Agriculture and Climate Change Mitigation: Challenges and Strategies

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American Farmland Trust

USDA Northeast Climate Hub
U.S. DEPARTMENT OF AGRICULTURE

CAMF

Part I: Why are we talking about this?

Agriculture contributes to climate change through the emission of greenhouse gases. We are going to be talking about how agriculture can **emit fewer greenhouse gases** and sequester more carbon to mitigate the effects of climate change.

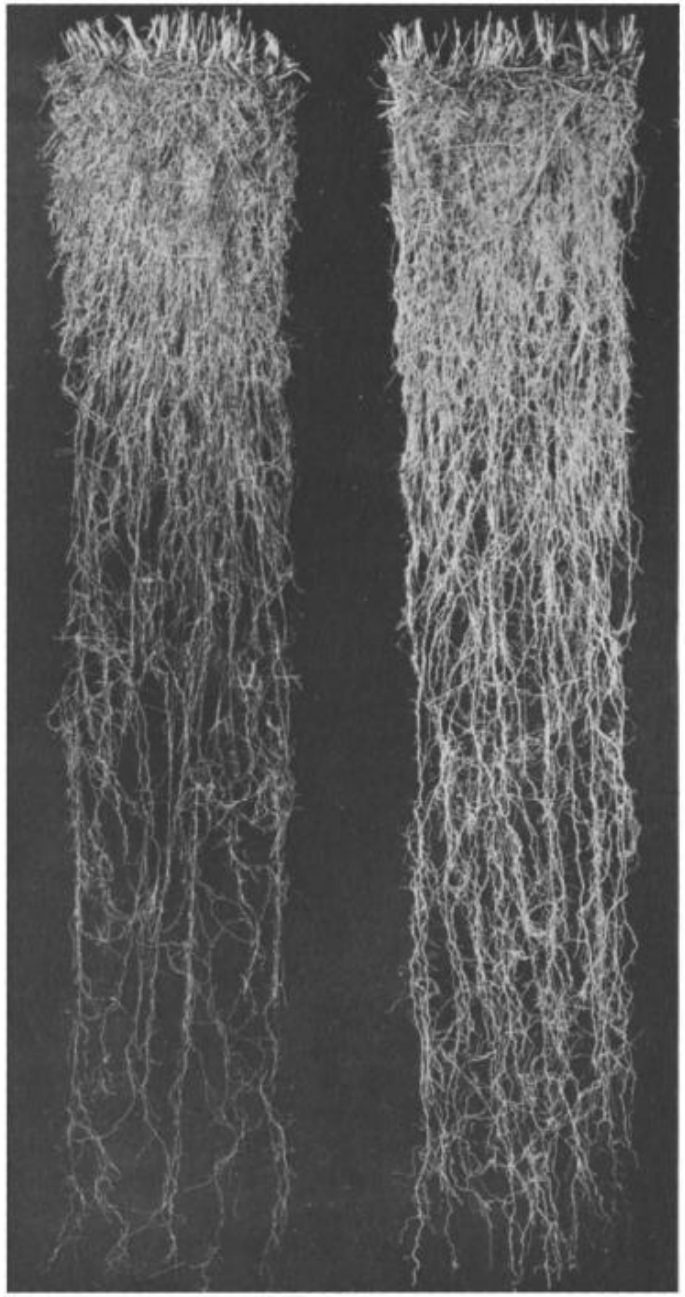
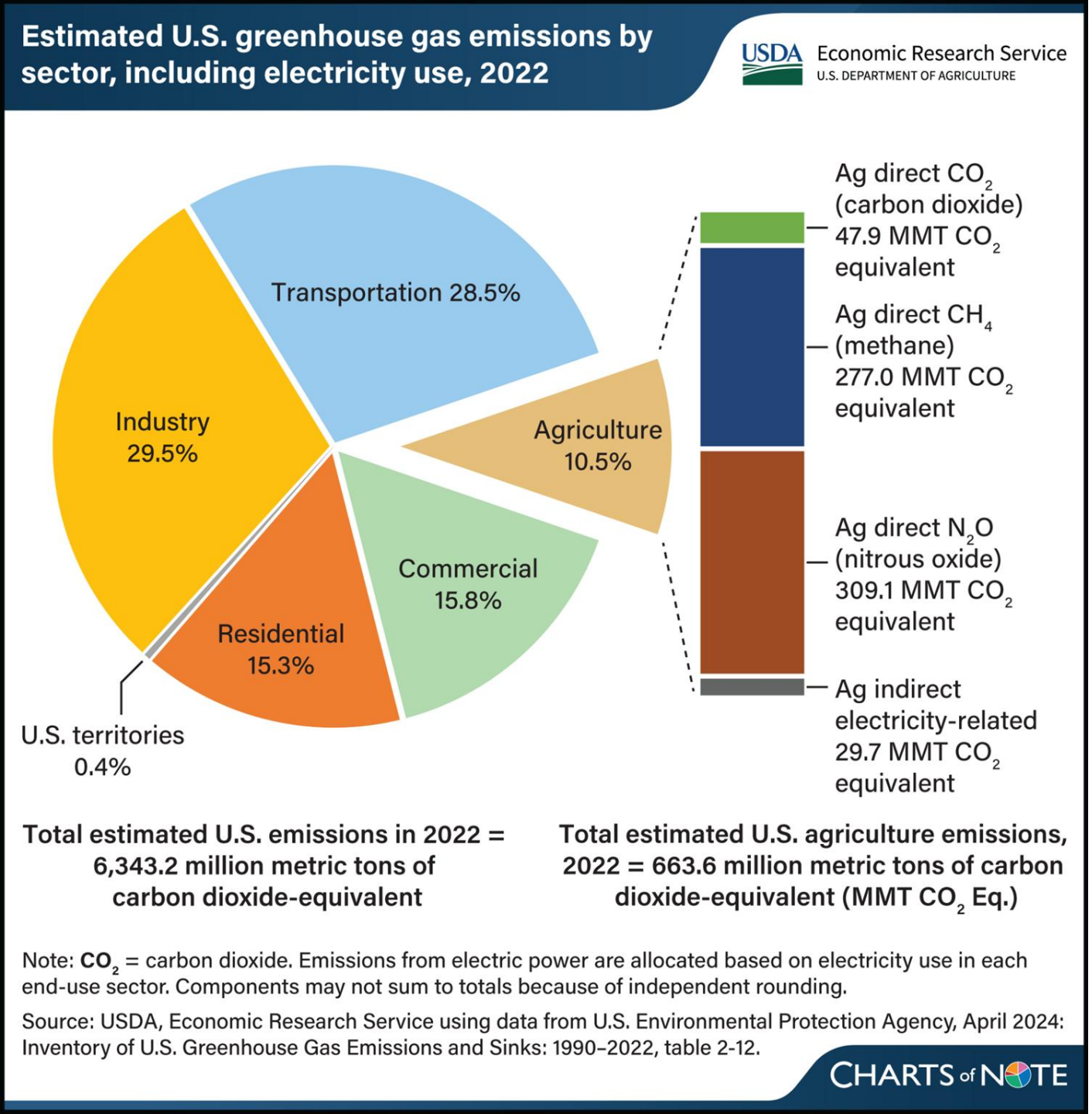


FIG. 5.—Roots of big bluestem (*Andropogon gerardi* [left]) and switchgrass (*Panicum virgatum*) from monoliths of soil 12 inches wide, 3 inches thick (into the trench wall), and 5 feet deep. The bluestem was 7 feet and the switchgrass more than 8 feet deep. From Weaver and Darland, *Ecological Monographs*, 1949*a*.

Agriculture's emissions come from three greenhouse gases

Global Warming Potential (GWP) of GHG relevant to agriculture

GHG	GWP (20 year time scale)	GWP (100 year time scale)	Source
Carbon Dioxide (CO_2)	1	1	IPCC. AR5. 2014
Methane (CH_4)	86	34	IPCC. AR5. 2014
Nitrous Oxide (N_2O)	268	298	IPCC. AR5. 2014



Synthetic fertilizer production

Manure management

Enteric fermentation

Rice cultivation

Crop residues

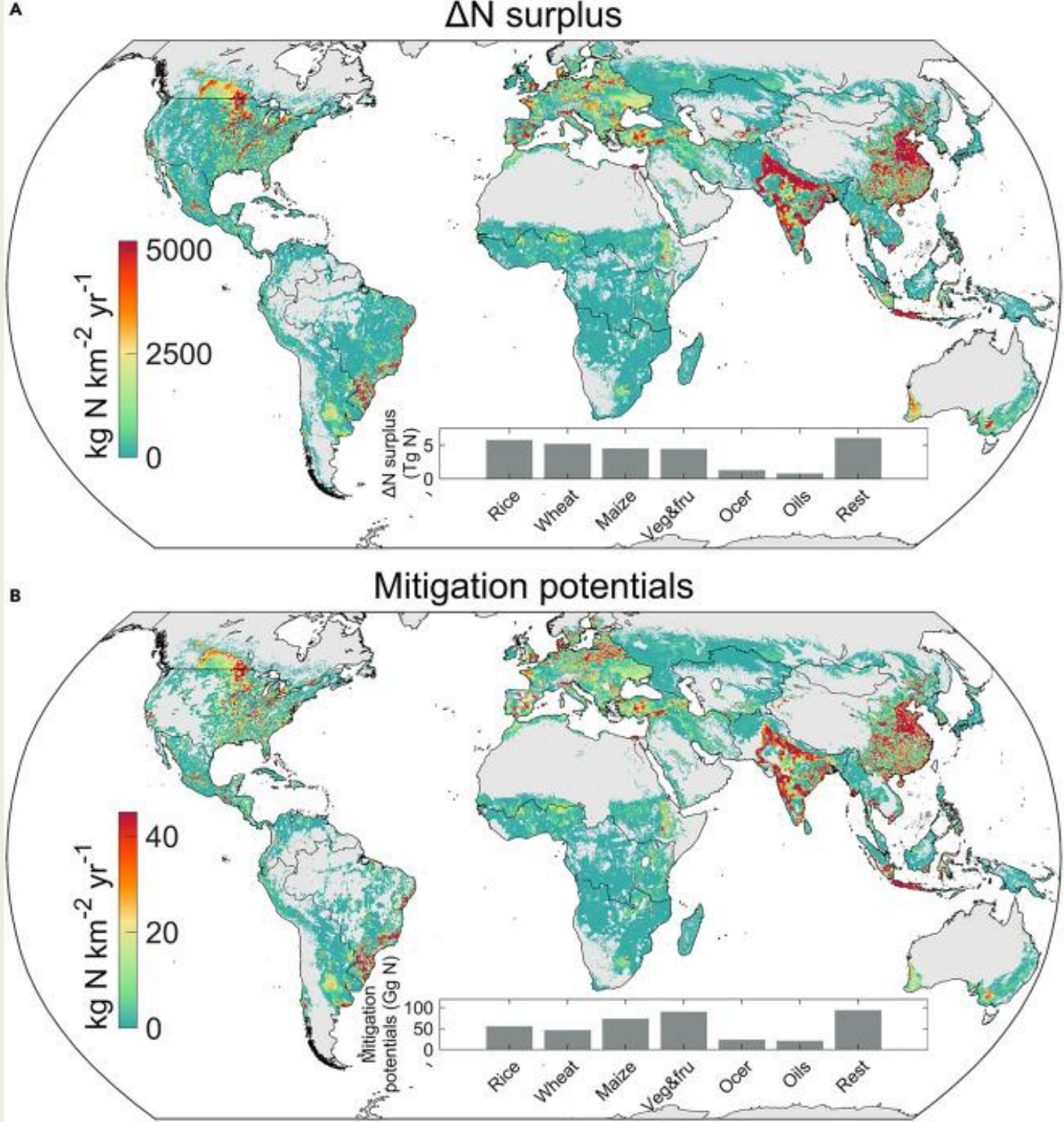
On-farm energy use

Soil management

Part 2 : Reducing Emissions

Reducing Nitrous Oxide Emissions: Nutrient management

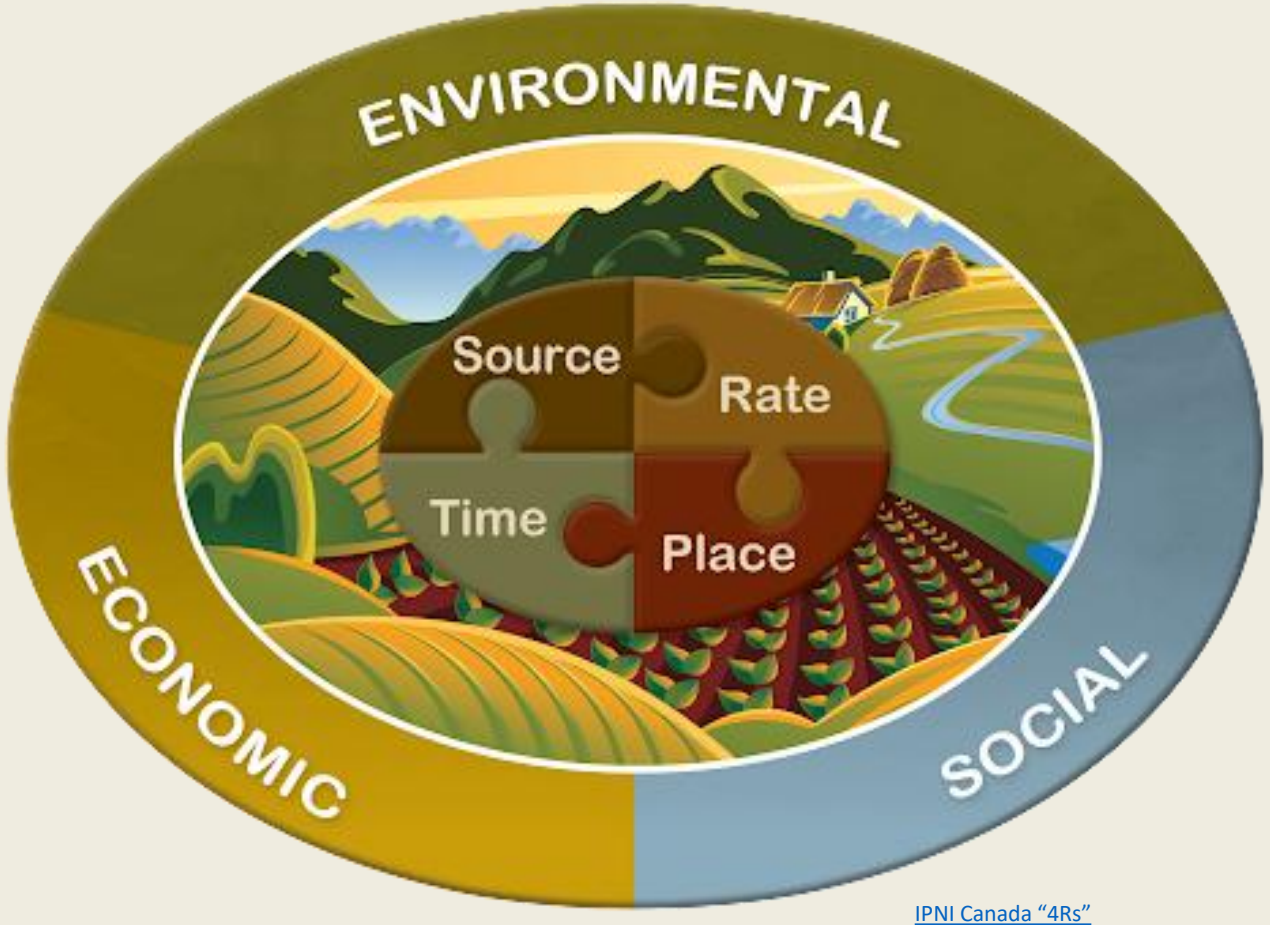
- We could apply much less Nitrogen and maintain crop production



https://www.sciencedirect.com/science/article/pii/S2590332224000058

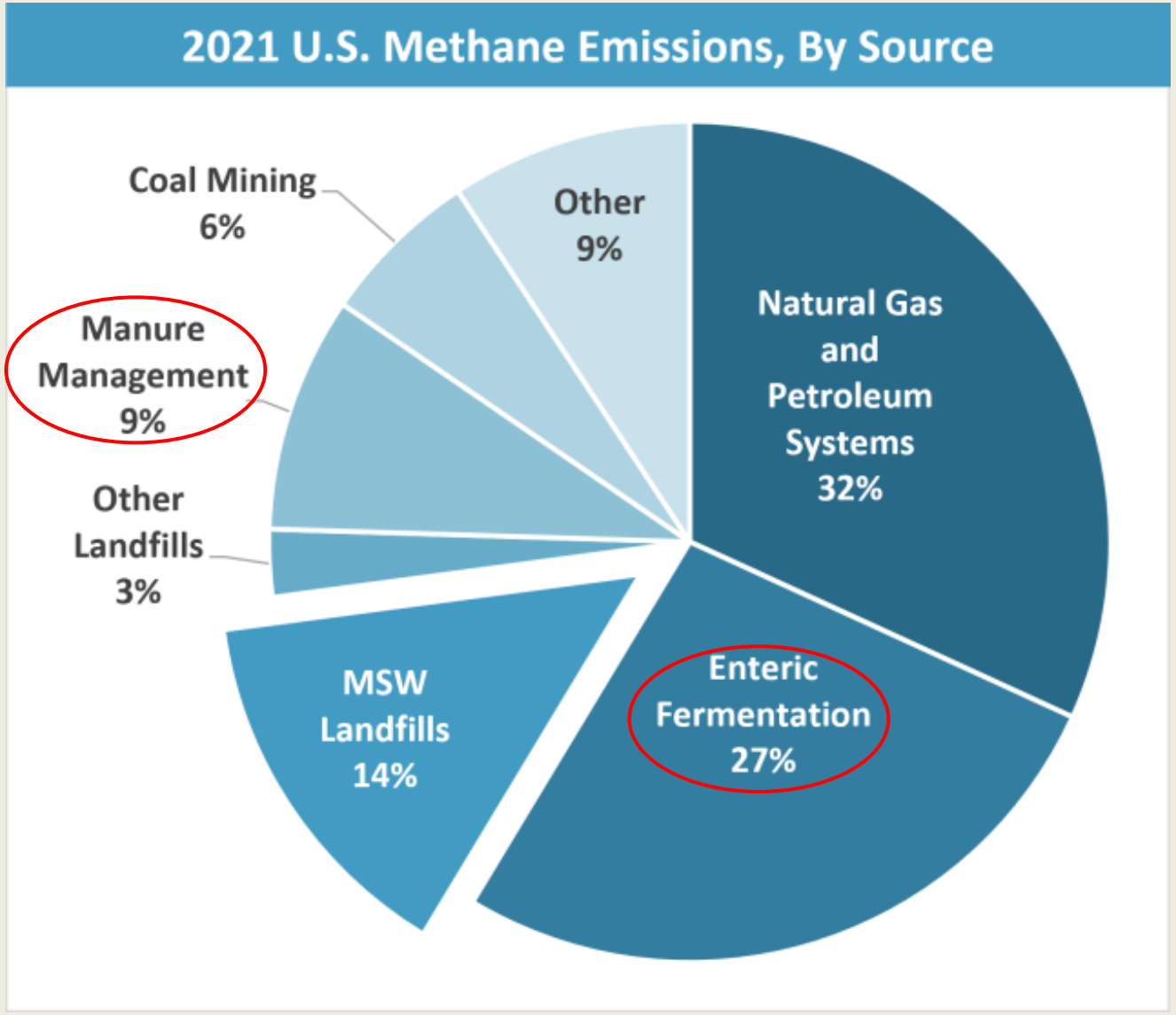
Reducing Nitrous Oxide Emissions: Nutrient management

- Agriculture is responsible for 70% of U.S. N_2O emissions
- N_2O emissions are significantly related to the application of N inputs
- Using the “4-R Framework” to increase N use efficiency has economic benefits to farmers while reducing N_2O emissions



IPNI Canada “4Rs”

United States methane emissions by source



Basic Information about Landfill Gas | US EPA

Reducing Methane Emissions

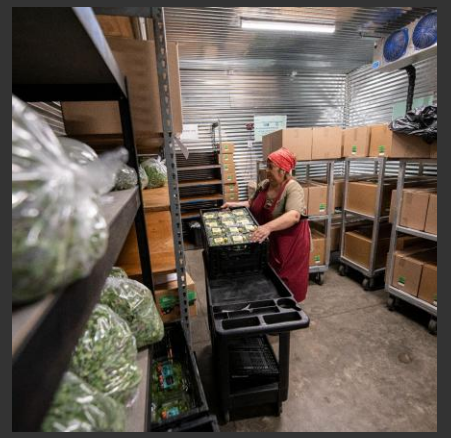
Relative Methane Reductions of Manure Management Practices
(Scale based on ½ leaf = 10% methane reduction)

Manure Management Practice	Relative Methane Reductions*
Anaerobic Digestion	5 leaves
Daily Spread	4.5 leaves
Pasture-Based Management	4.5 leaves
Composting	4.5 leaves
Solid Storage	4.5 leaves
Manure Drying Practices	4.5 leaves
Semi-Permeable Covers, Natural or Induced Crusts	4 leaves
Decreased Manure Storage Time	4 leaves
Compost Bedded Pack Barns	3 leaves
Solid Separation of Manure Solids Prior to Entry into a Wet/Anaerobic Environment	2 leaves

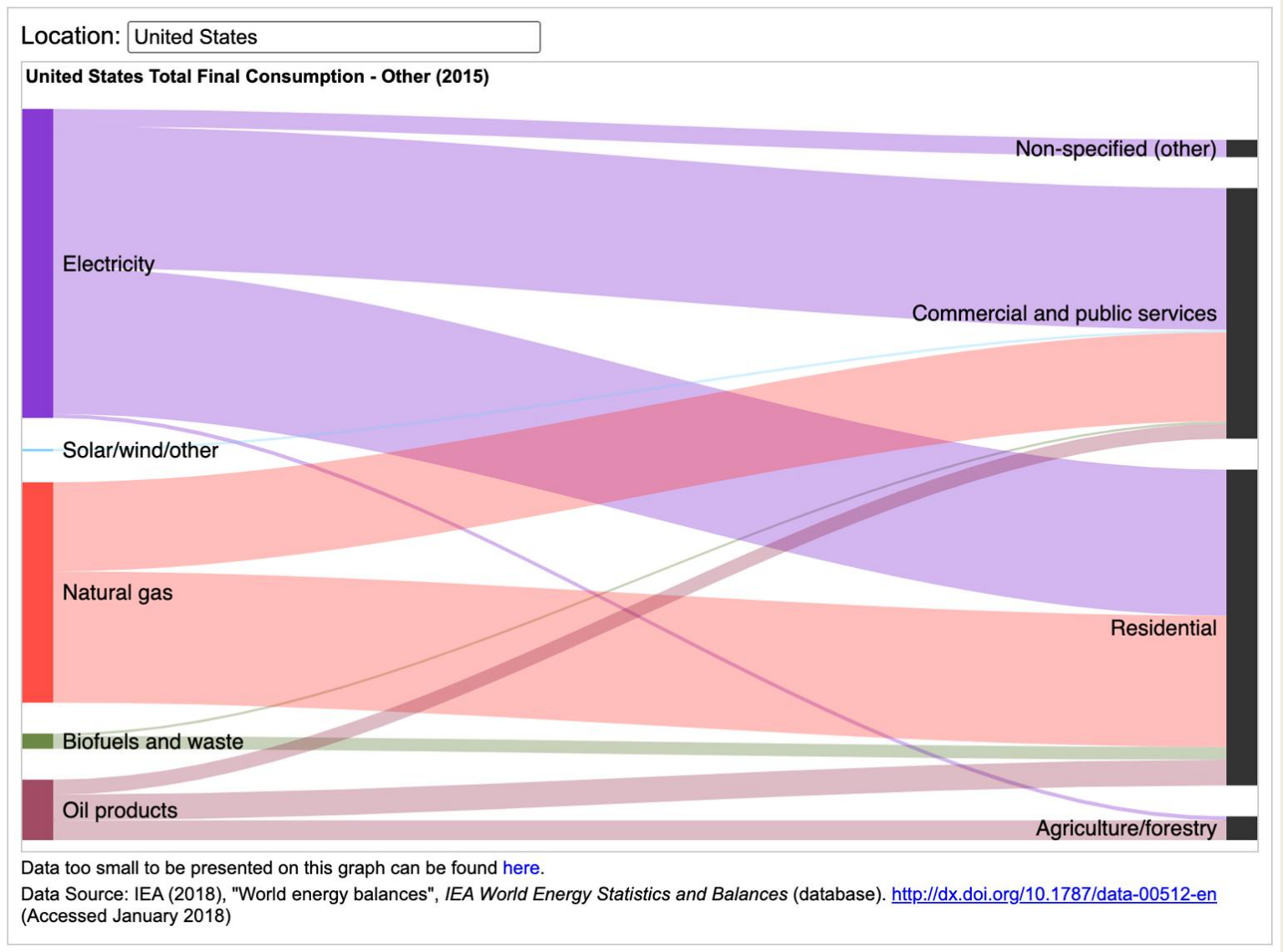
Practices to Reduce Methane Emissions from Livestock Manure Management | US EPA

Part $2^{1/2}$: Reducing on farm emissions

Energy conservation and efficiency & renewable energy

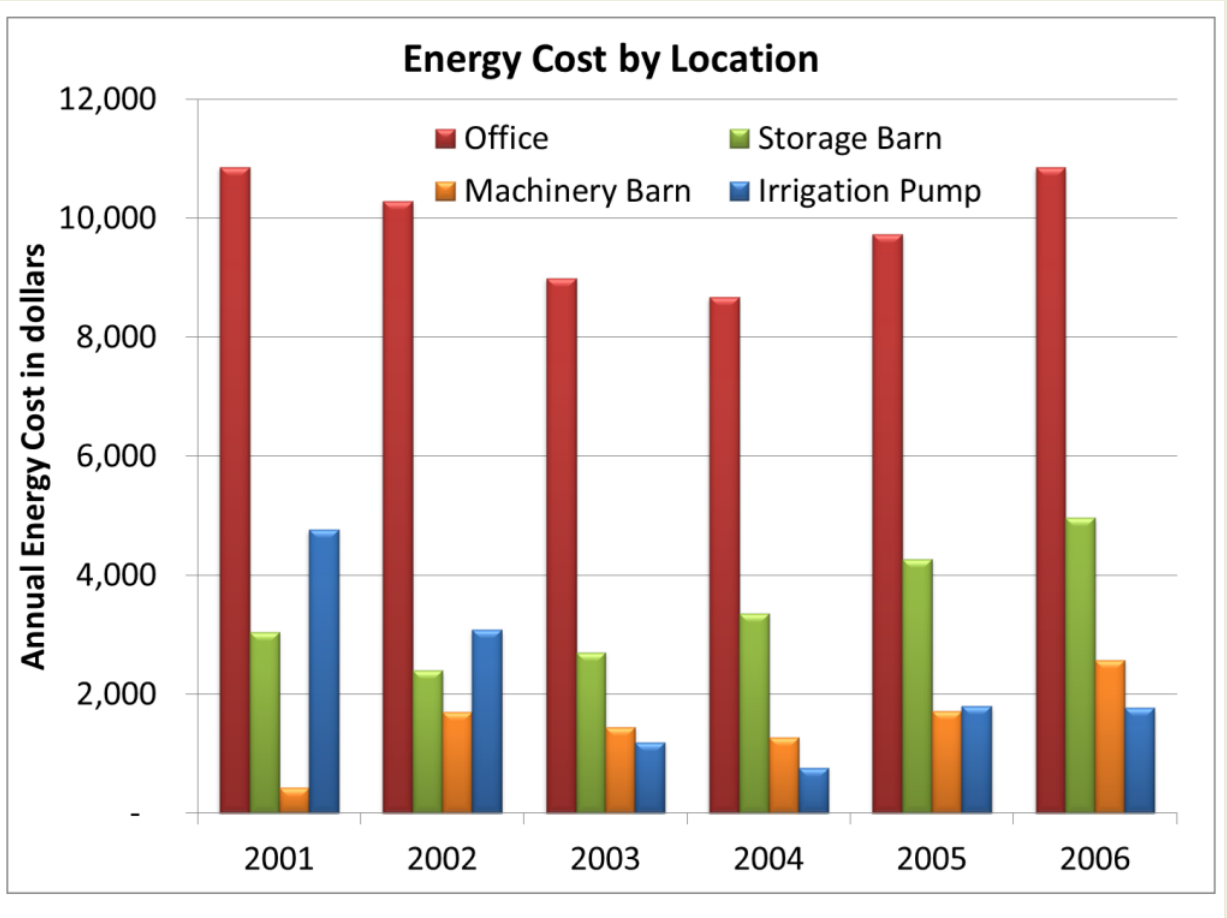


On Farm Energy Use: Energy Efficiency



Strategies for reducing on-farm energy consumption

- Perform an energy audit
- Understanding a farm's utility bill -
  - what is using the most energy?
  - Is there a way to reduce load?
  - Solar to replace grid electric supply?
- Paying for efficiency updates
  - EQIP
  - REAP
- Greenhouse energy conservation
- Improving tractor and field operations efficiency



Farm Energy Audits (extension.org)

Renewable Energy

Wind, Solar, and Bioenergy

Sunflowers for biofuel

http://vermontbioenergy.com/wp-content/uploads/2014/09/sunflowers-growing-at-ekolott-farm-in-newbury-vt.jpg

Wind turbines on agricultural land in New York
https://www.newyorkupstate.com/northern-ny/2016/08/wind_farms_in_upstate_ny_13_places_to_see_the_massive_windmills_photos.html

Livestock and solar panels sharing space
https://www.uvm.edu/extension/sustainableagriculture/news/grazing-and-solar-energy-vermonts-working-landscape

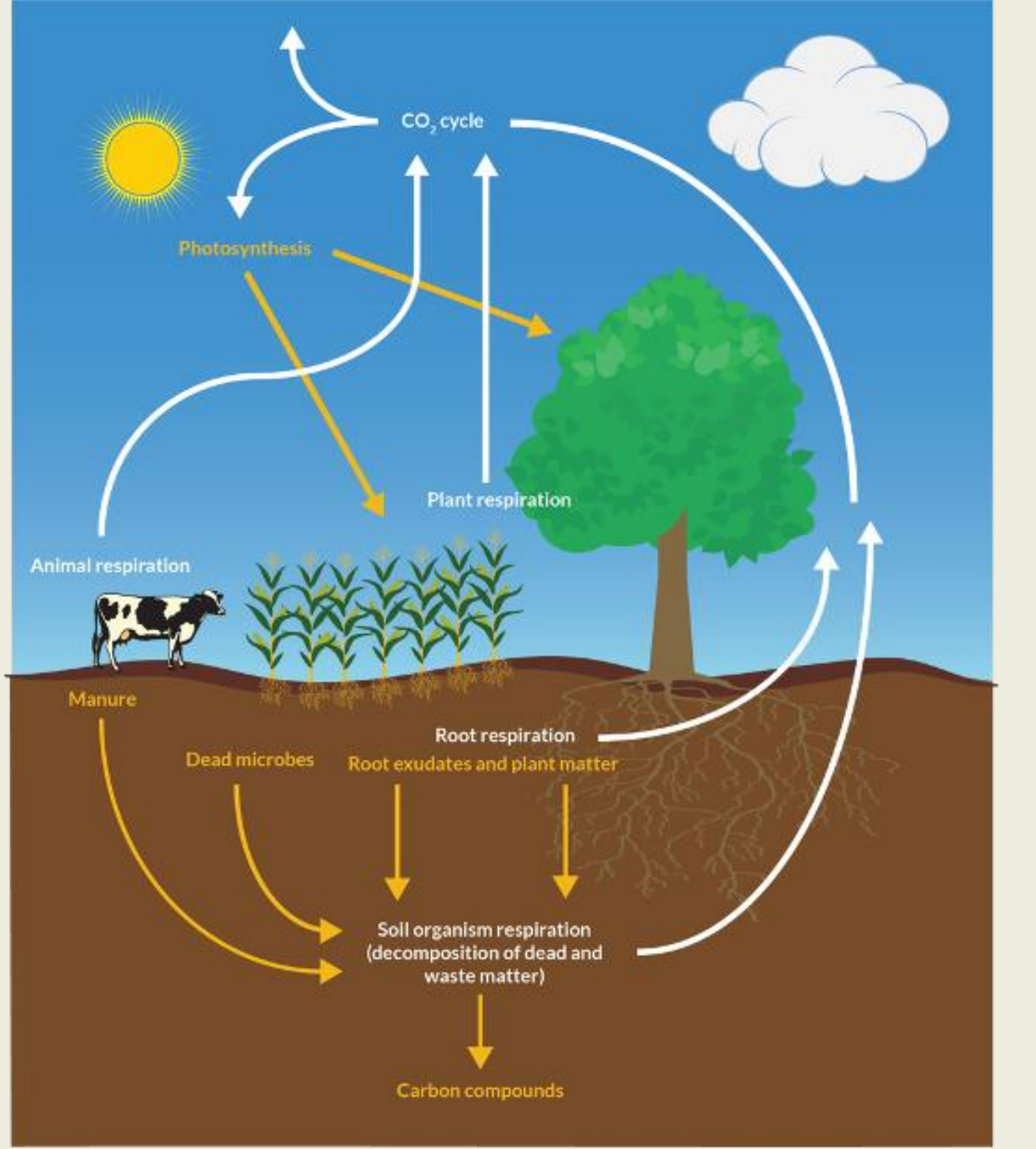
Part 3: Carbon Sequestration

- What do we know about carbon sequestration?

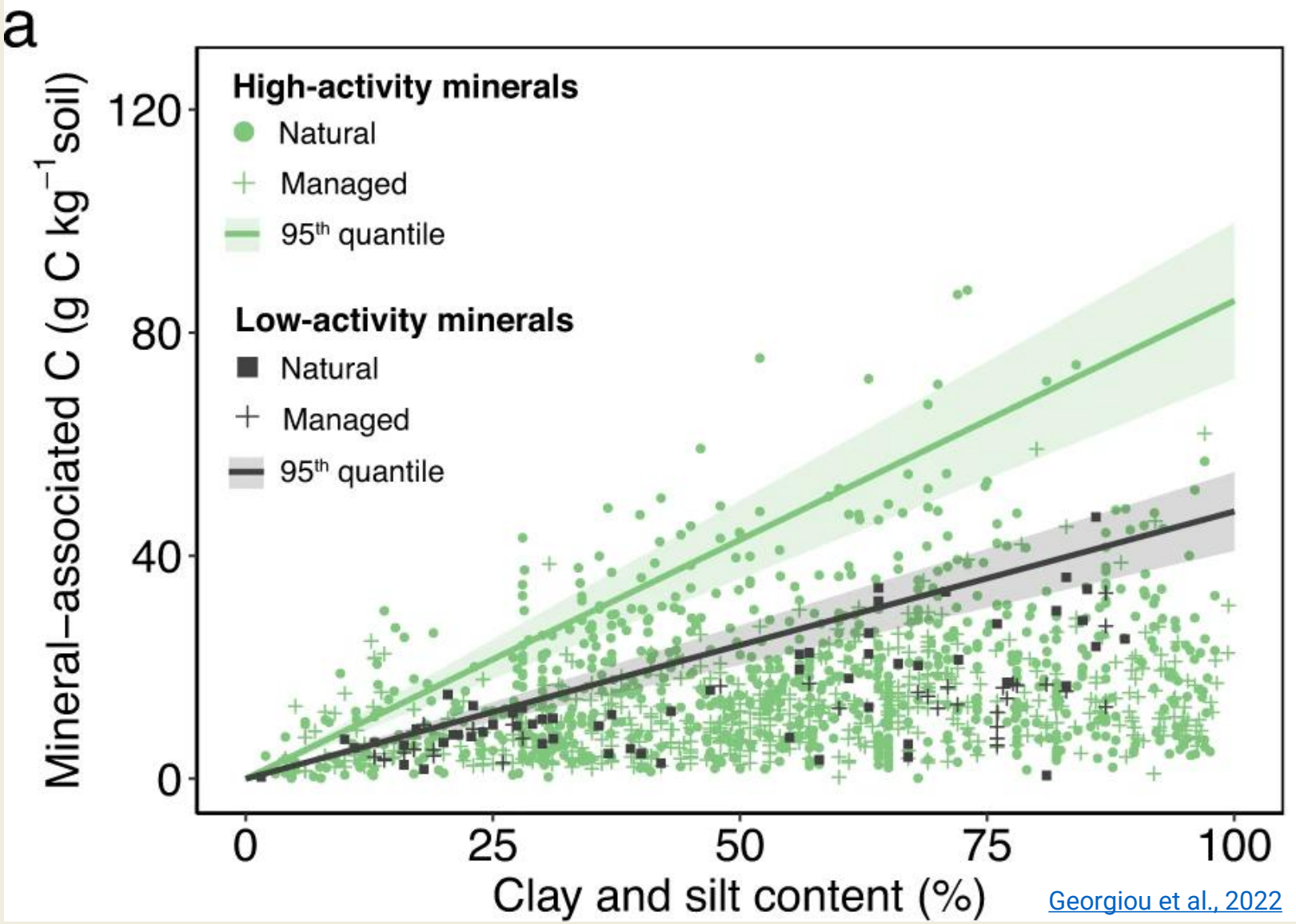
- What are some methods for *potentially* sequestering carbon in soils, and what are the effects of these practices on N_2O, CH_4, and CO_2 emissions?

    - Reducing tillage
    - Adding cover crops
    - Adding organic matter
    - Replacing annual crops with perennial crops
    - Adding, protecting, and growing trees

What is carbon sequestration?



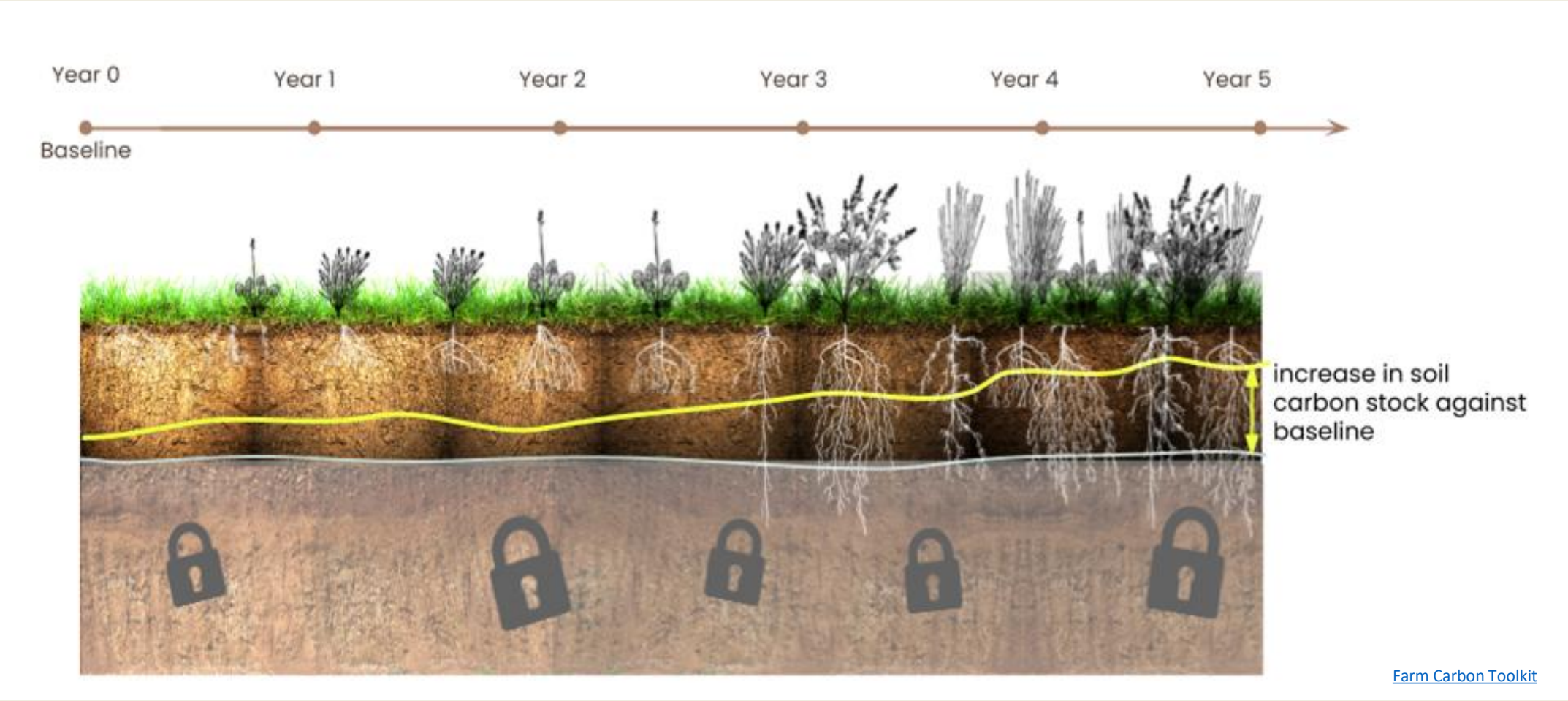
How much carbon can we actually sequester in soils?



Georgiou et al., 2022

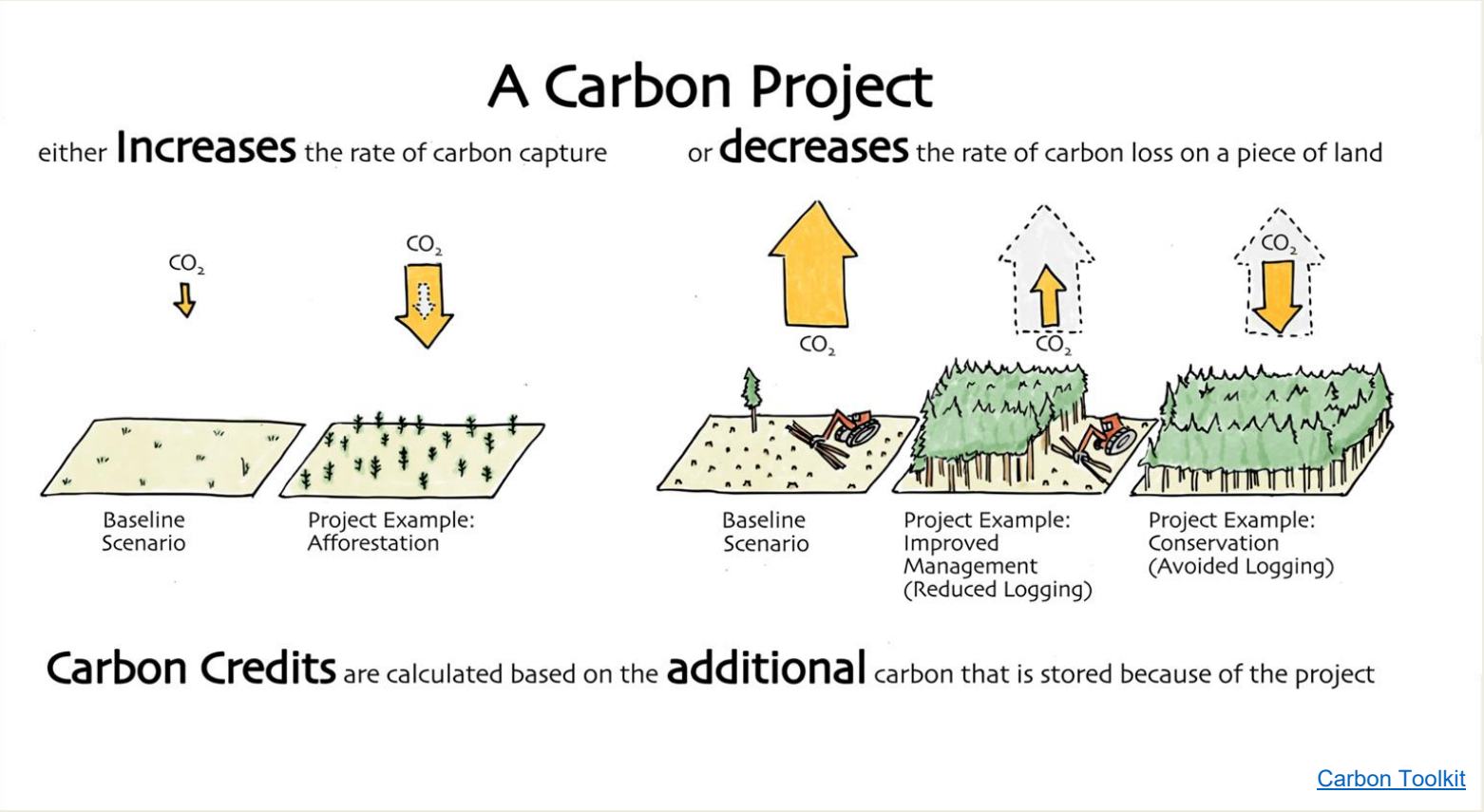
What we talk about when we talk about soil carbon…

- Permanence - is the carbon sequestered in the soil for the long term?



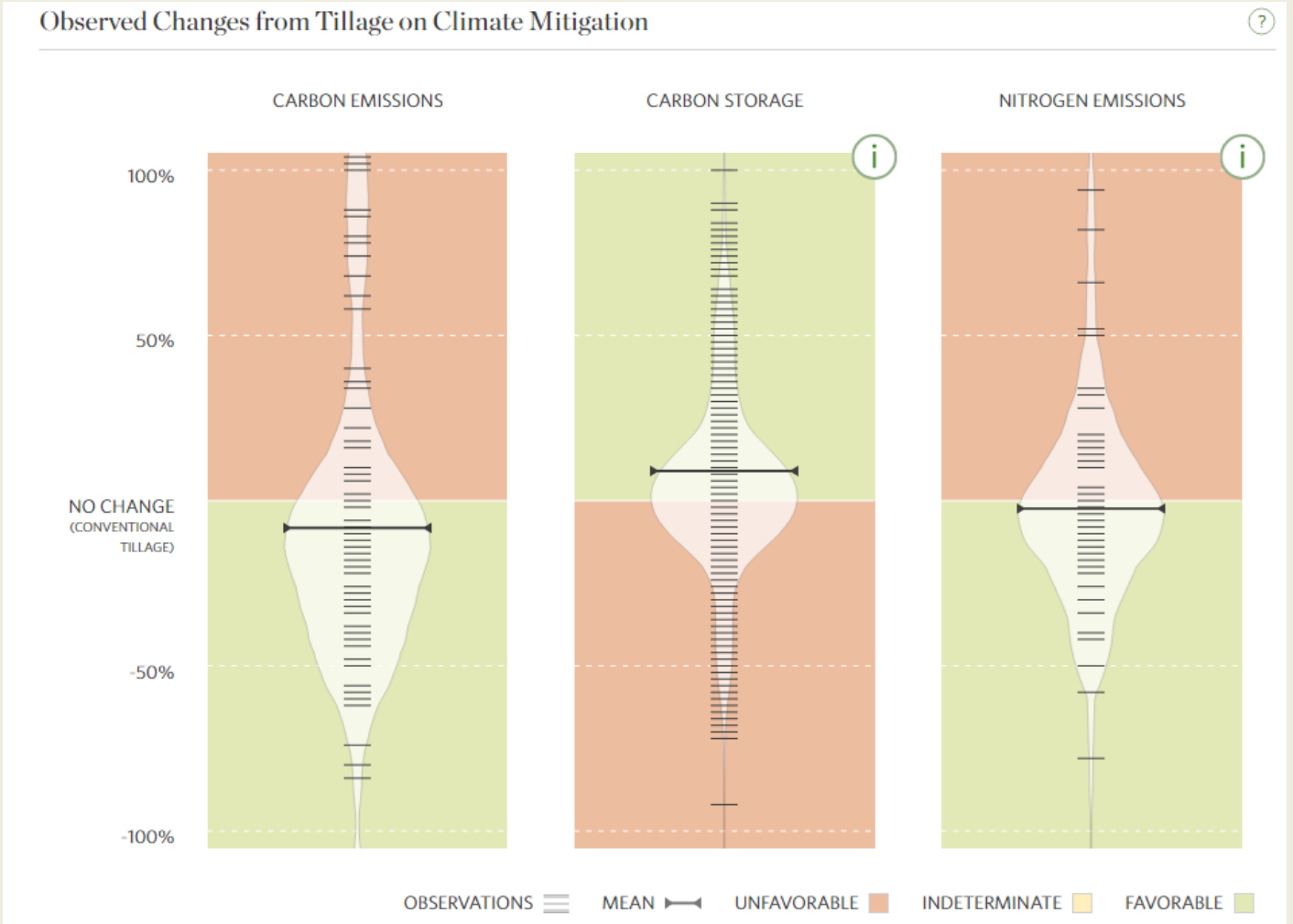
What we talk about when we talk about soil carbon…

- Additionality - would this carbon have ended up in the soil in a business-as-usual scenario?



Reducing Tillage

- Reducing tillage, particularly no-till can increase soil carbon
- There is debate about how much carbon can be sequestered by reduction in tillage
- Reducing tillage is beneficial to soil health & creates improved crop growing conditions
- Benefits take time to build up and can be quickly reversed
- The depth at which carbon is sequestered matters



AgEvidence

Cover Cropping

- Benefits of cover cropping include increased water quality, increased water infiltration and reduced erosion. Adding cover crops can also be an effective way to to increase soil carbon.
- Cover cropping is one of the least expensive methods for increasing soil carbon
- The largest increase in SOC stock due to addition of cover crops occurs in the first 50 years
- A few studies look at the impact of cover cropping on N_2O emissions

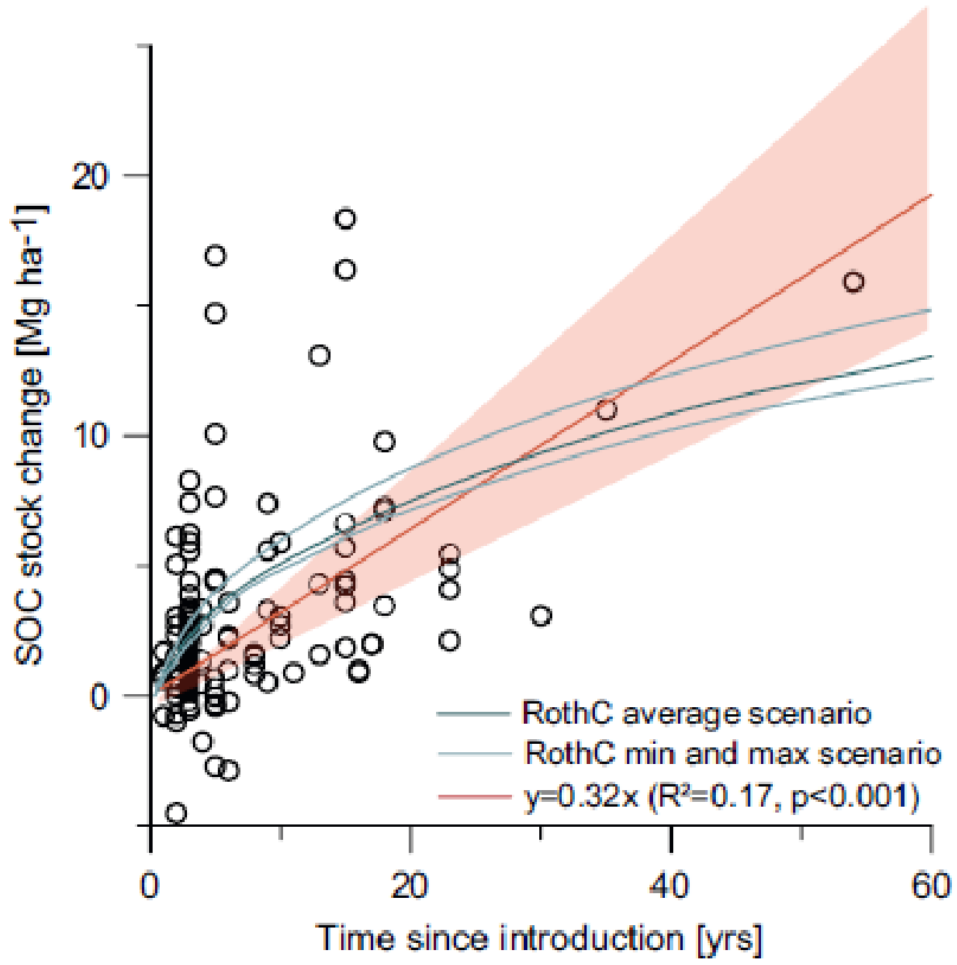


Fig. 2. SOC stock change after cover crop introduction as a function of time with linear regression (with 95% confidence interval) and the RothC simulated average cropland (with min and max scenario).

Poeplau and Don, 2015

Adding organic matter (other than cover crops)

- Cover crops, crop residue, manure, compost, biochar
- Compost, biochar, and crop residues are more **stable** than manure, meaning there will be less emissions associated with using them as amendments **but...**
- Factor in GHG emissions from production and transportation

Biochar

Manure

Compost

Replacing annual crops with perennial crops

- Strong potential to increase soil carbon
- Planting perennial crops means increased vegetation cover, more biomass, more plant residues, less (or no) tillage, and less N fertilizer use
- Perennial crops could be fruit trees, short rotation woody crops for pulp/paper or bioenergy, or perennial grasses, and legumes

Turkey Foot Elderberry Farm

Add, grow, and protect trees and forests

- Highest mitigation potential of any mitigation strategy we have discussed (or will discuss) **by far**
- Improve management of woodlots
- Afforestation - plant trees where you can
- Prevent deforestation
- Agroforestry

Paul Franz, 2025

Takeaways and conclusions

- We are still learning about how to best mitigate climate change in agriculture. We are also still learning how to quantify changes in carbon sequestration.

- Despite some uncertainty, most of the practices and strategies we have discussed here have important benefits beyond reducing emissions or sequestering carbon

- Often, implementing efficient strategies offers an opportunities for saving money

- Think about emissions of all agricultural GHGs (not just CO_2) when making management decisions