

NOT ALL SOIL CARBON IS MADE EQUAL:

How Biofuel Crops May
Increase Particulate or Mineral
Associated Organic Matter

M. FRANCESCA COTRUFO

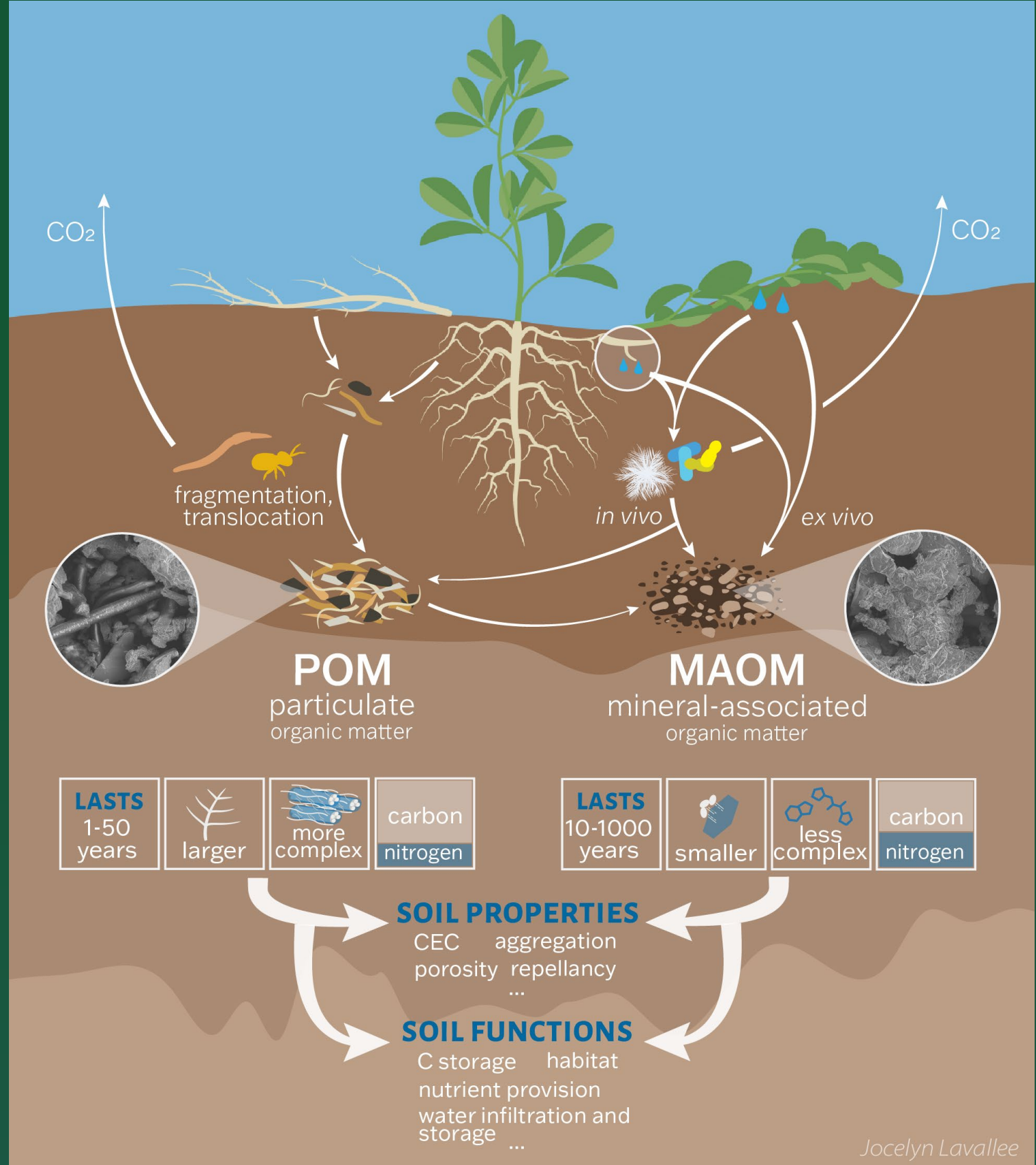


SOIL AND CROP SCIENCES
COLORADO STATE UNIVERSITY

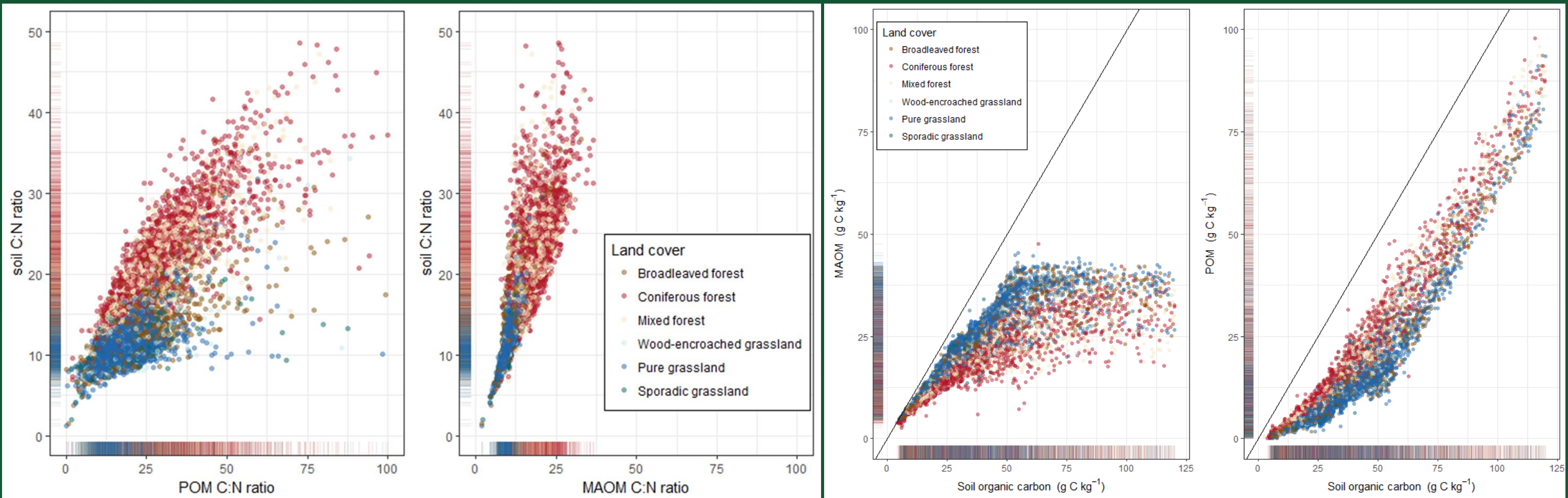
Not all soil carbon is made equal

Separating carbon in POM from MAOM is important to assess:

- ✓ Vulnerability to disturbance
- ✓ Potentials for C sequestration
- ✓ Management strategies to accrue more and persistent carbon while increasing soil health and natural fertility



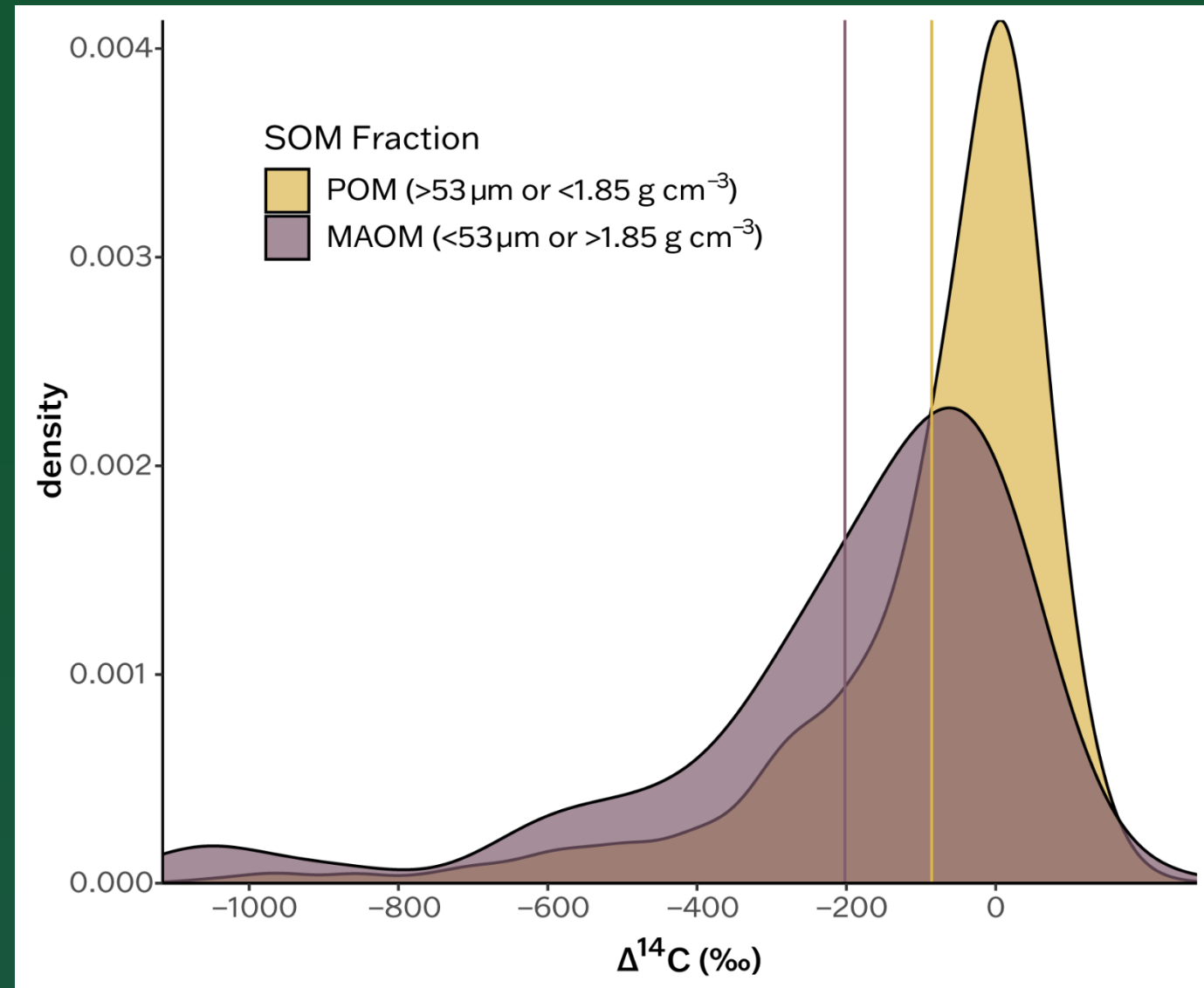
Why it is important to separate POM from MAOM?



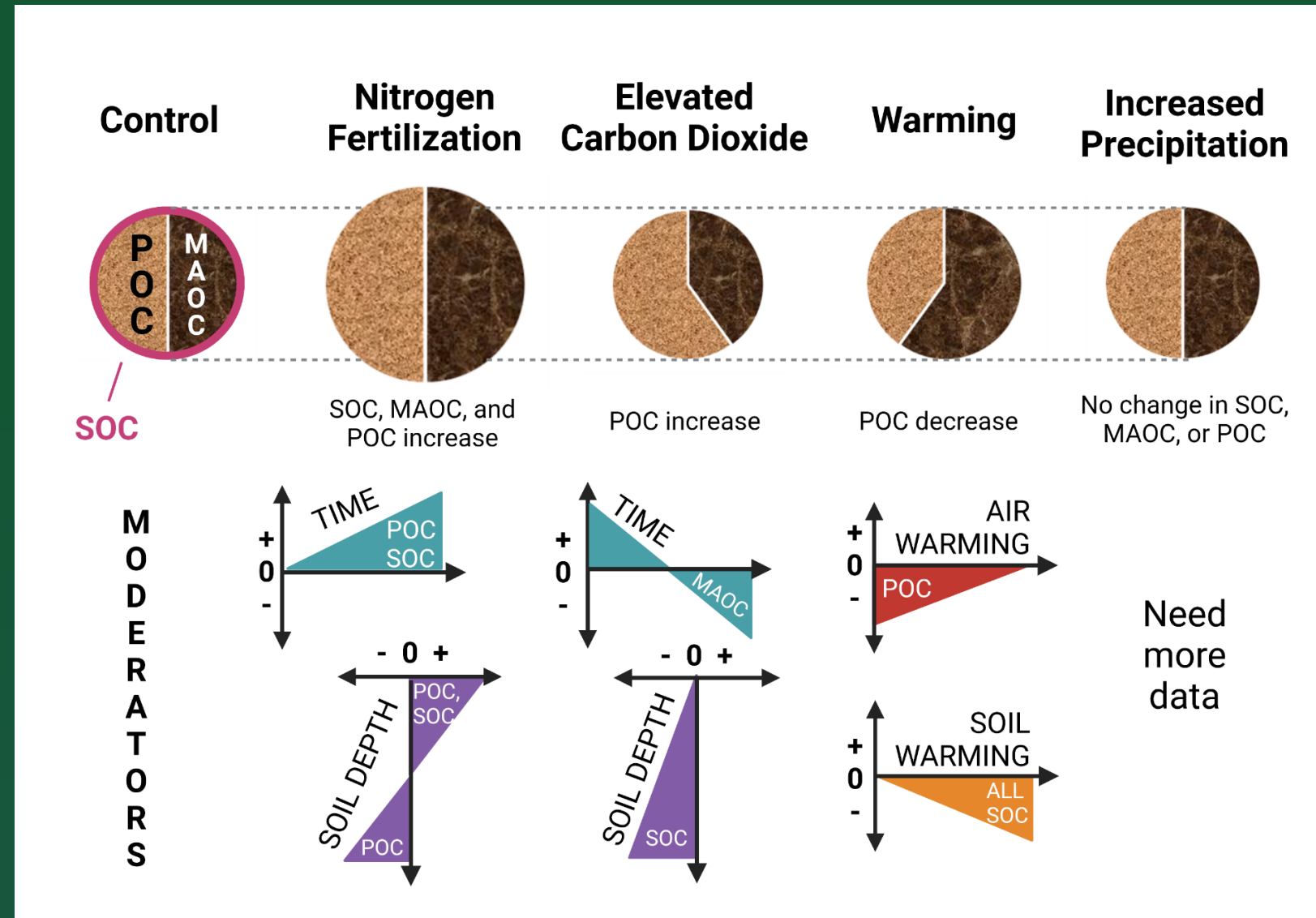
Cotrufo et al., Nature Geosciences, 2019

POM and MAOM have different **N demands** and **saturation levels**

Why it is important to separate POM from MAOM?



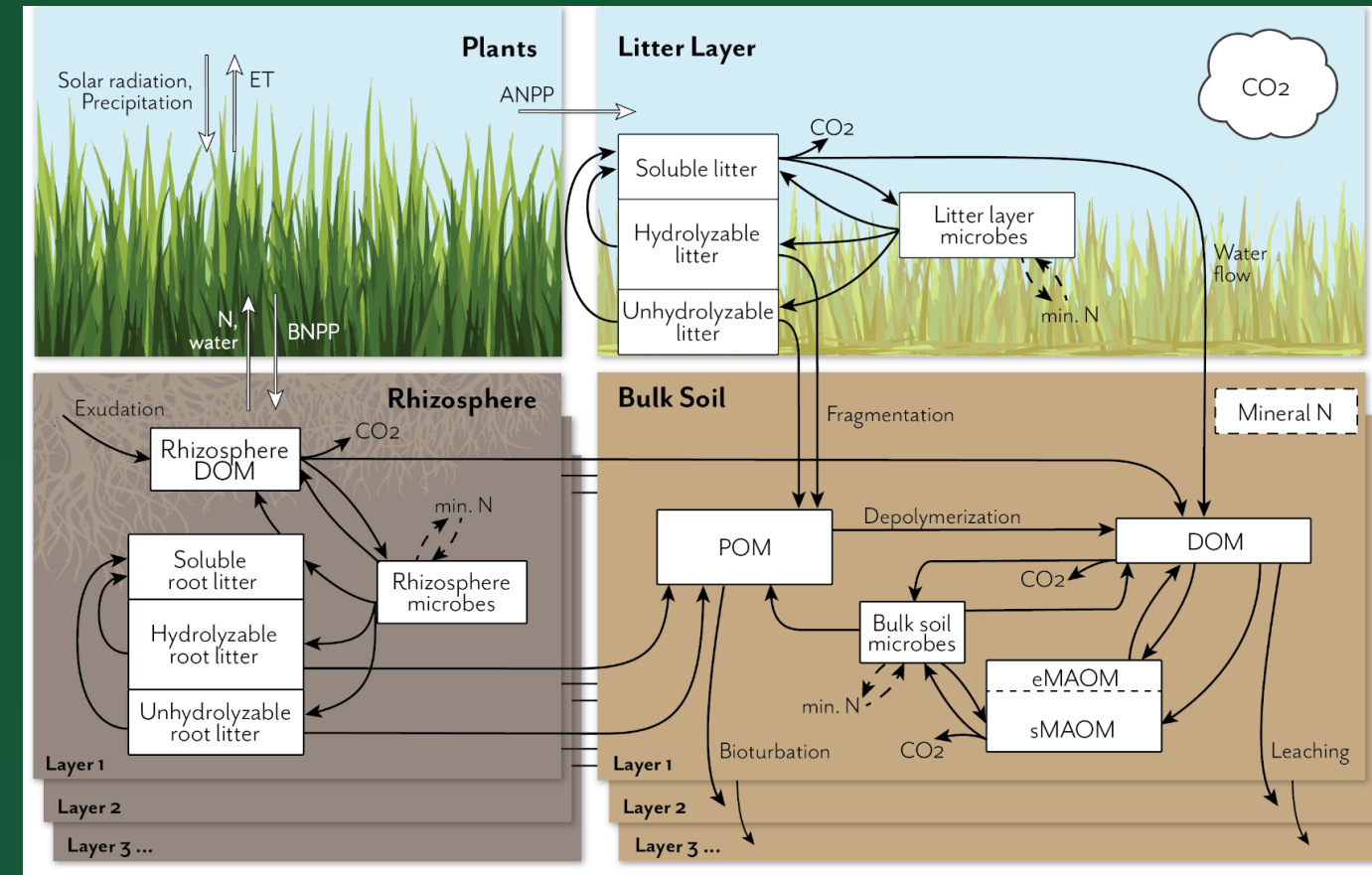
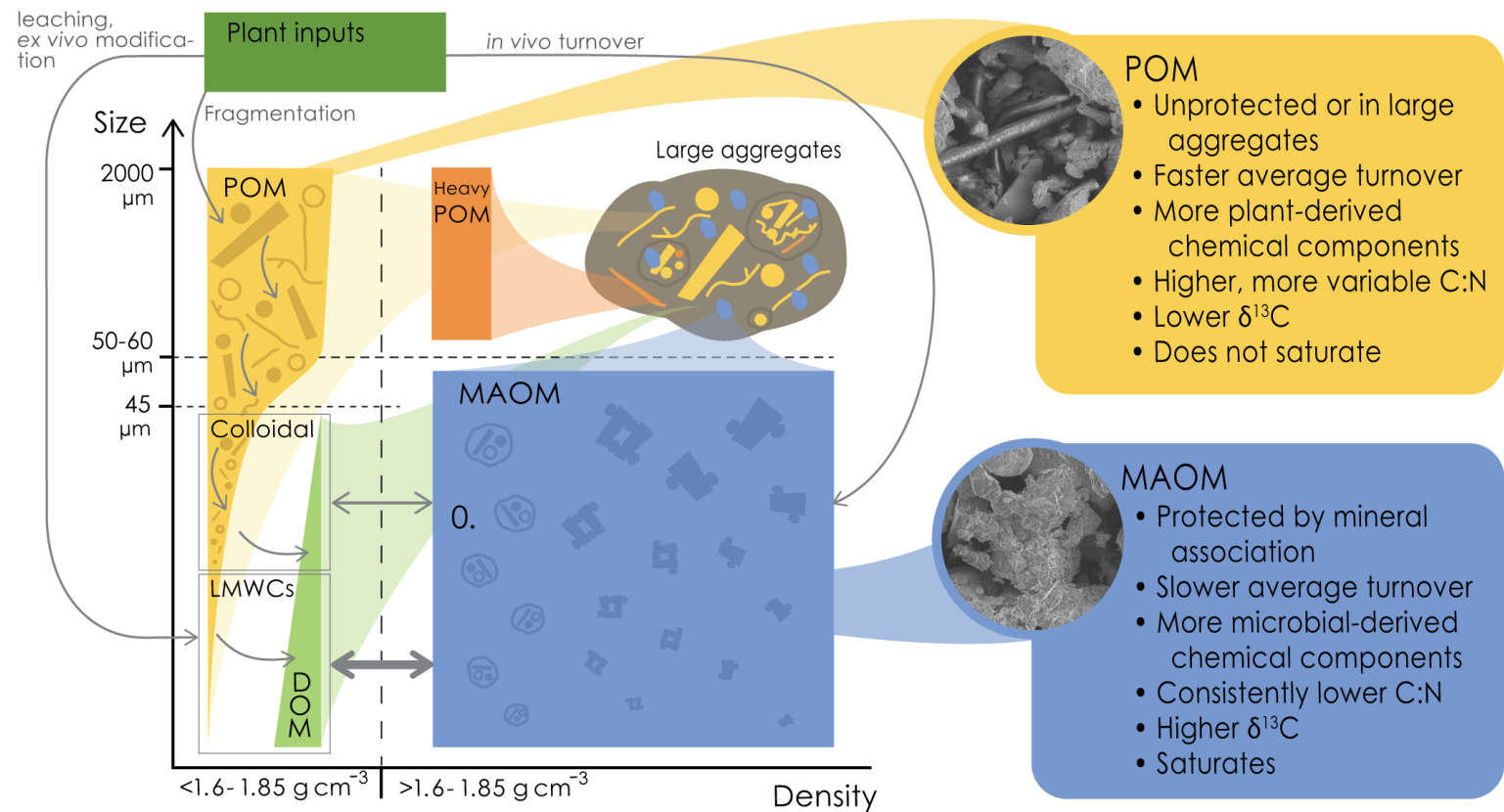
Cotrufo and Lavelle, 2022



Rocci et al., 2021

POM and MAOM have different **persistence** and **vulnerability to change**

POM and MAOM can be measured and modeled



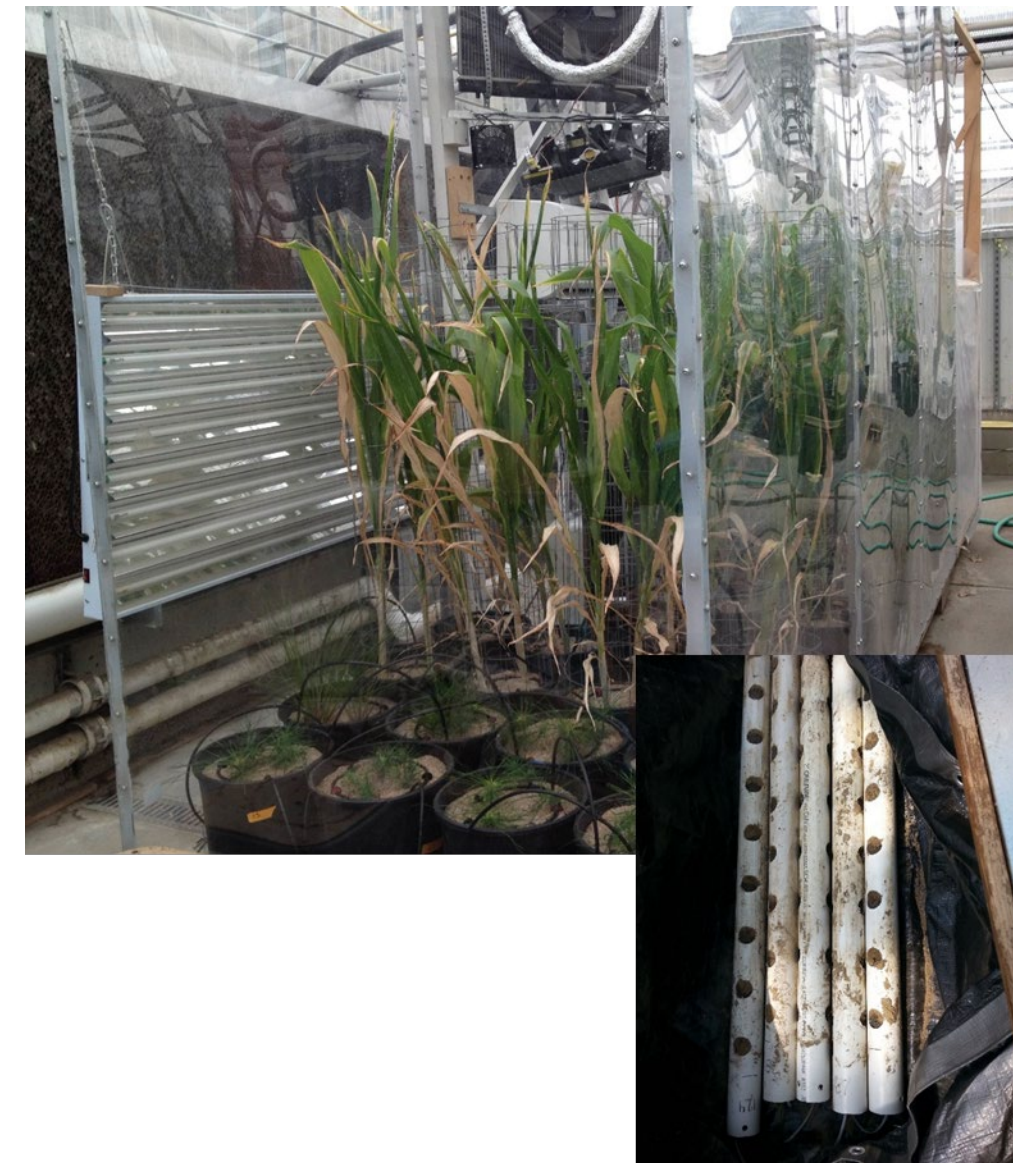
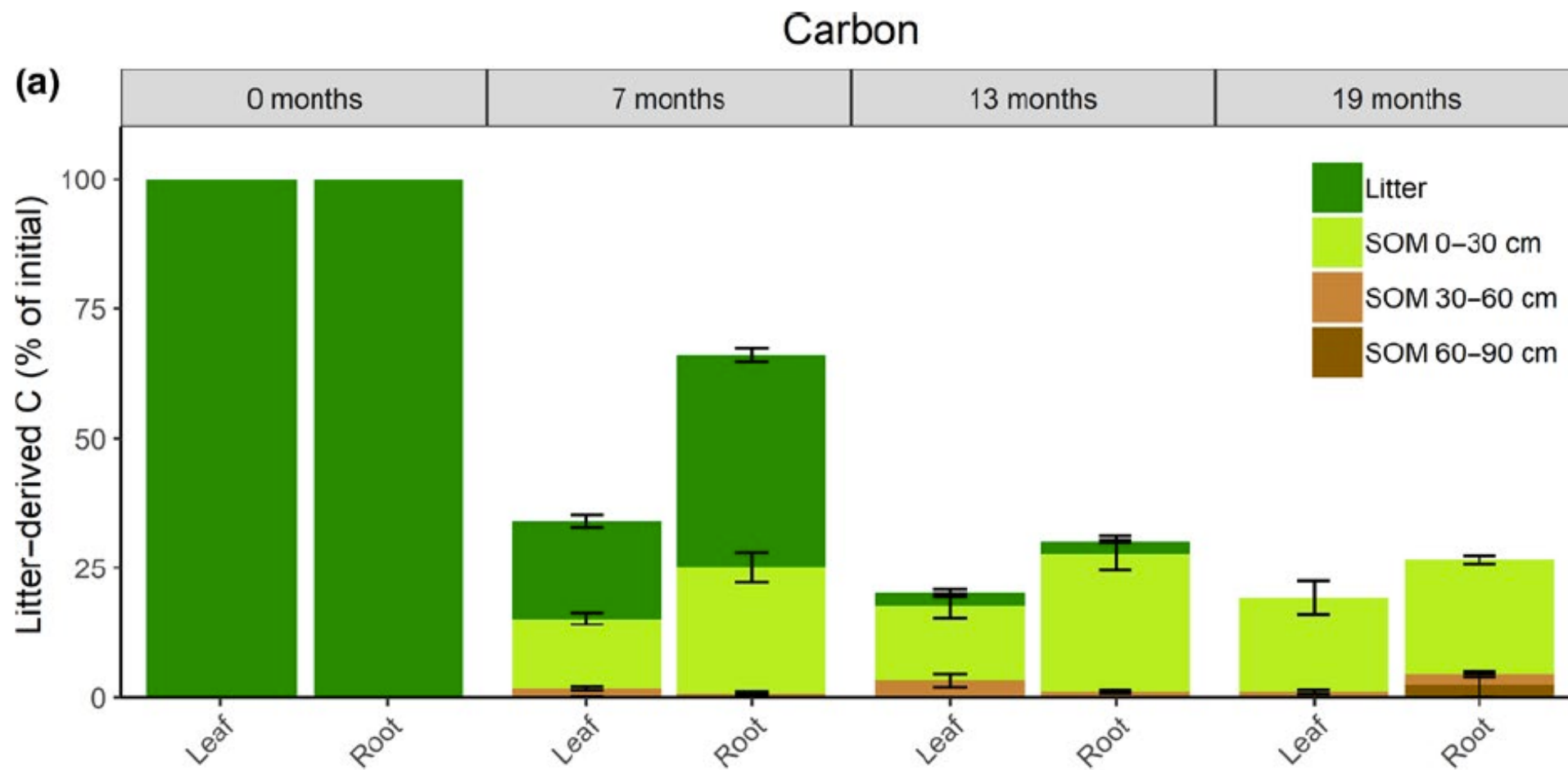
Lavallee, Soong & Cotrufo, *Global Change Biology*, 2020

Zhang et al., *Biogeoscience*, 2021

Integrated measuring-modeling approaches enables accurate MRV for C markets

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More SOM formation from roots than shoots inputs in a *Sorghum bicolor* bioenergy crop



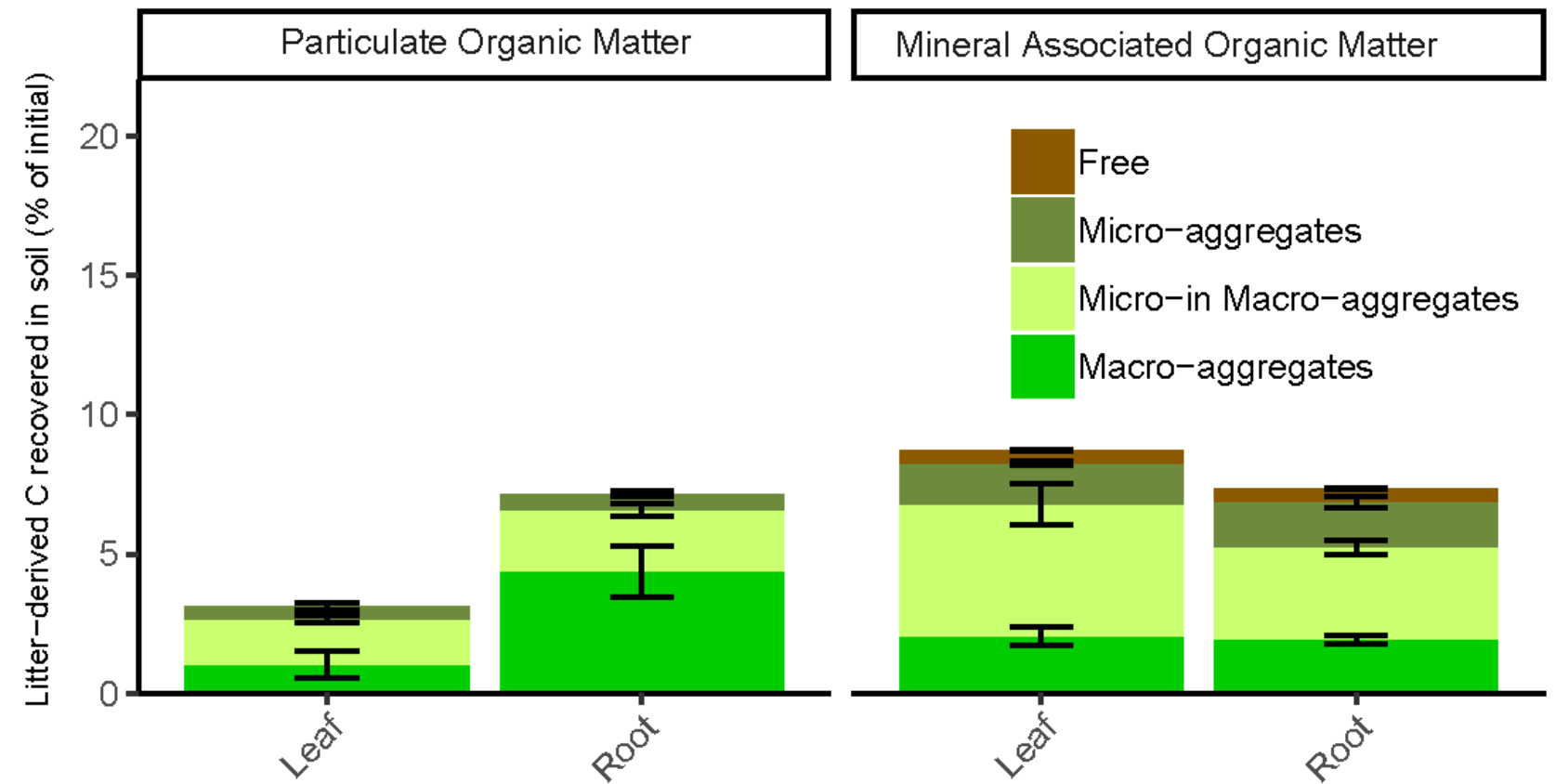
Fulton-Smith & Cotrufo, GCBB, 2019



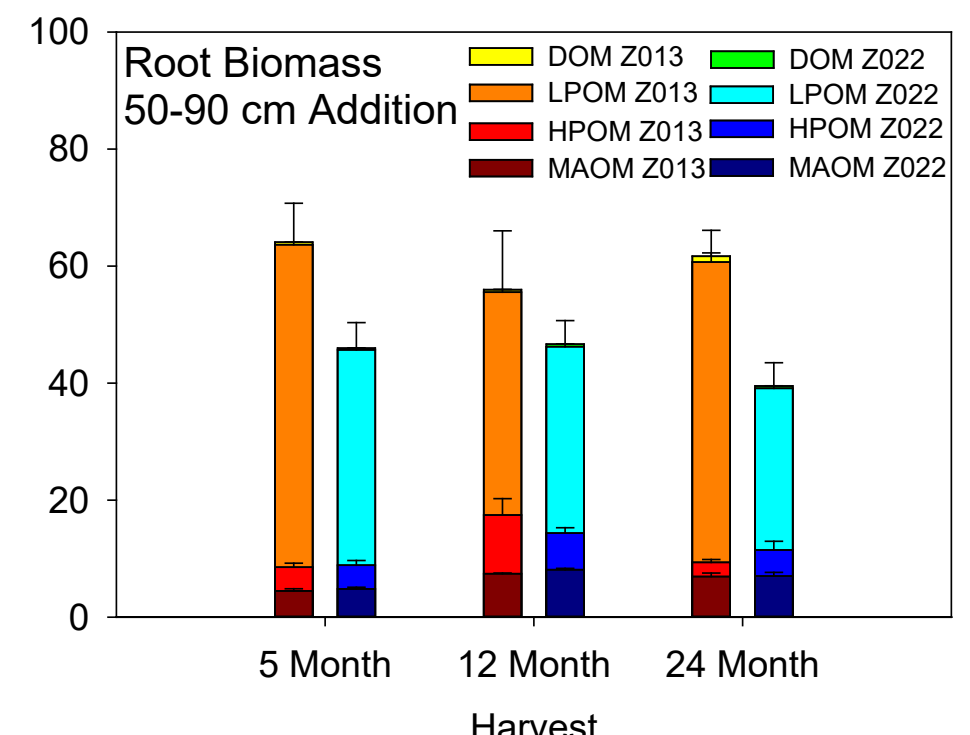
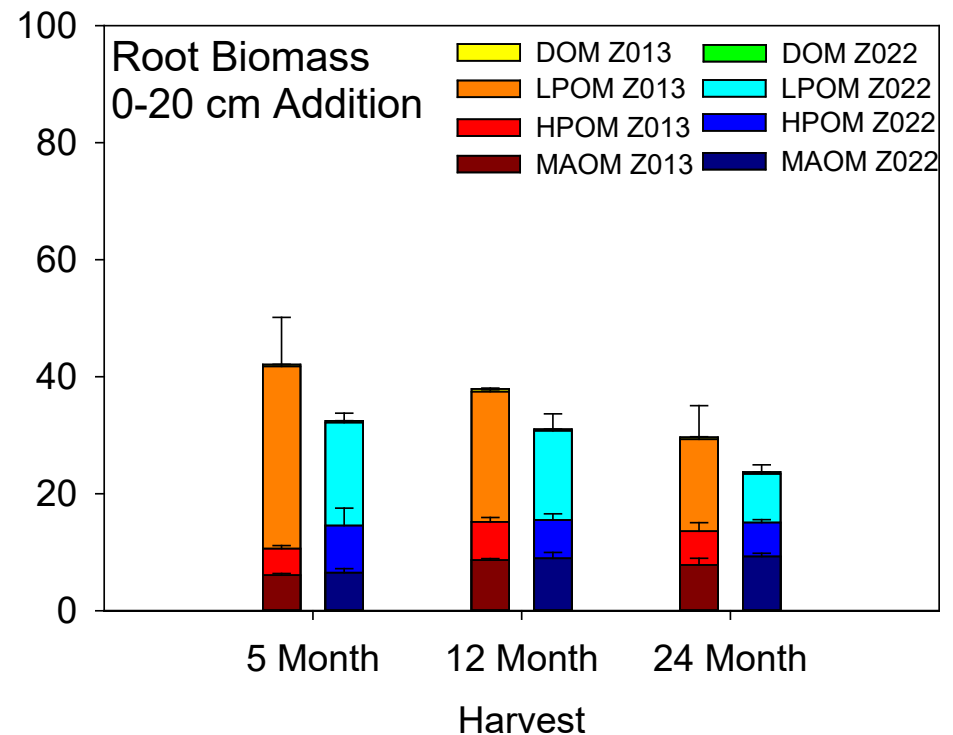
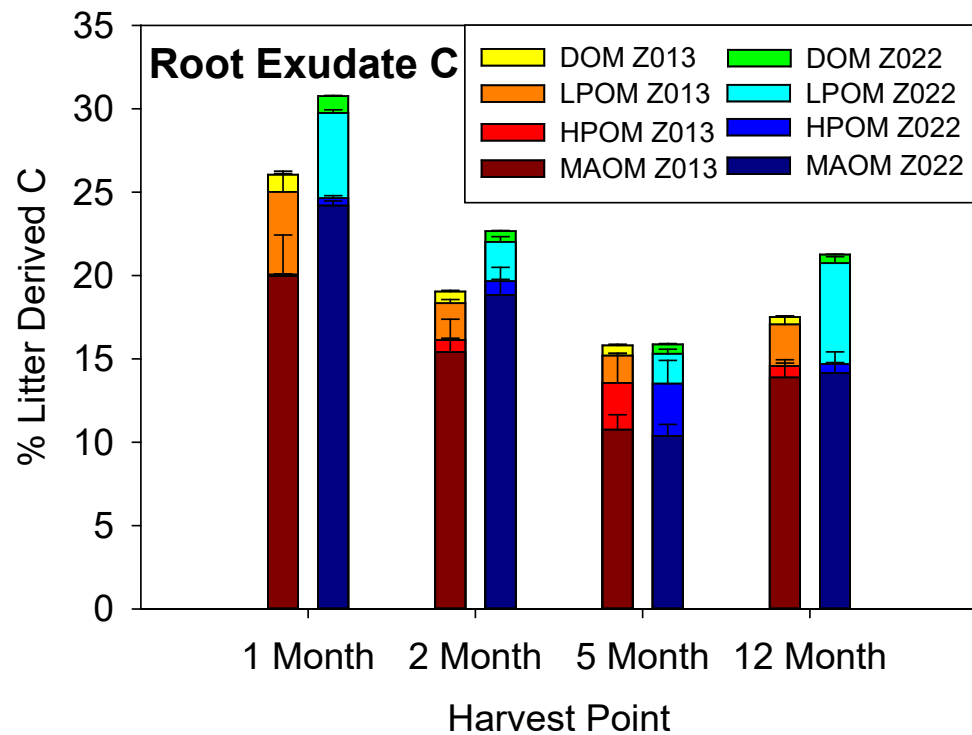
However, roots structural inputs result in more POM while the more labile shoots result in more MAOM

	C	N	C:N	hemi-cell.	α -cell.	AUR	LCI	HWE
	(%)	(%)		(%)	(%)	(%)		(%)
Roots	46.66** (0.10)	1.04*** (0.60)	45.02*** (0.56)	22.48 (0.34)	35.57 (0.23)	8.27*** (0.07)	0.188*** (0.002)	14.49*** (0.01)
Leaves	48.81** (0.23)	1.45*** (0.02)	33.68*** (0.42)	21.20 (1.43)	37.45 (1.26)	3.80*** (0.22)	0.092*** (0.005)	27.50*** (0.01)

Fulton-Smith & Cotrufo, GCBB, 2019



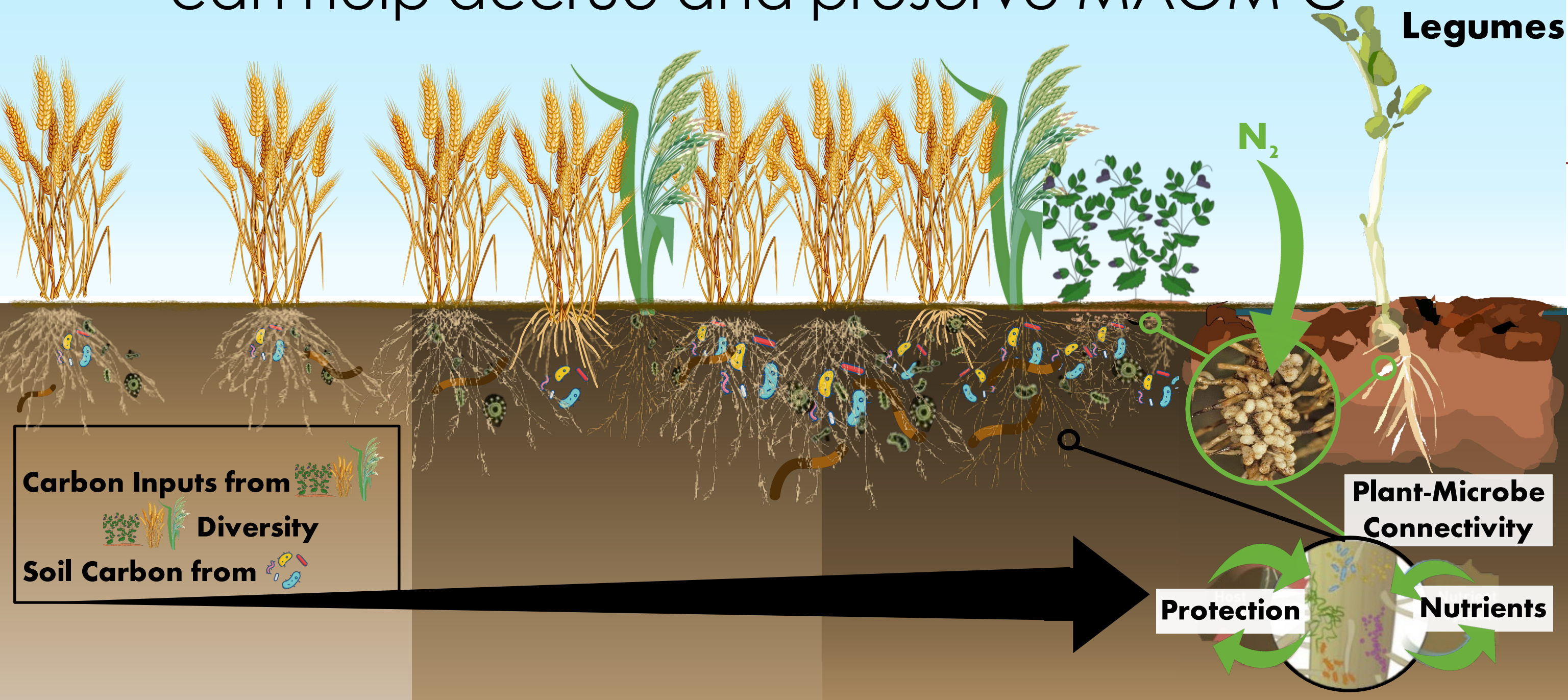
Should we breed for more and deeper root structures or manage for more exudates?



Z022 maize line had lower C:N and lignin than the Z013 maize line

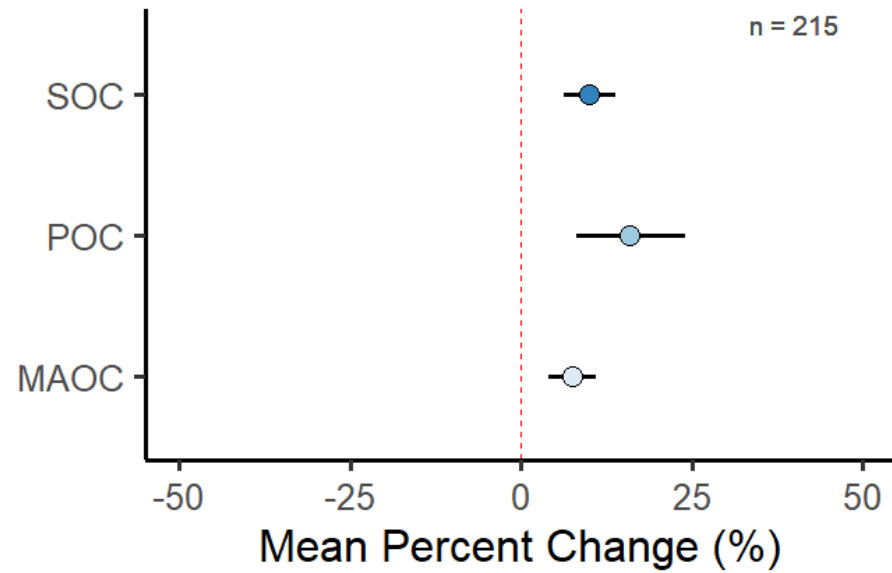
DOE ARPA_E ROOT project; Haddix et al., in prep

Stable C sequestration requires more N:
Introducing legume cover crop in bioenergy rotation
can help accrue and preserve MAOM C

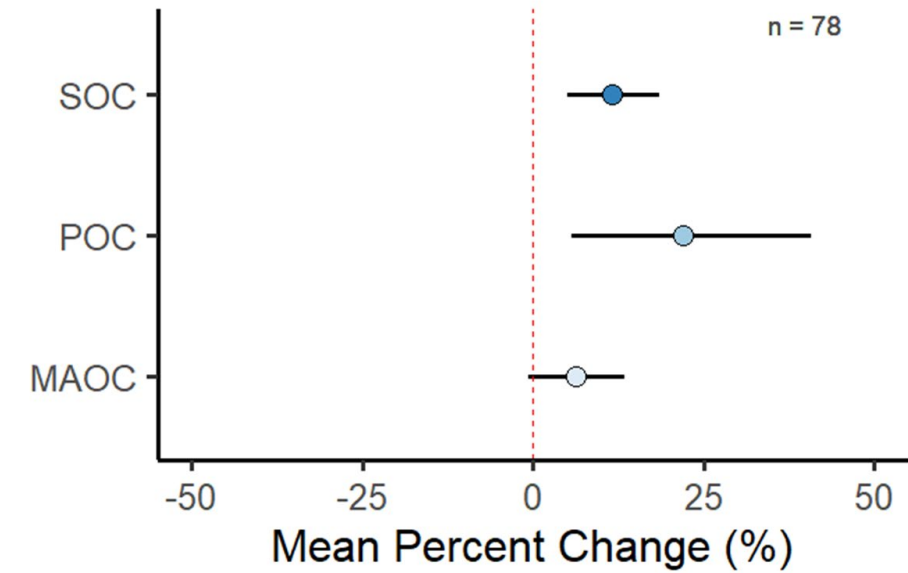


POC is most responsive to regenerative practices

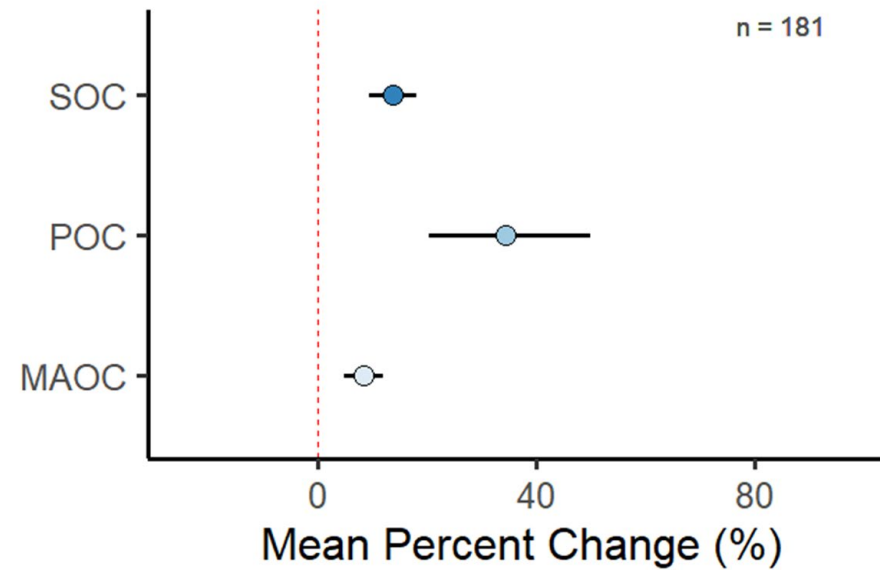
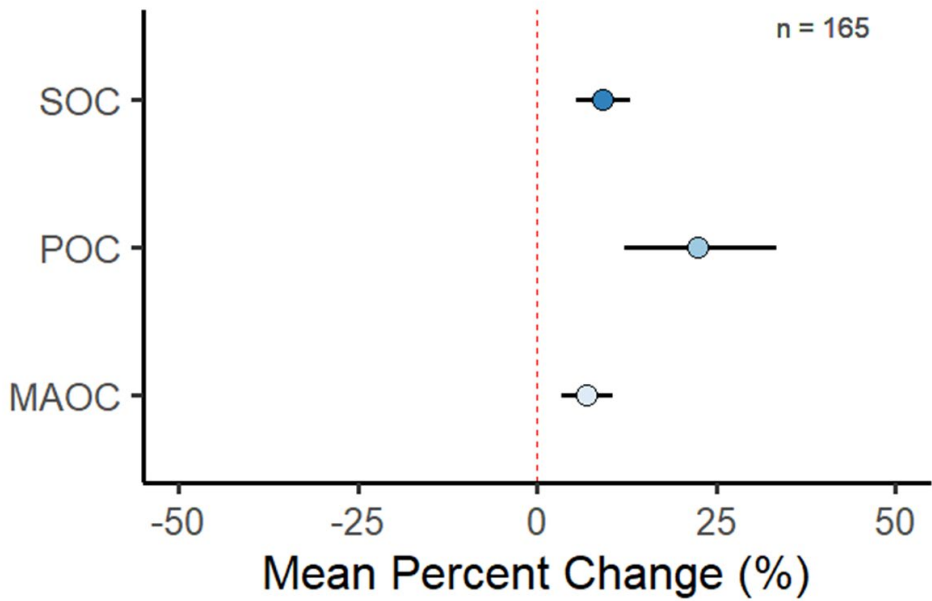
Eliminating tillage increases SOC, both in POC and MAOC



Integrating livestock into cropping systems increases MAOC & POC



Planting a cover crop increases SOC, both in POC, and MAOC



Including a perennial crop in rotation greatly increases POC



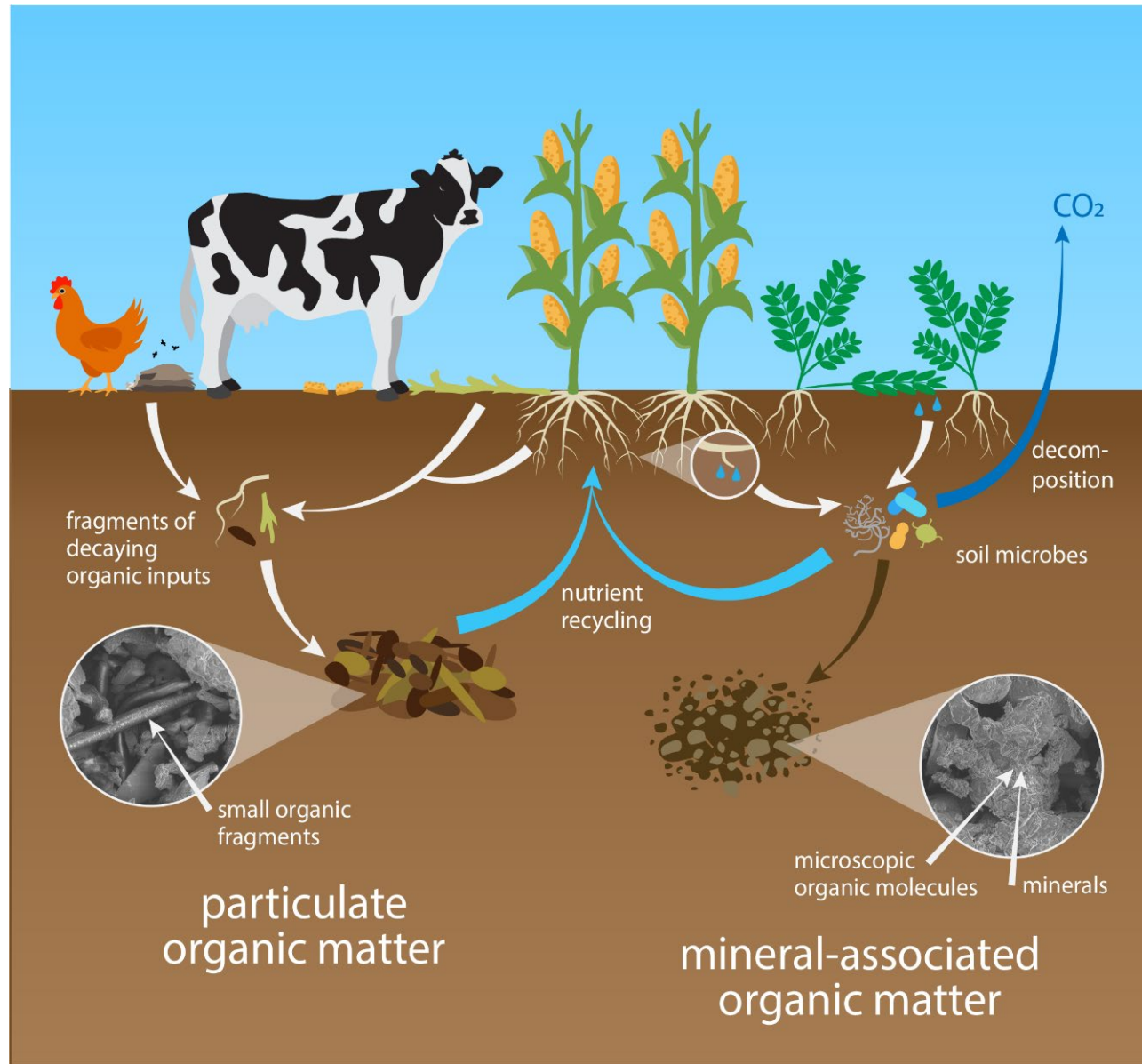
Prairie et al., in prep



In conclusion:

1. Increasing structural inputs below ground – deeper and larger roots – is expected to increase POM
2. Increasing soluble, and low C/N inputs is expected to increase MAOM
3. Reduced disturbance, by no till and maintaining perennial cover is expected to increase both POM and MAOM.
4. POM will be most responsive to all treatments, being more directly linked to plant inputs and being most vulnerable to disturbance

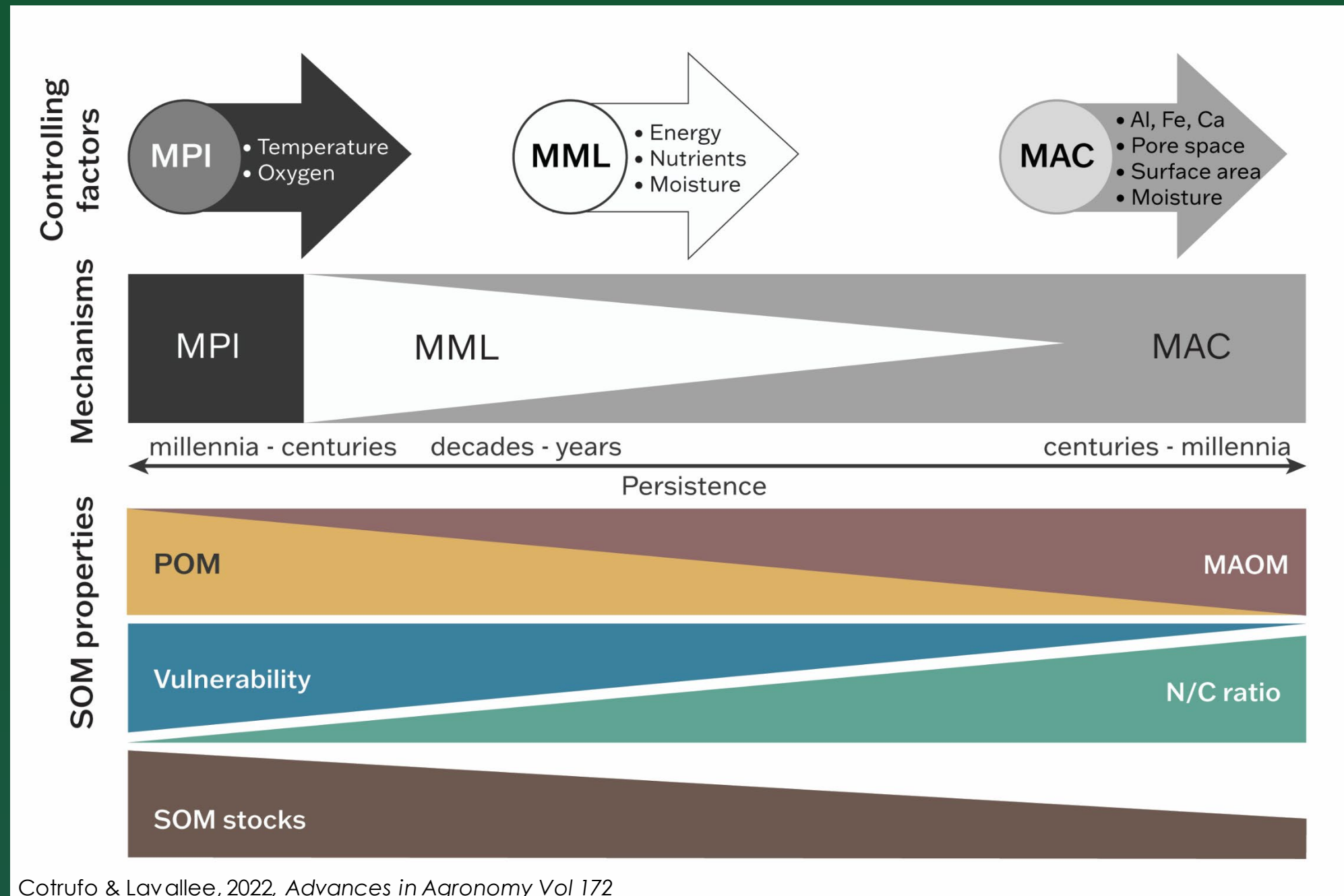
Applying the two-pathways framework of SOM formation and persistence can help guiding management decision for SOC sequestration in bioenergy crop systems



Acknowledgements:



Why it is important to separate POM from MAOM?



MPI = Microbial physiological Inhibition

MML = Microbial Metabolic Limitation

MAC = Microbial Access Constraint

Cotrufo & Lavelle, 2022, *Advances in Agronomy* Vol 172

They have different **mechanism of stabilization, N demand, persistence** and **vulnerability to change**