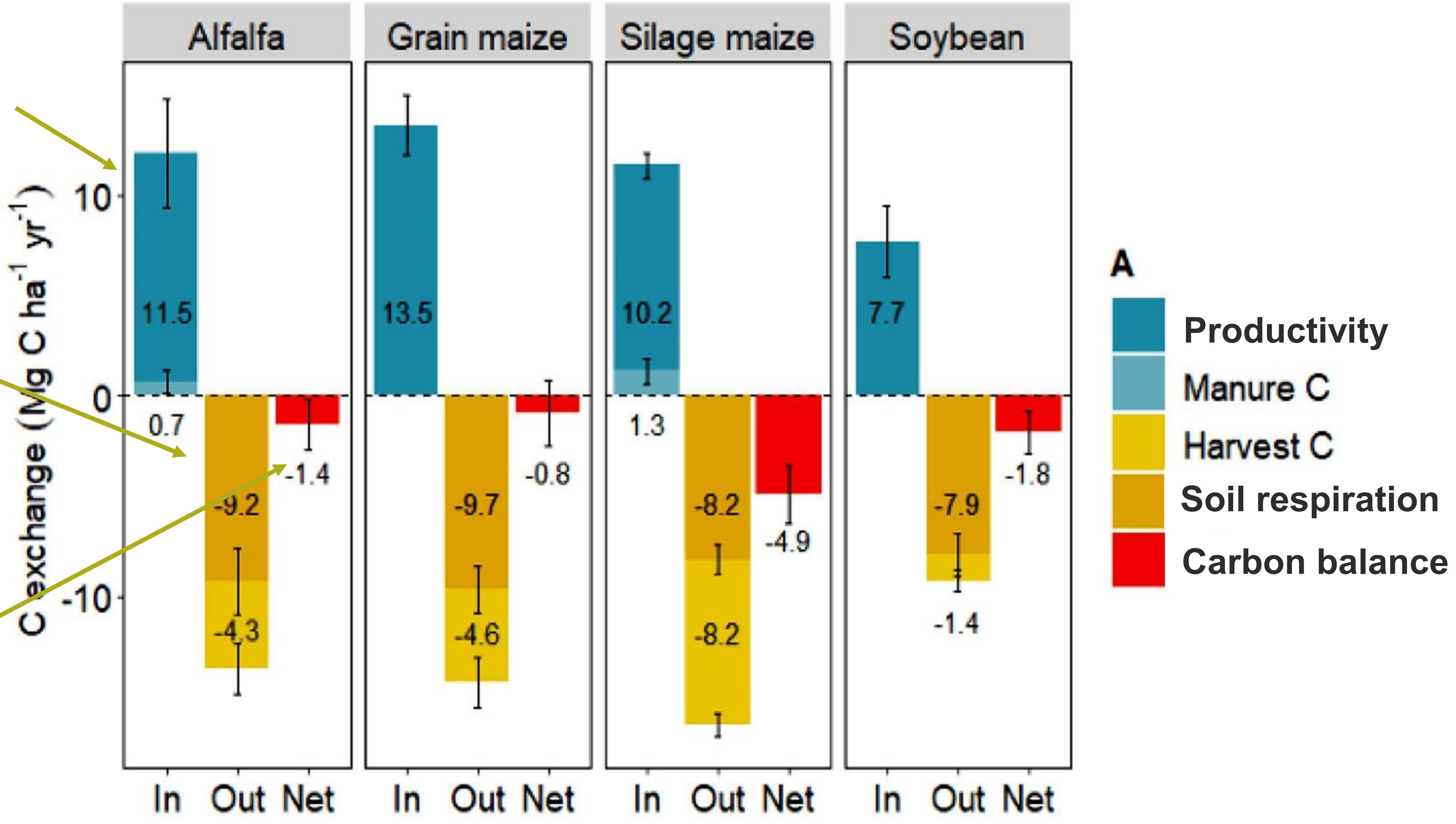


Increase biomass + residue to increase C

C gained (photosynthesis)

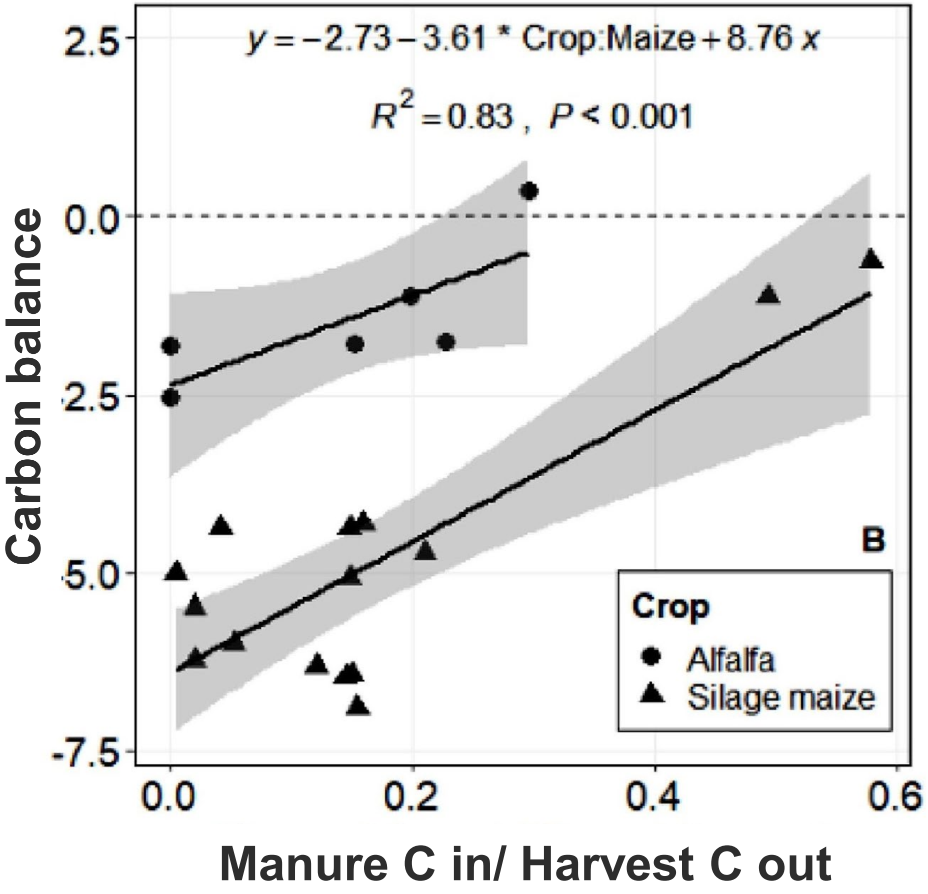
C lost (harvested and respired)

C balance
Gains- losses



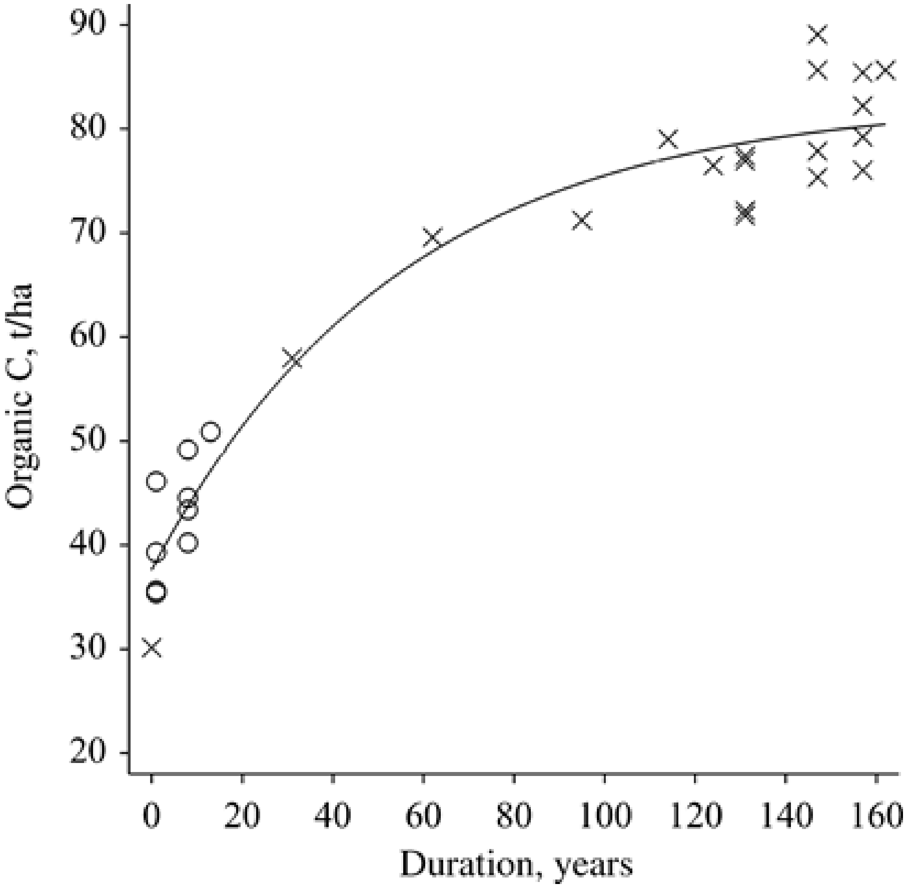
Gamble et al. 2021

Increase manure + residue to increase C



Gamble et al. 2021

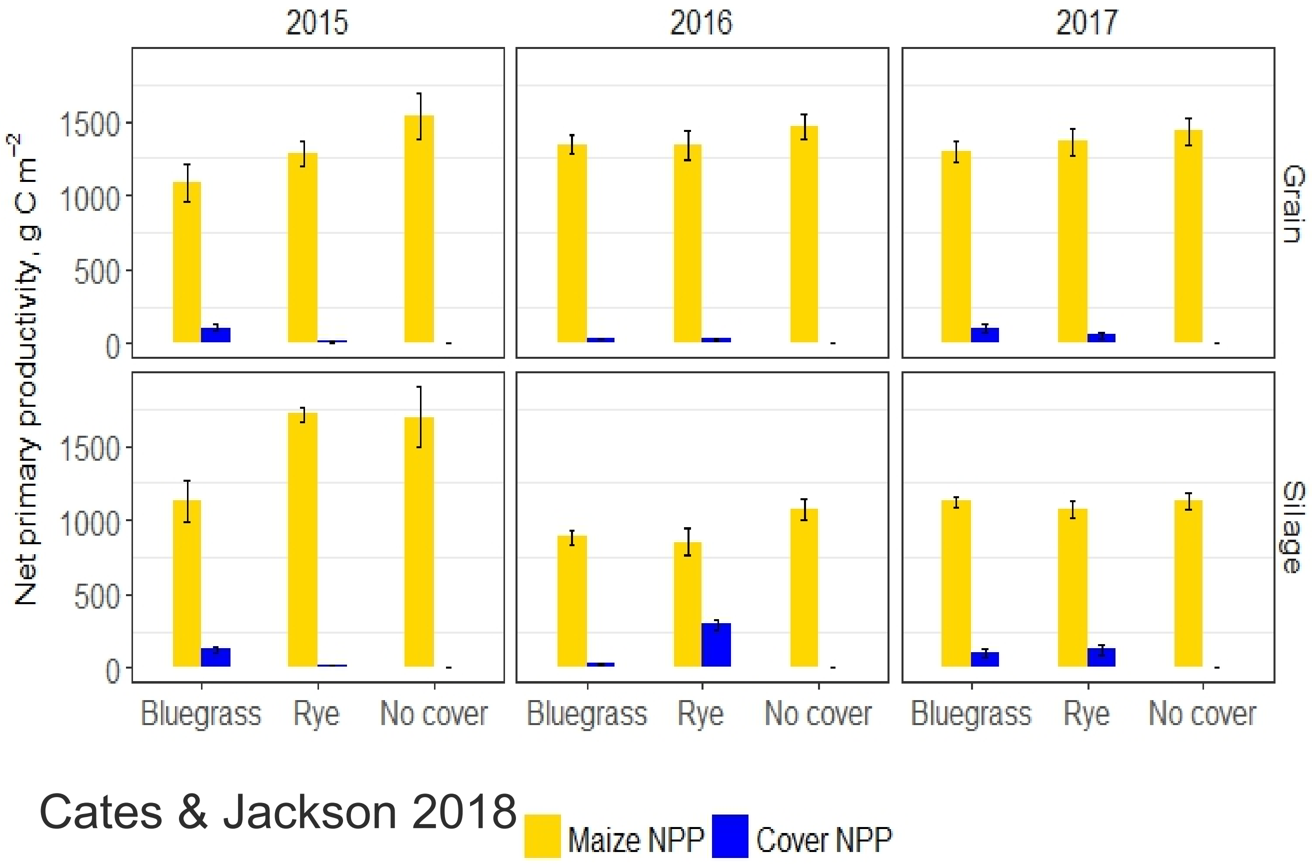
…this will flatten out eventually



Poulton et al. 2018

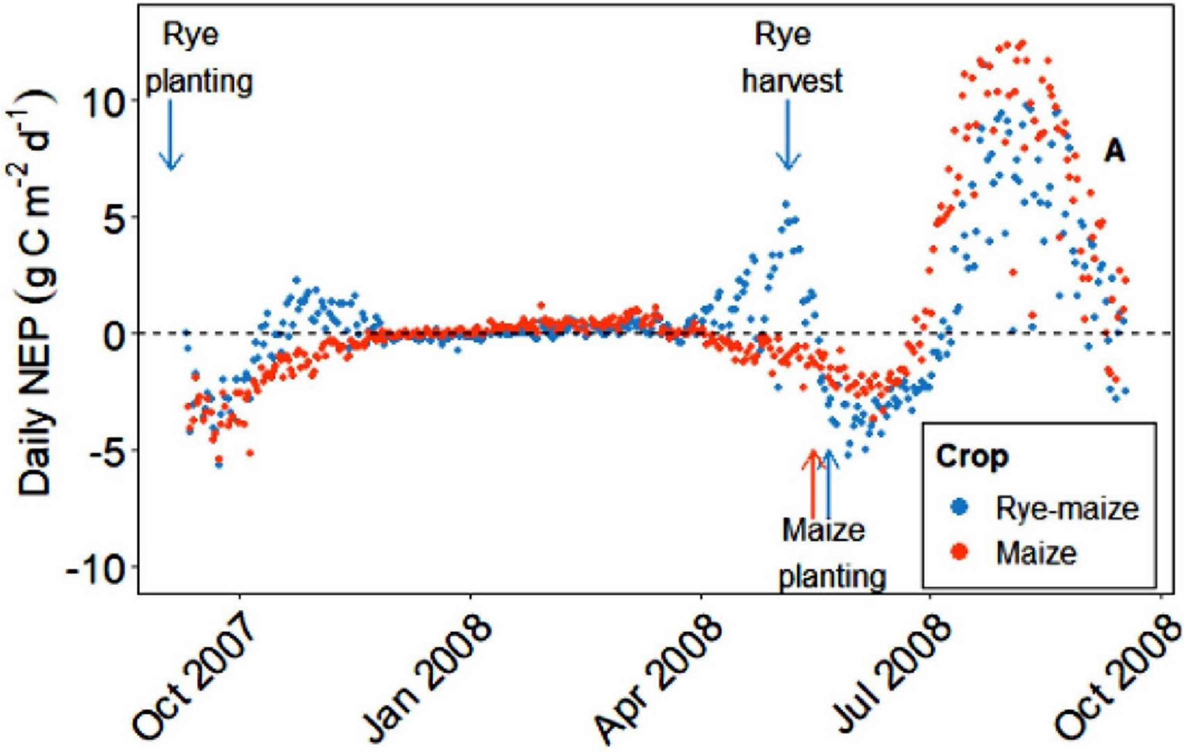
Cover crops provide some C, tradeoffs

Total productivity



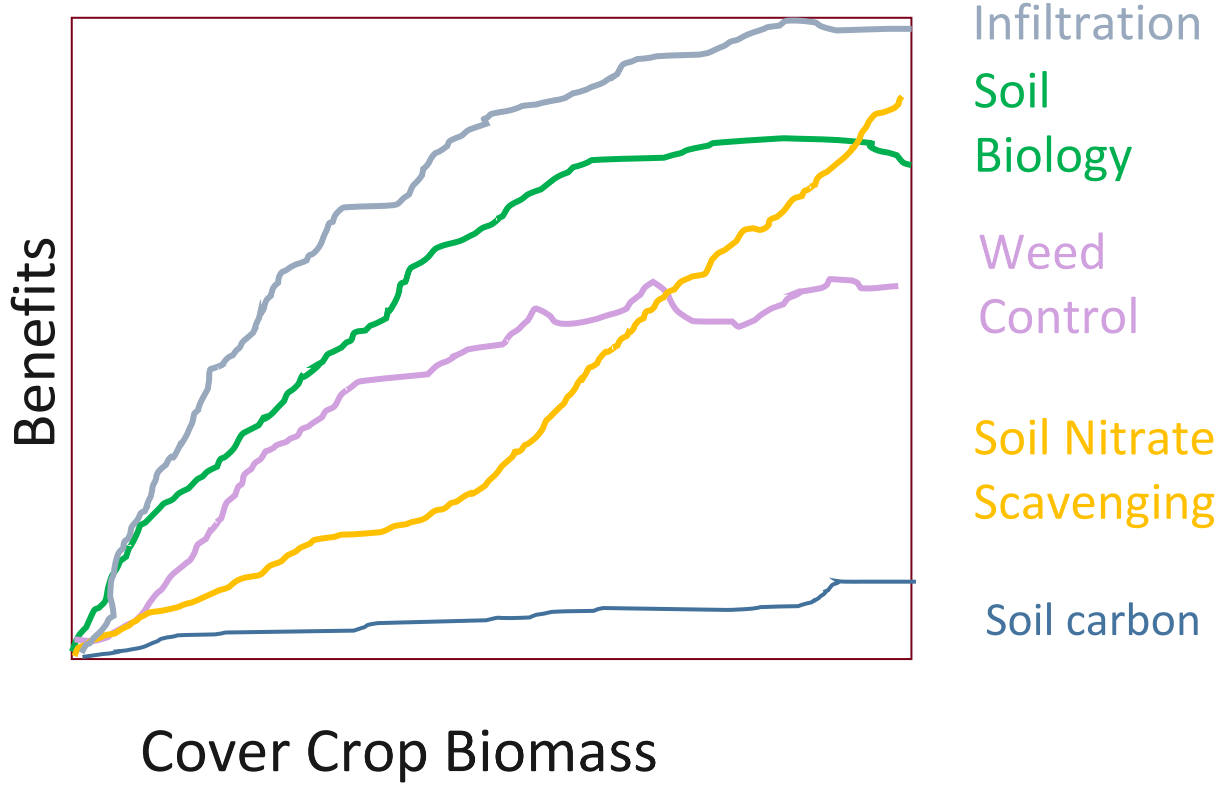
Cates & Jackson 2018

Daily C balance

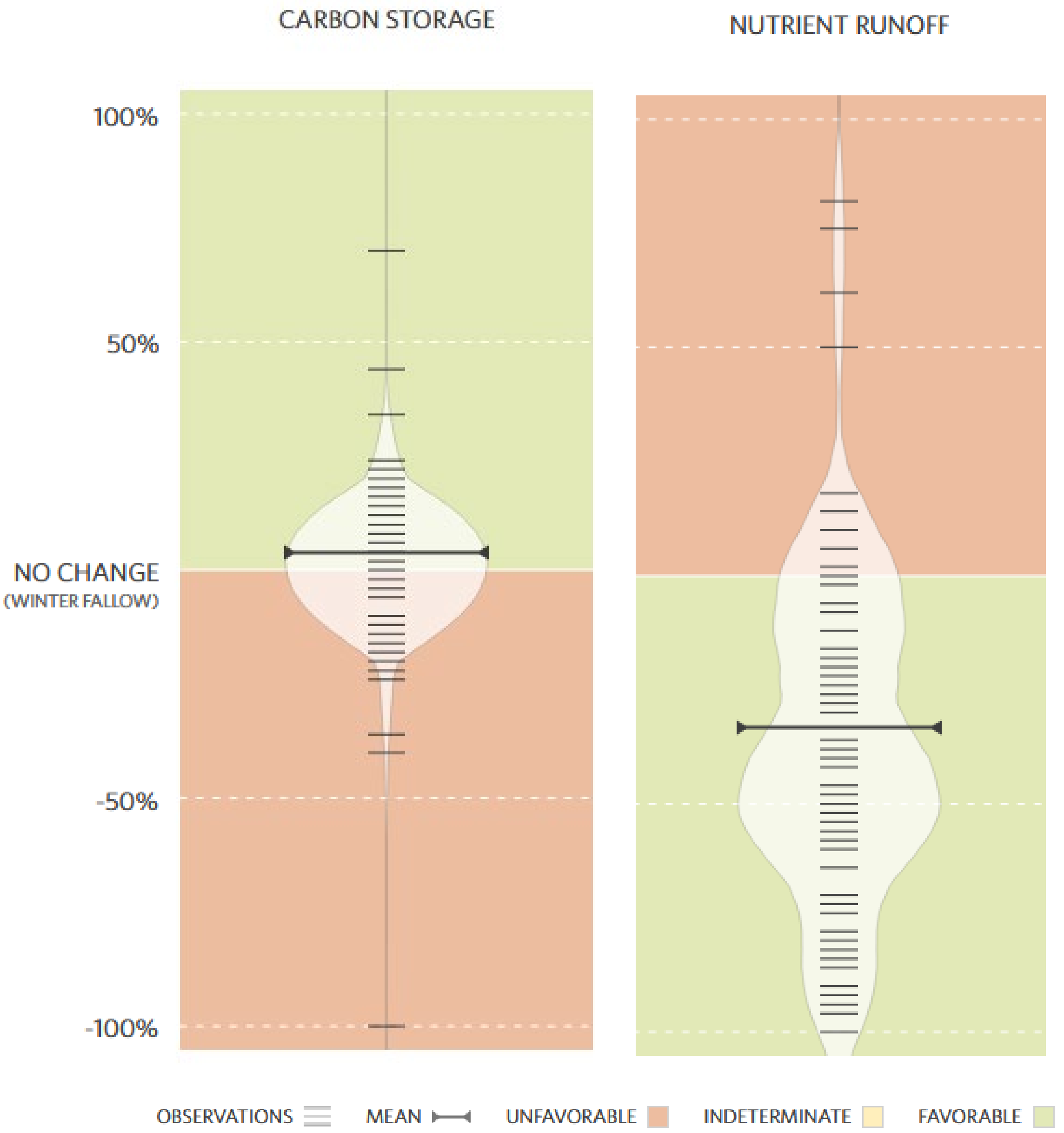


Gamble et al. 2021

Cover crops show other benefits more reliably



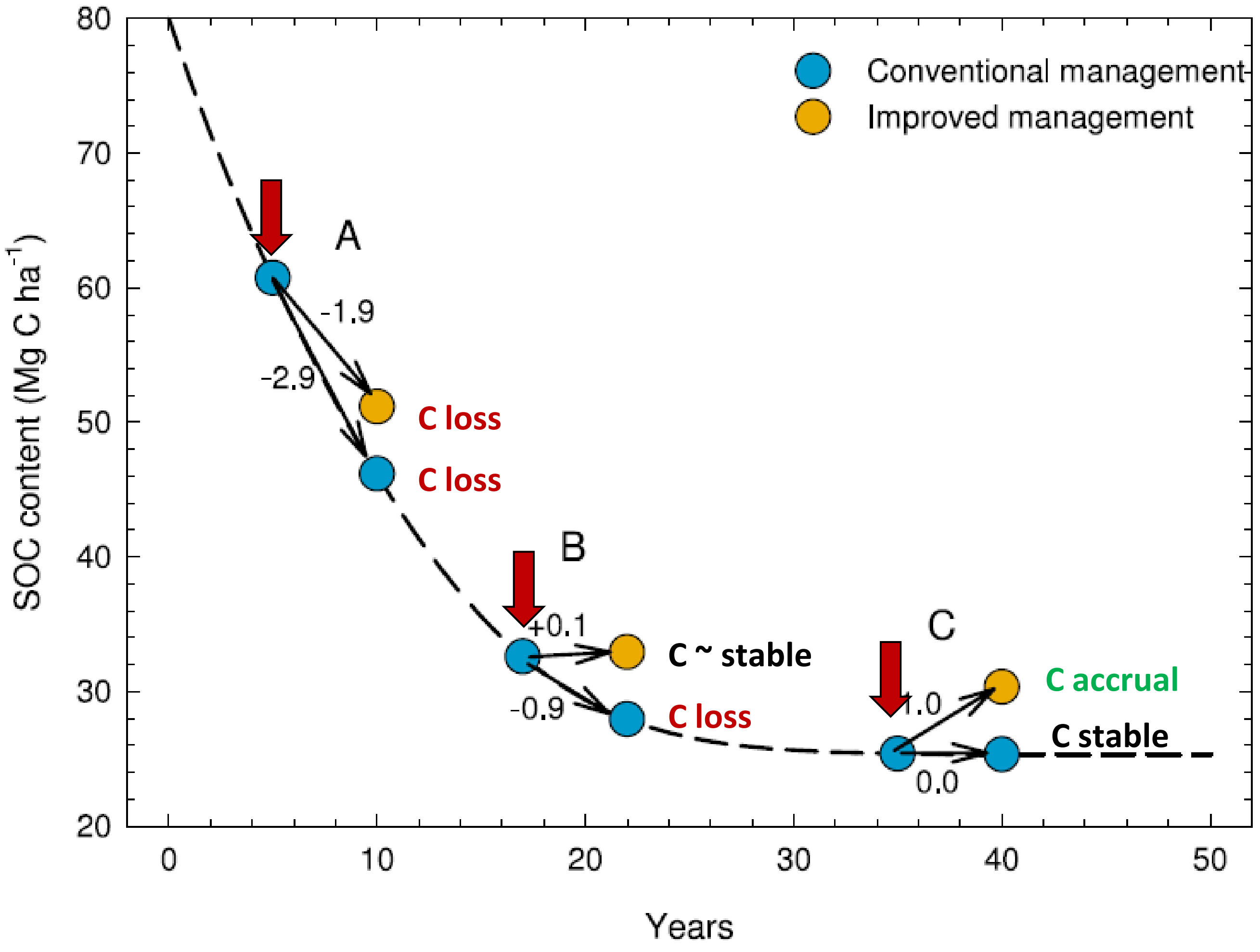
adapted from Cates et al. 2019



agevidence.org

Best Measurement Practices

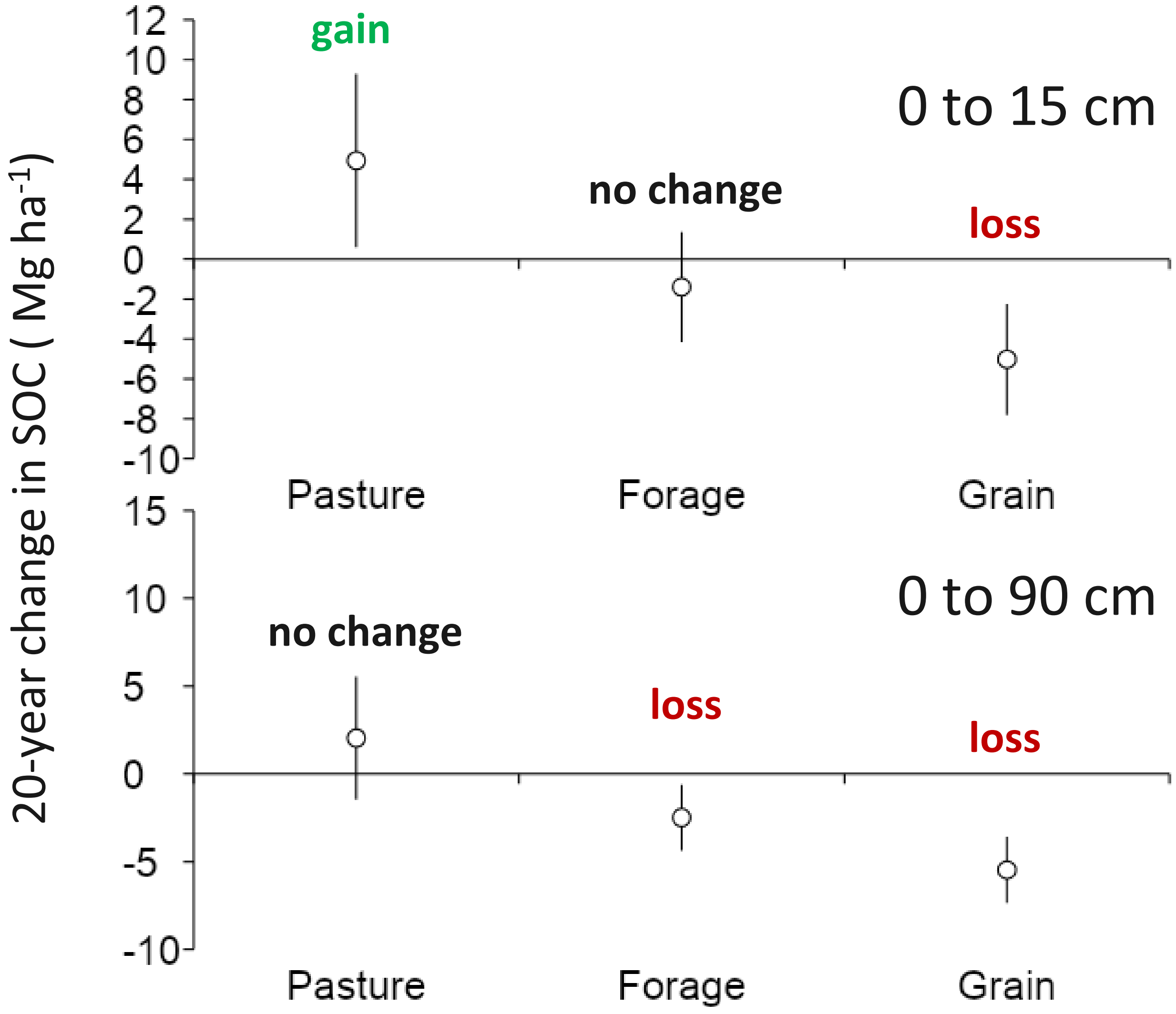
Measuring C accrual – Time



- Each scenario = 5 Mg C ha^{-1} difference
- Paired comparison is misleading
- Baseline measurement critical for interpretation

slide by G. Sanford, adapted from Sanderman and Baldock, 2010, Env. Res. Letters

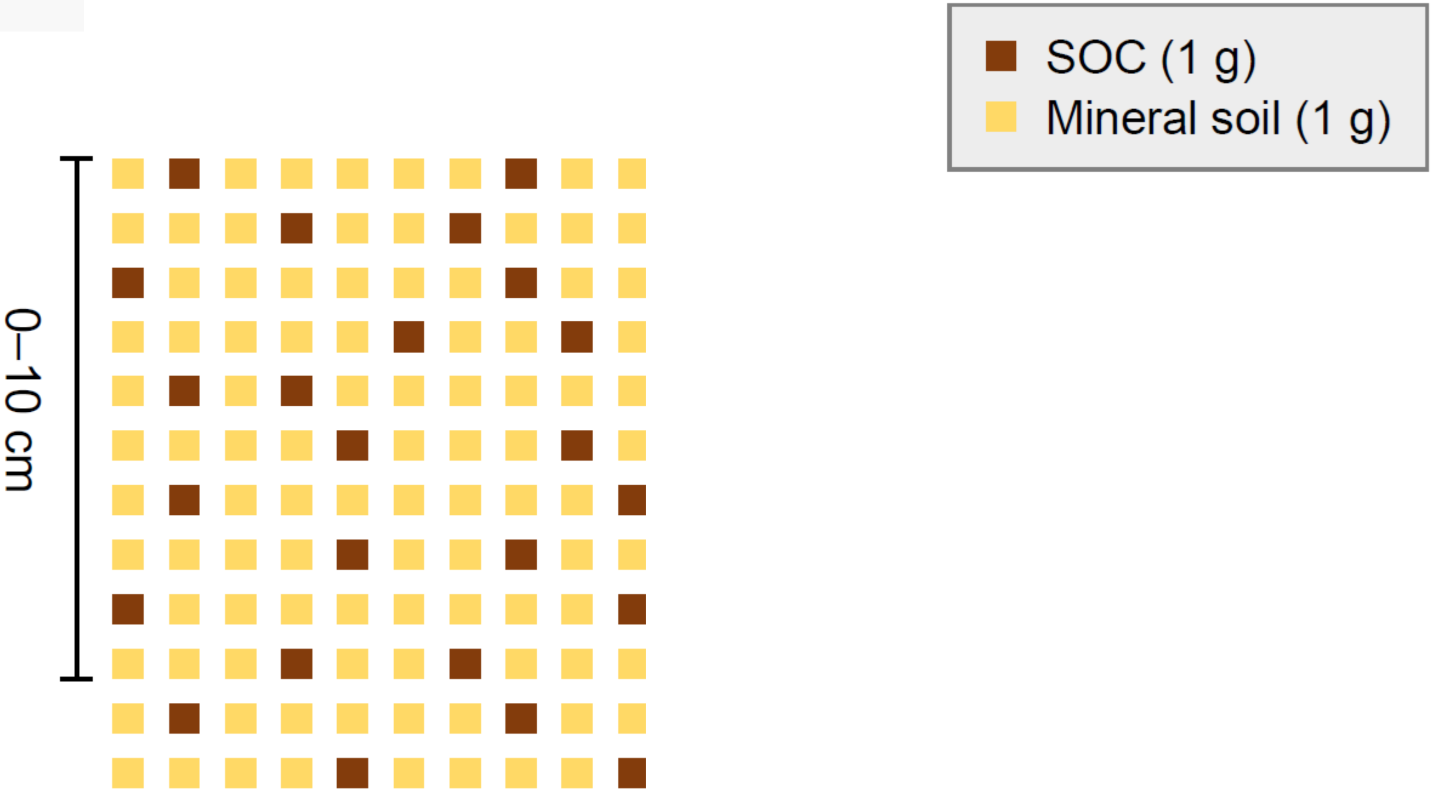
Measuring C accrual – Soil Depth



- Most changes happen in the top 15 to 30 cm of soil
- Changes at depth can significantly affect interpretation

slide by G. Sanford,
bars = 90% confidence limits
adapted from Sanford, 2014, Soil Carbon

Measuring C accrual – Soil Mass



- fixed depth sampling is standard practice
- changes in bulk density can mask or exaggerate sequestration
- imperative to compare ***equivalent soil mass***

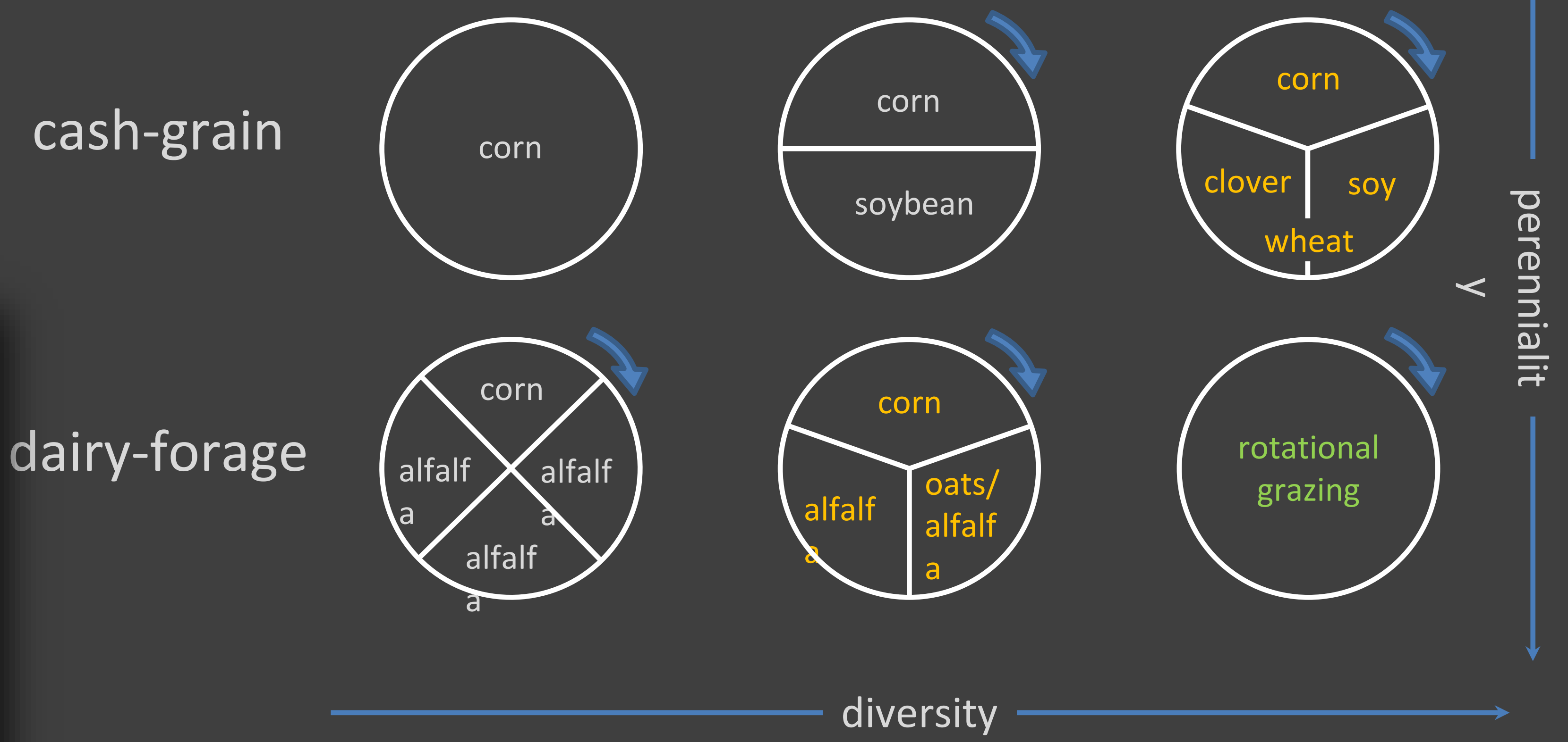
Depth: 0 – 10 cm
Mass: 100 g
SOC: 2.0 g/cm2

Depth: 0 – 10 cm
Mass: 120 g
SOC: **2.4 g/cm2**

slide by G. Sanford, adapted from von Haden et al. 2020, Global Change Biol.

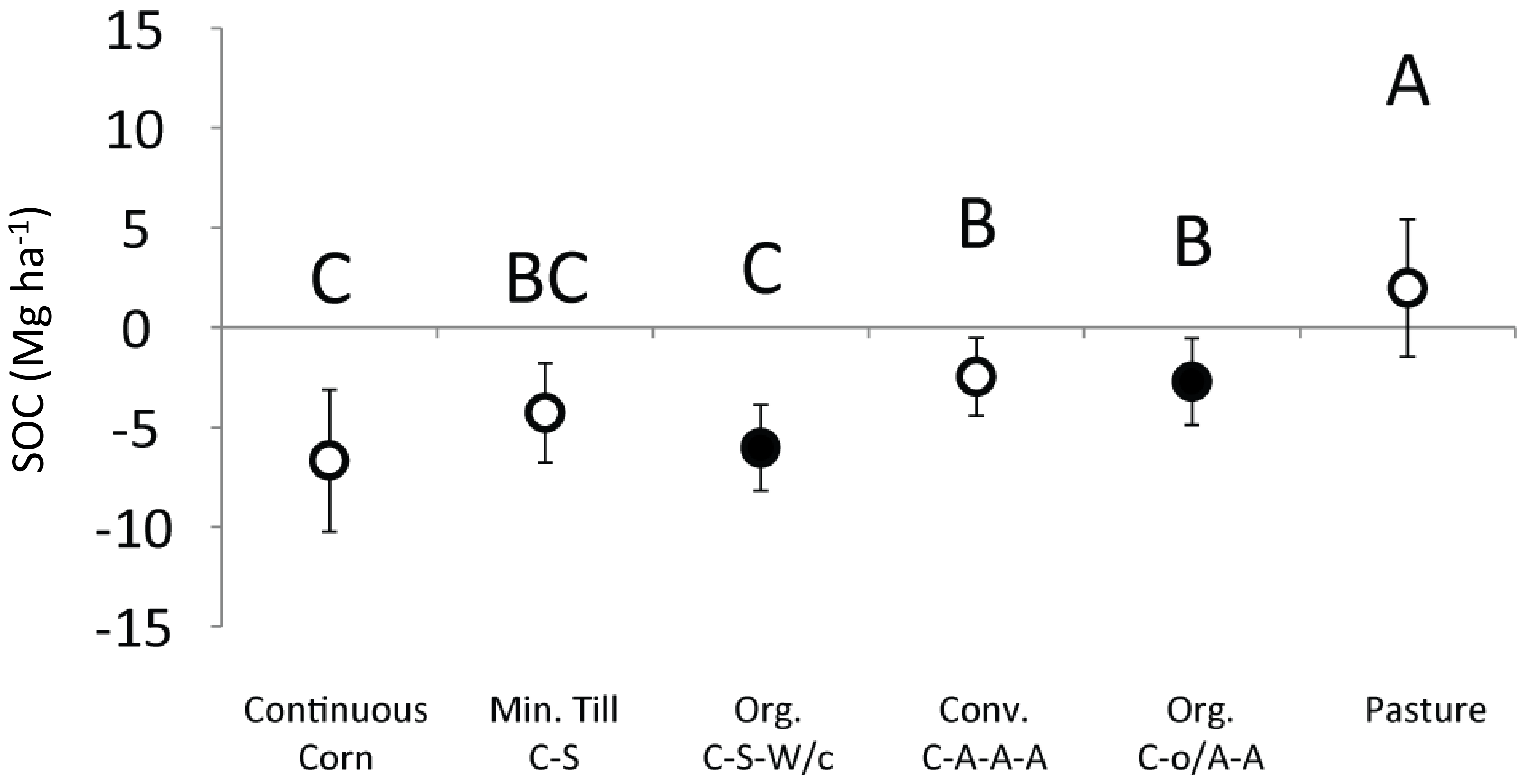
WISCONSIN INTEGRATED CROPPING SYSTEMS TRIAL
COLLEGE OF AGRICULTURAL & LIFE SCIENCES

4 reps
each phase every year



Field-scale plots- 60 ft x 240 ft- Established 1989

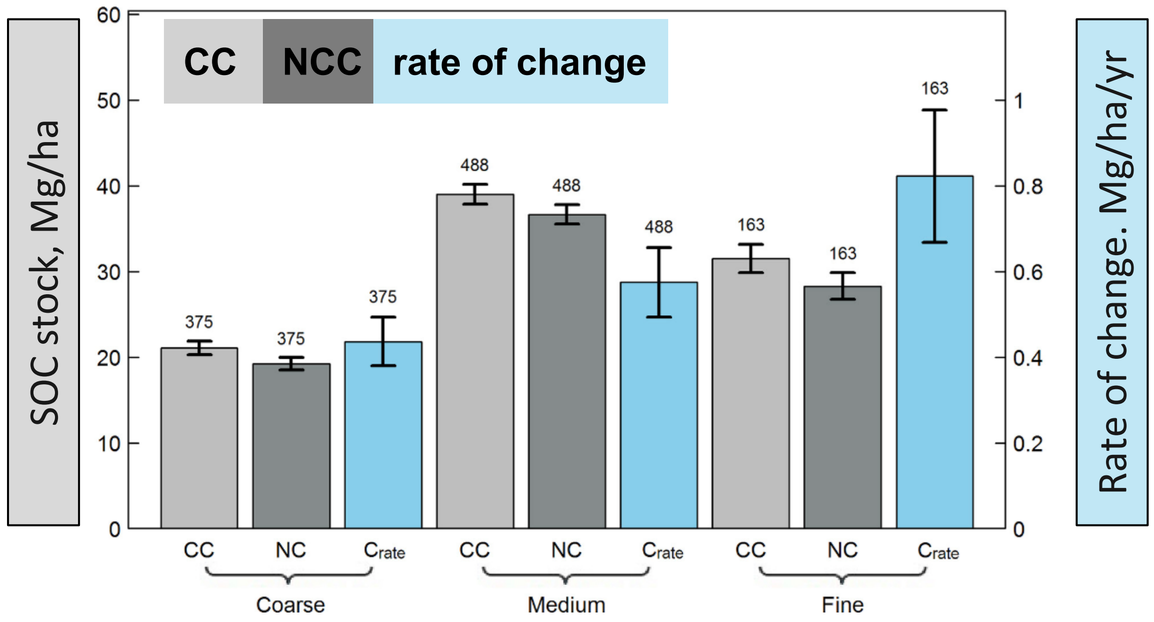
Fig. 1. Twenty-year differences in soil organic carbon (1989 to 2009) across entire soil depth (~3 ft.) at the Wisconsin Integrated Cropping Systems Trial. Crops on x-axis from L to R: (1) high-input continuous corn, (2) high-input corn-soybean rotation, (3) organic corn-soybean rotation with wheat cover crop, (4) high-input corn-alfalfa rotation, (5) organic corn-alfalfa rotation with oat cover crop, and (6) cool-season pasture with managed rotational grazing (from Sanford et al. 2012 *Agriculture, Ecosystems & Environment)*.



Factors Beyond Our Control

Effects of climate and soil on C increase

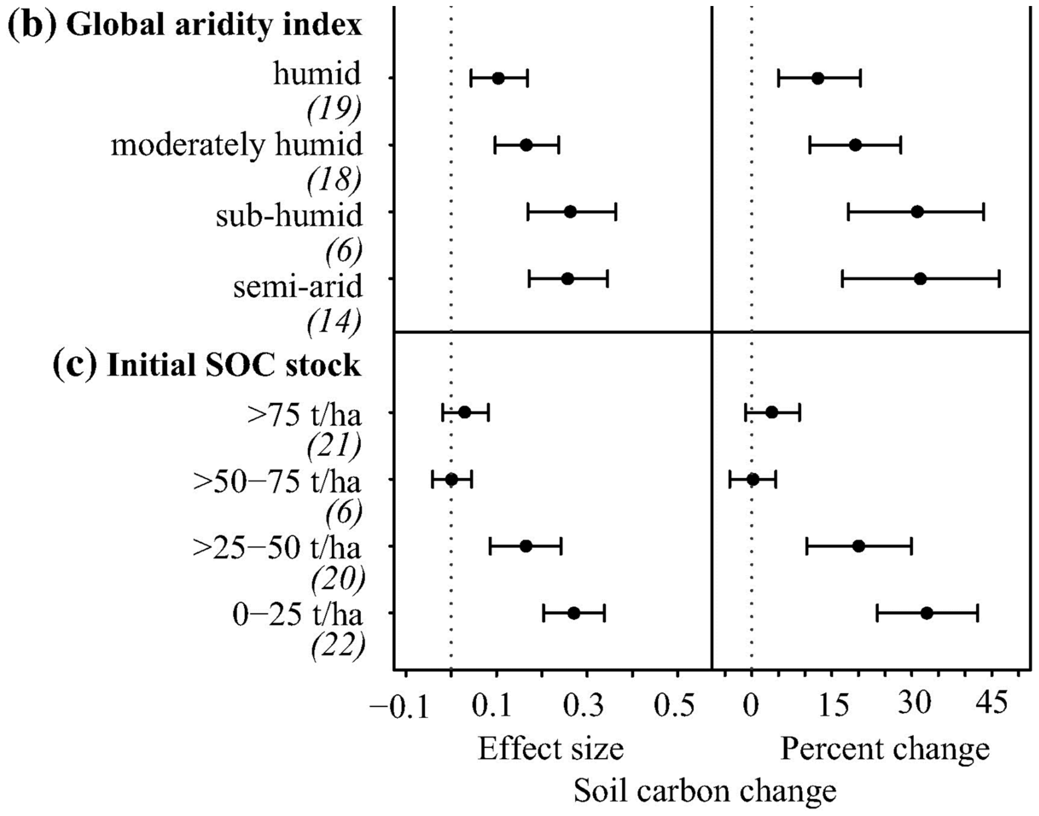
Add cover crops: Faster SOC increase in fine soil



Soil texture: coarse→ fine

Jian et al. 2020

Conversion to grass: greater SOC increase with low start, low precip

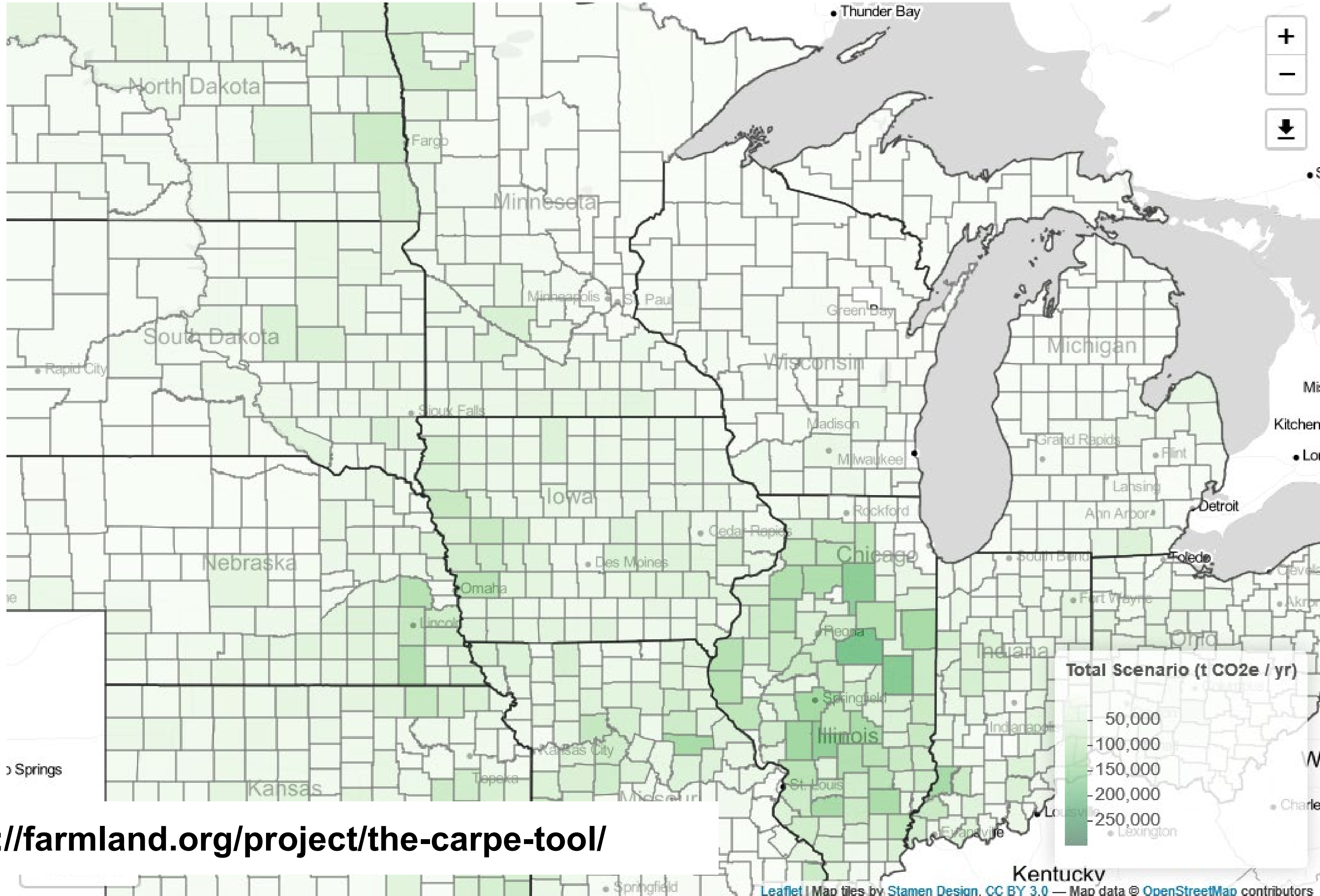


Kampf et al. 2016

Models take these factors into account

Carpetool scenario:

50% adoption of cover crops, mostly non-legume



https://farmland.org/project/the-carpe-tool/

How to Build Soil Health

Soil health is more than soil carbon

- Healthy soil captures and supplies water to plants
- Resilience protects yield

Building soil health

- Reduce or use no tillage
  - >40% residue cover
- Keep the soil covered
  - diverse crop rotation
  - cover crops

Building soil health

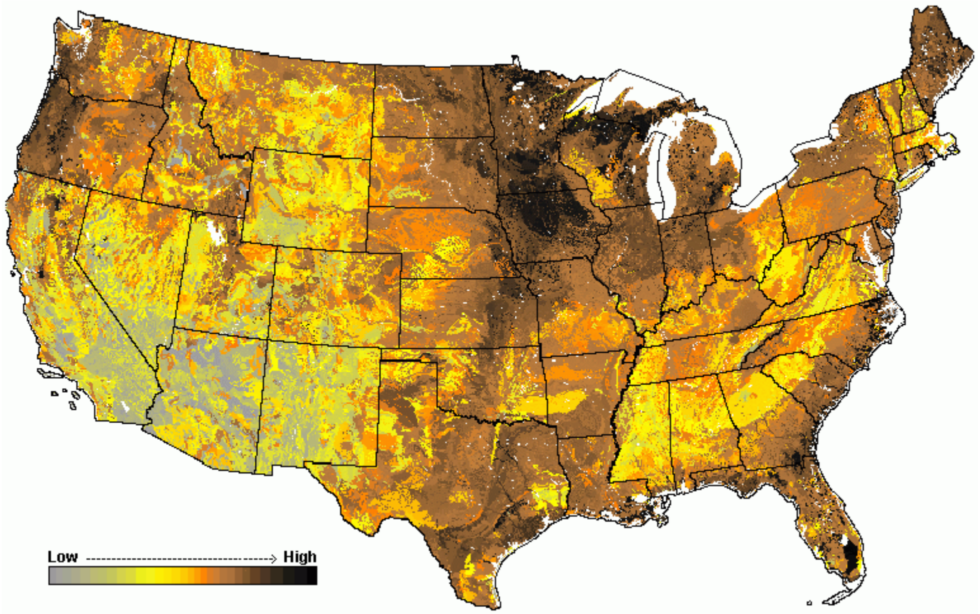
- Add organic inputs
  - compost
  - livestock manure
  - green manure
- Add livestock

Building soil health: patience

“....Invest in the millennium. Plant sequoias.
Say that your main crop is the forest
that you did not plant,
that you will not live to harvest.

Say that the leaves are harvested
when they have rotted into the mold.
Call that profit. Prophesy such returns.
Put your faith in the two inches of humus
that will build under the trees
every thousand years....”

“Manifesto: the Mad Farmer’s Liberation Front”, Wendell Berry



Hargrove and Luxmoore

Carbon Programs: The Wild West or a Promising Opportunity?

2022 Advanced Crop Advisors Workshop

February 8, 2022

Mark Lefebvre
Conservation Planner Manager
Stearns County Soil and Water Conservation District

MN ESMC Pilot

ESMC
Ecosystem Services Market Consortium

NRCS Natural Resources Conservation Service
Minnesota Milk
Minnesota Water Quality Certified Farm
Stearns County Soil & Water Conservation District SWCD
AgCentric Connecting Education & Agriculture
MBOLD Minnesota: Leading the Way to the Future of Food
Certified Crop Adviser
Midwest Dairy
Environmental Initiative Powerful Partnerships, Effective Solutions
Field to Market
auri Agricultural Utilization Research Institute
University of Minnesota
The Nature Conservancy Protecting nature. Preserving life.
Centra Sota
syngenta
TRUTERRA
Houston Engineering Inc.
Minnesota Pollution Control Agency
Forever Green

H.A.S.P.

Headwaters Agriculture Sustainability Partnership

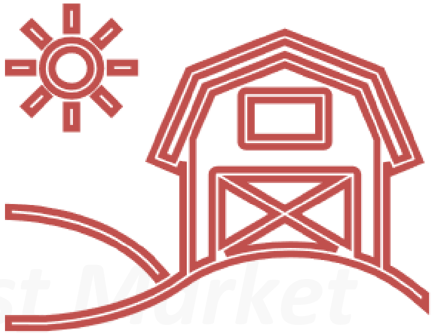
Why ESMC?

- Multiple Credits Created
- Non-profit
- Voluntary & Regulatory / Insets & Offset
- Open Protocols
- Technology + Soil Testing
- Row Crop & Grassland
- Test then launch
- Ag Industry Lead
- Scientific Rigor

Multiple Credits: Generation and Quantification

One protocol generates stacked credits and assets

- Increased soil carbon and Reduced GHG emissions
- Improved water quality
- Reduced water use
- Piloting: Biodiversity



Producer impacts monetized

- **Greenhouse gas**: SOC (removals), and GHG (CH_4, N_2O and CO_2) (reductions)
- **Water quality**: total phosphorus and nitrogen, and sediment
- **Water quantity**: irrigation efficiency based on monitoring

MN - ESMC Pilot

- No minimum or maximum acreage limits and no requirement to enroll all their acreage at any time
- Producers can phase in more acres and/or practices over time
- Producers are not required to relinquish data ownership

Contracts

- During 2022 pilot years contracts are annual
- Producers will have an option to roll into a 5-year contract at market launch at the end of 2022

The Minnesota Pilot Project is focused on acres that have corn and soybean cropping systems with a heavy dairy or livestock component in Central and South Minnesota to help farmers understand how their improved soil health practices translate into economic benefits.

50,000 Acre Goal

Why Here?

- Miss. Headwaters
- Existing Cost Share
- High Livestock Density
- Downstream Water Quality buyer

Crops

- Corn/Silage - Soy
- Dairy (#28 Co. in US)
- Poultry

https://mrbdc.mnsu.edu/mnnutrients/watersheds/sauk-river-watershed

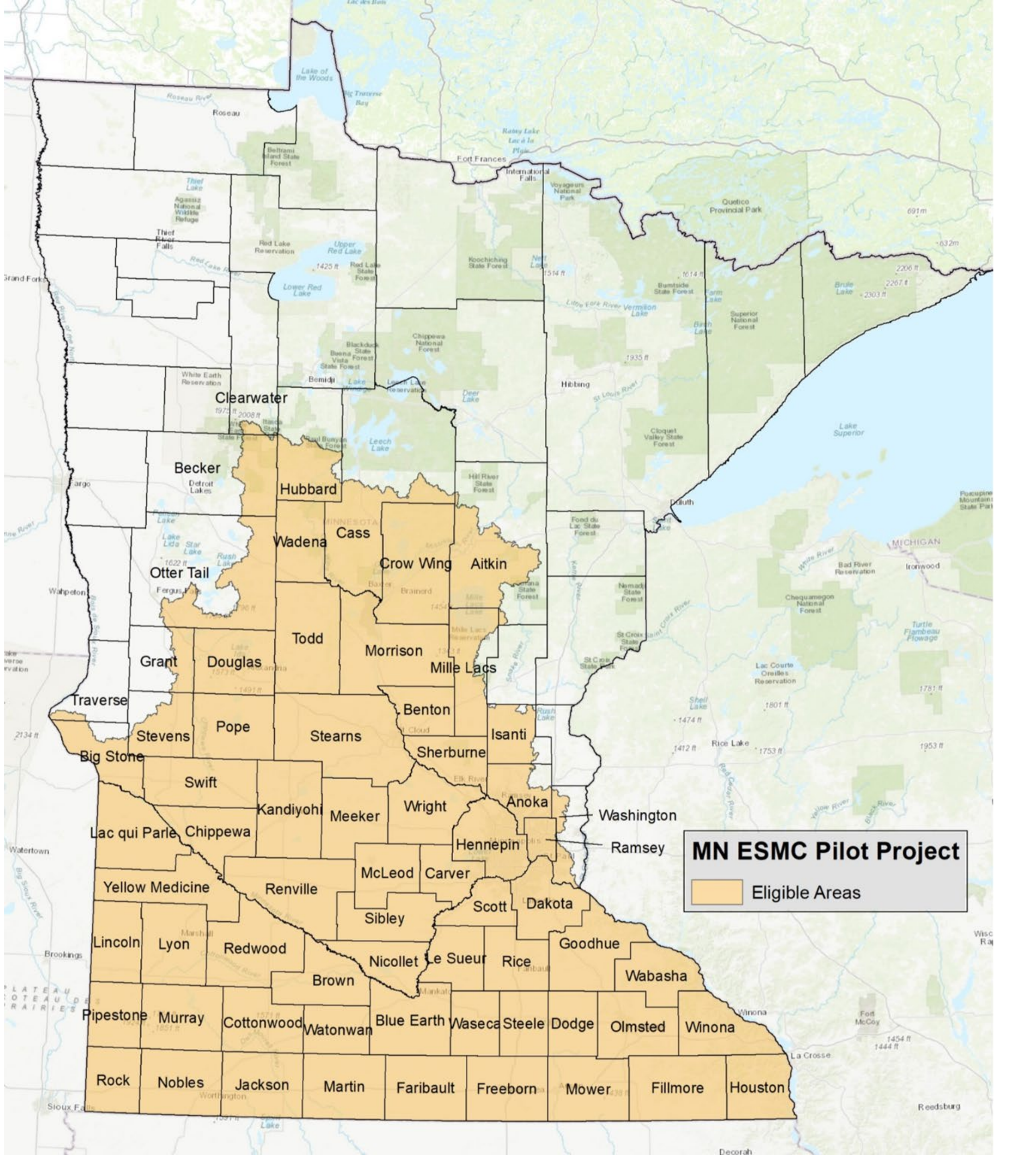
50,000
Acre Goal

Project area expanded in 2021

- 2020 – 4 farms and 116 ac.
- 2021 – 6 farms and 1000 ac.
- 2022 – 4 farms and 1000 ac.

In Stearns County to date

https://mrbdc.mnsu.edu/mnnutrients/watersheds/sauk-river-watershed



Producer Eligibility & Requirements

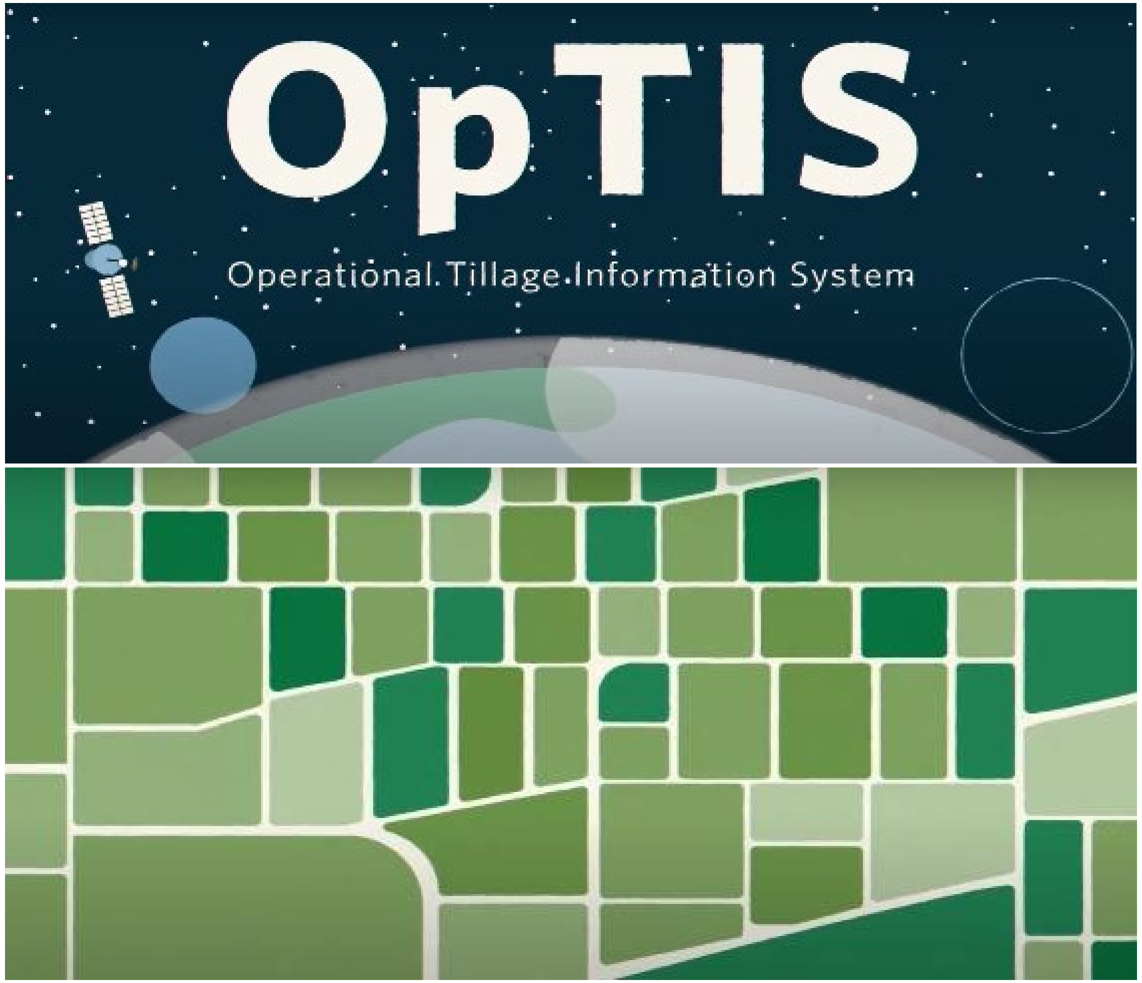
Screening process is done via Producer Portal or/and Enrollment Specialist

- Interested in adopting soil health and conservation practice change(s)
- Interested in implementation of improvements that exceed minimum standards set by law
- Managing land that has not been deforested in the past 10 years
- Fields located within an approved ESMC Project region and production system
- Can provide proof of land ownership or lease agreement
- ESMC fields that are not enrolled in another carbon market

Modeling Overview

- Soil Sampling is conducted in year 1 (Spring 2022) to determine the baseline.
- Use field management data and soil sampling results to model:
  - **Soil Organic Carbon (SOC) removals**
  - **GHG Emission Reductions**

- Carbon reductions and removals are modeled using DNDC model (DeNitrification-DeComposition) which simulates carbon and nitrogen biogeochemistry in agricultural ecosystems
- Water quality and quantity are modeled using APEX (Agricultural Policy / Environmental eXtender)
  - **Water quality**: total phosphorus and nitrogen, and sediment
  - **Water quantity**: irrigation efficiency based on monitoring



Year 1

Baseline Soil Test
Practice Implementation

Year 2-4

Annual Credit Generation via Remote sensing and Modeling

Year 5

Soil test "True-Up"

Practice Change for 2022

- Timing
  - Needs to occur after harvest of 2021 to harvest of 2022
- What is considered a practice change?
  - The practice must be additional = new to the field that is enrolled
  - Examples: Cover crops, tillage reduction, conservation crop rotation, edge of field practices
- What doesn't qualify?
  - Historical practices that have been part of the field operation

Conservation Practice	Applicable Attributes [1]
Residue and tillage management, reduced till/no till	GHG, Water Quality
Cover crop	GHG, Water Quality
Nutrient management	GHG, Water Quality
Prescribed grazing	GHG, Water Quality
Field buffer, filter strip, field border	Water Quality
Contour buffer strip, vegetative barrier within a field	GHG, Water Quality
Constructed ponds and wetlands	Water Quality
Grassed waterway	Water Quality
Conservation crop rotation	GHG, Water Quality
Prescribed burning	GHG
Irrigation water management	GHG, Water Quality, Water Quantity
Drainage water management practices	Water Quality

1. Data requirements vary between Scope 1 and Scope 3 attributes

Scope Definitions

Scope 1

- Carbon Offset Credits
- GHG directly emitted by a company
- ‘Compliance Grade’ Water Quality Credits
- Example: Southern MN Beet Sugar Coop Cover Crop Program

Scope 3

- Supply Chain Reporting Assets
- GHG emitted indirectly via supply chain
- Carbon footprint reduction claim
- Example: Target stores to be Net Zero GHG by 2040

Verification

Scope 1

- Third-party verification through Gold Standard/SustainCert, some on-site visits

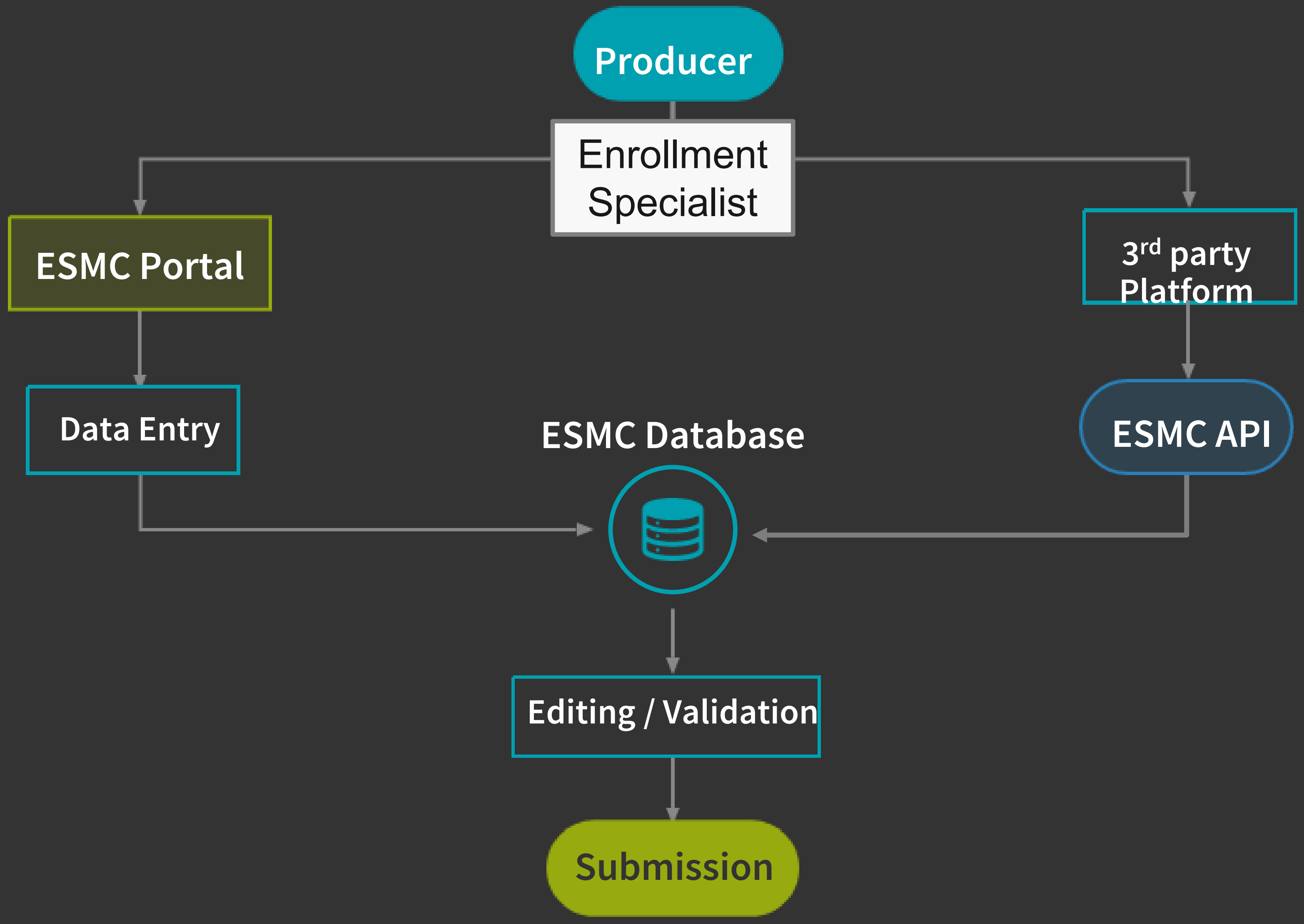
Scope 3

- Second-party from a trained, approved Verifier
- Advisors, SWCDs, etc. (no conflict of interest)
- Most will be done remotely
- Documentation requirements under development

Cropland Timeline

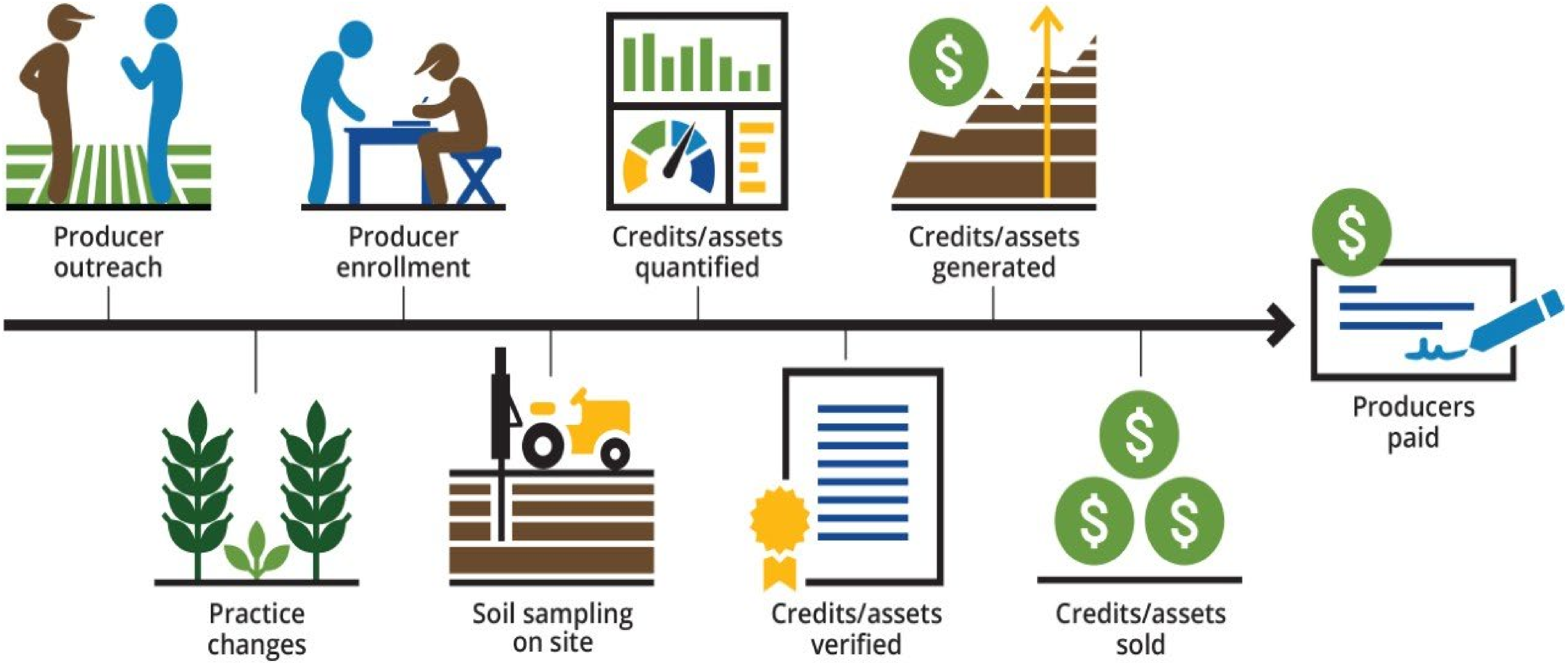
March 1, 2022: Producers are enrolled into the pilot project via ESMC Producer Portal
December 31, 2022: Field level management data is completed via ESMC Producer Portal

Data Collection Option



ESMC Market Function Overview:

How Growers are Paid Annually for Multiple Ecosystem Services Impacts & Outcomes



Advantages

- Increase income
- Stack payments with financial assistance or cost share
- Encourages conservation practice adoption
- We all benefit
- Any sized farm is eligible

Barriers

- Additionality requirement
- Data entry
- Long term contract
- Does payment cover the cost of new practice adoption?
- Shortage of technical expertise/Enrollment Specialist

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www.esmcportal.org

Questions?

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