Pacific Northwest
NATIONAL LABORATORY

What is the role of bioenergy in soil carbon storage?

March 16, 2022

Mariefel V. Olarte, Sarah Barrows, Kamila Kazimierczuk, Nikolla Qafoku, Corinne Drennan, TJ Heibel

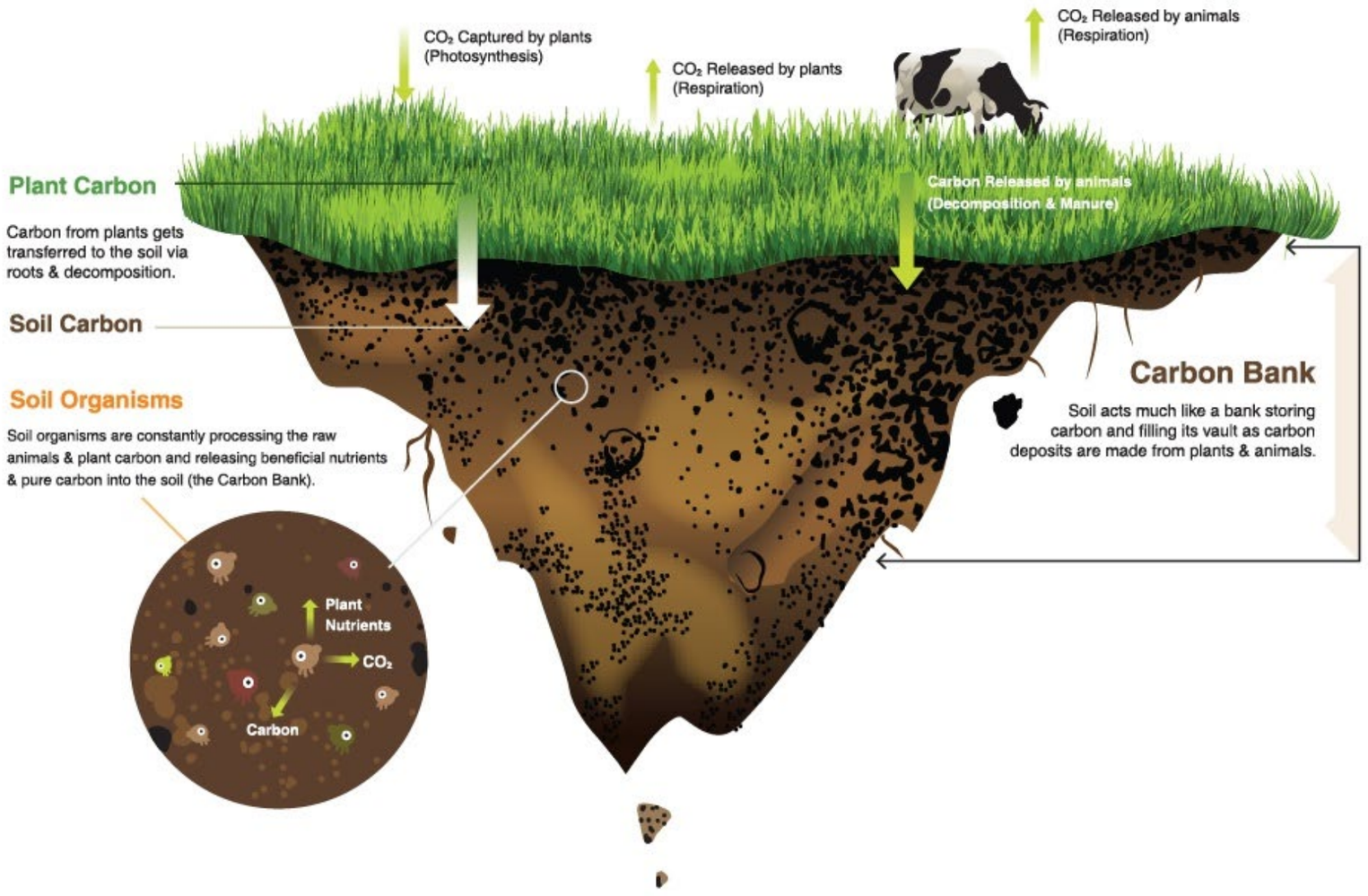
U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

PNNL-SA-170955

Carbon fluxes in the soil

- **Soil carbon pool includes organic carbon and inorganic carbon.**
- Carbon storage depends on many things, including climate, soil type/soil zone, type of crop or vegetation cover, and management practices.
- **Agriculture and forestry currently sequester about 12% of U.S. GHG emissions.[1]**
- Soil response to climate change is expected to be multifaceted with effects that are not yet well understood.[2] However, warming soils increase soil respiration which releases more CO_2 into the atmosphere.[3]



Managing carbon is key to soil health.

https://www.australiansoil.com.au/soil-management-benefits

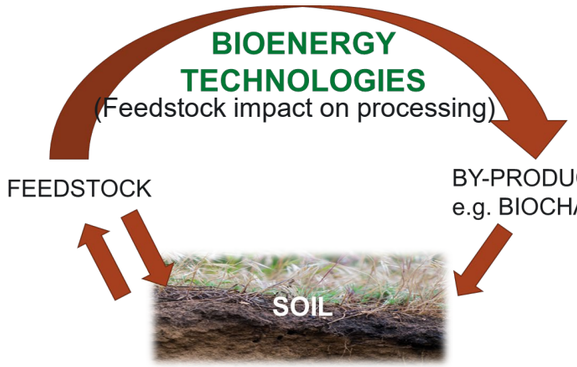
[1] EPA 2021 Inventory of Greenhouse Gas Emissions and Sinks: 1990-2019
[2] Qafoku 2015 https://doi.org/10.1016/bs.agron.2014.12.002
[3] Hicks Pries et al. 2017 DOI: 10.1126/science.aal1319

Bioenergy relationship with agriculture

- **Majority of identified biomass and waste feedstocks still rely on land use.**
  - ***Agricultural residues*** (e.g., corn stover)
  - Dedicated ***energy crops***
  - ***Forestry residues***
  - Waste streams and re-usable carbon sources (e.g., ***waste food and manure slurries, anaerobic digestor sludge, biosolids)***

https://www.energy.gov/eere/bioenergy/feedstock-technologies

The agricultural and food system accounts for **26-31% of our total GHG emissions.** 100% GHG emissions reduction in biofuels cannot be attained without the whole supply chain.



- **Changes in soil organic carbon (SOC) influence net GHG emissions from bioproducts.[4,5]**
  - Land use change and biomass removal are two examples of how SOC can be affected by biofuel/bioproduct production.
- **Nitrous oxide emissions also affect the GHG balance of biofuels/bioproducts.[6,7]**
  - ~ 80% of US N_2O emission is from soil management.[1]
  - Bioenergy crops, specifically, can require a significant amount of fertilizer and weed killer.[8]

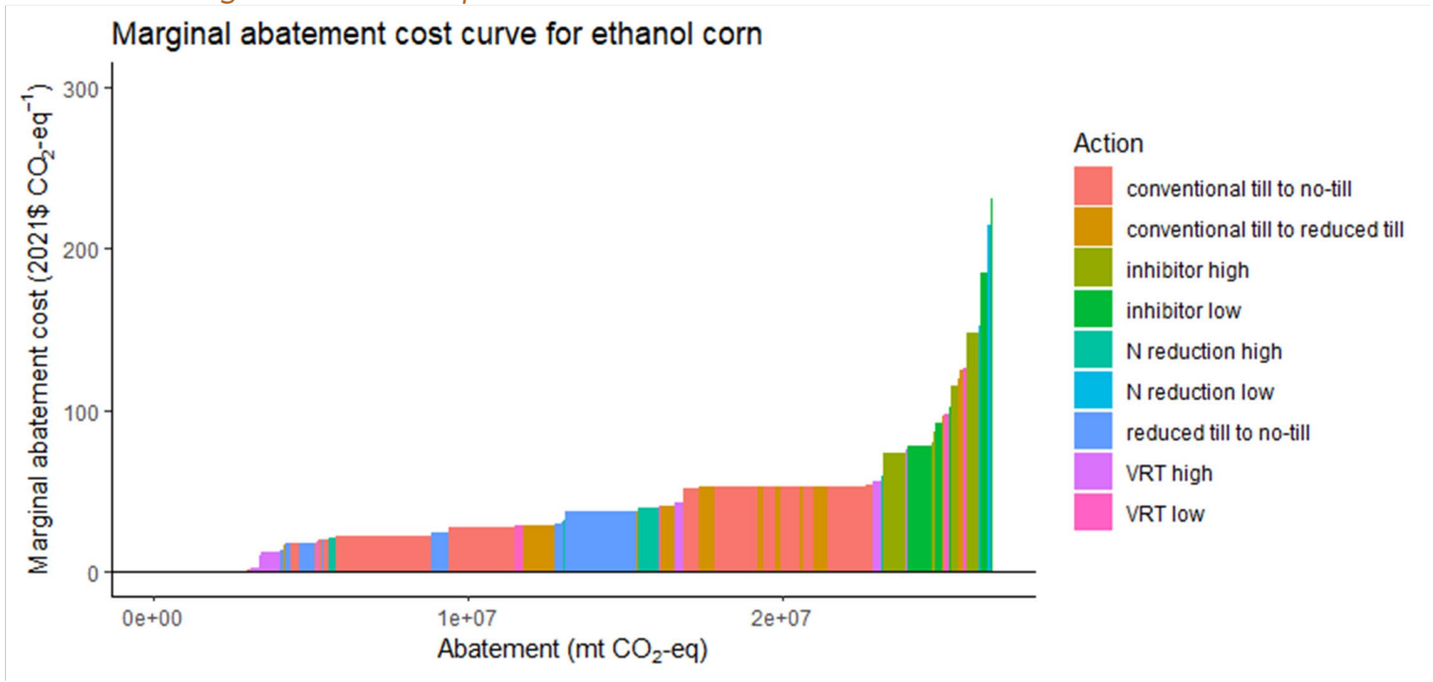
[4] Jeswani et al. 2020 https://dx.doi.org/10.1098/rspa.2020.0351
[5] Locker et al. 2019 https://doi.org/10.1016/j.jclepro.2019.03.154
[6] Yang et al. 2021 DOI: 10.1016/j.scitotenv.2020.141795
[7] Smith et al. 2012 https://dx.doi.org/10.1098/rstb.2011.0313
[8] Li et al. 2021 https://doi.org/10.1021/acs.est.1c02238

Technical gaps and opportunities

Opportunities with renewable fuels incentives and carbon offsetting schemes

- Mitigating lifecycle emissions from **biofuels** through agricultural practices
- Identifying efficacious **carbon drawdown practices**
- Developing **reliable measures** for carbon credits from agriculture including bioenergy crops
- Identifying **potential feedstocks** that can optimize soil carbon storage and biofuel and bioproduct yield
- Quantifying **impacts on biomass processing/conversion**
- Helping **farmers' economic bottom line** for sustained application and implementation through market adoption

Farming practices can mitigate GHG emissions of corn for ethanol -
Tillage management and variable rate application of N are relatively low cost with large abatement potential



Barrows, et al., manuscript in preparation

PNNL-SA-170955

Contact: *sarah.barrows@pnnl.gov, nik.gafoku@pnnl.gov, mariefel.olarte@pnnl.gov*