Building Carbon with Carinata

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Soil carbon (C) and biofuels: liability or opportunity?

Feedstock	Study	Method	SOC[a] change Mg C ha^{-1} y^{-1}	Footprint g CO2e MJ^{-1}
Corn grain	Lark *et al.* 2022	Semi-empirical model	–1.6[b]	+29.7
Corn stover	Liska *et al.* 2014	Semi-empirical model	–0.66	+70
Grasses on pasture land	Field *et al.* 2020	Process-based model	+0.9	–12.7
Grasses on abandoned cropland	Yang & Tilman 2020	Field trial observation	+1.1[c]	–134

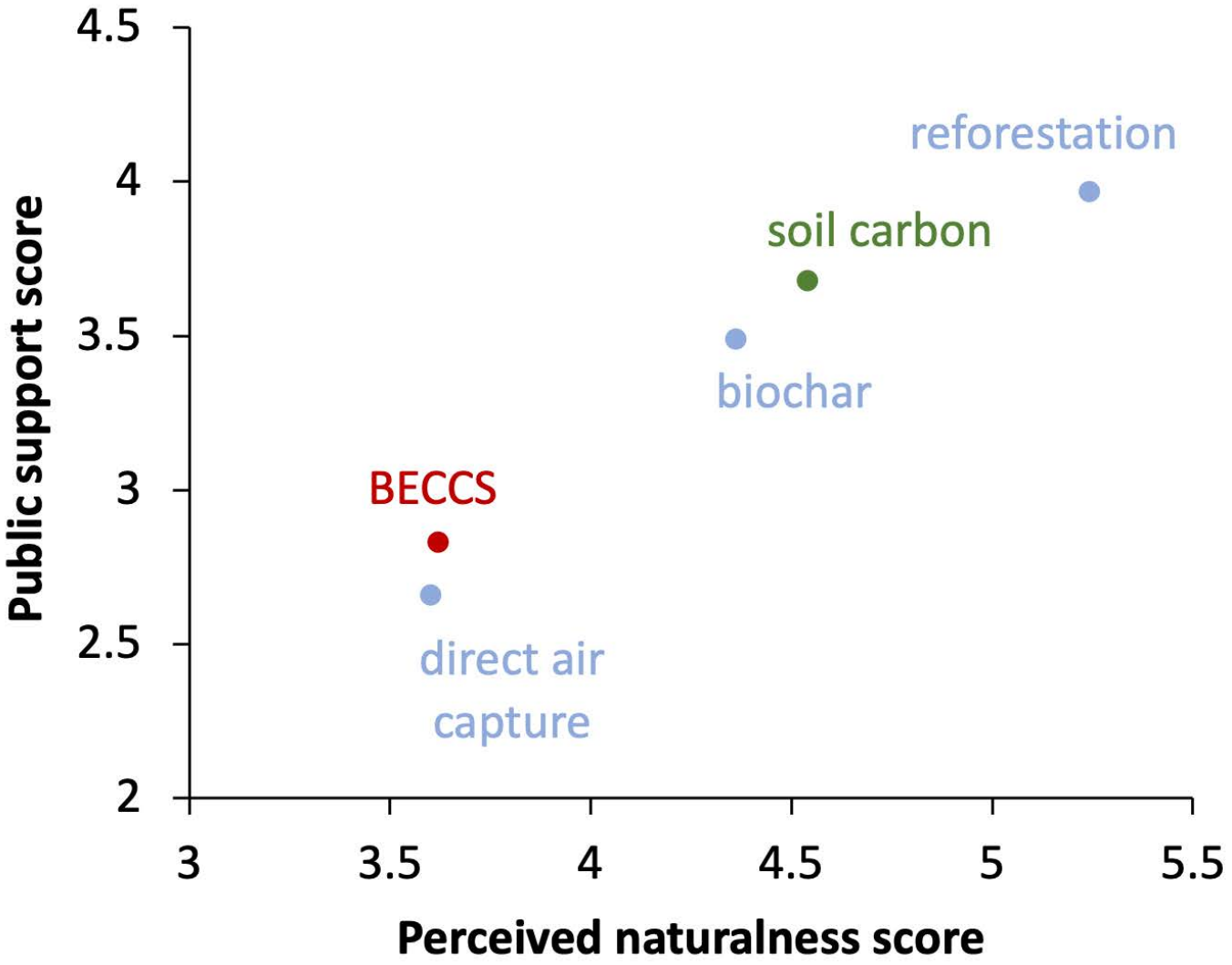
[a] SOC = soil organic carbon

[a] Domestic land use change total (primarily SOC)

[b] SOC plus root biomass C

Soil C punches above its CO_2-equivalent weight

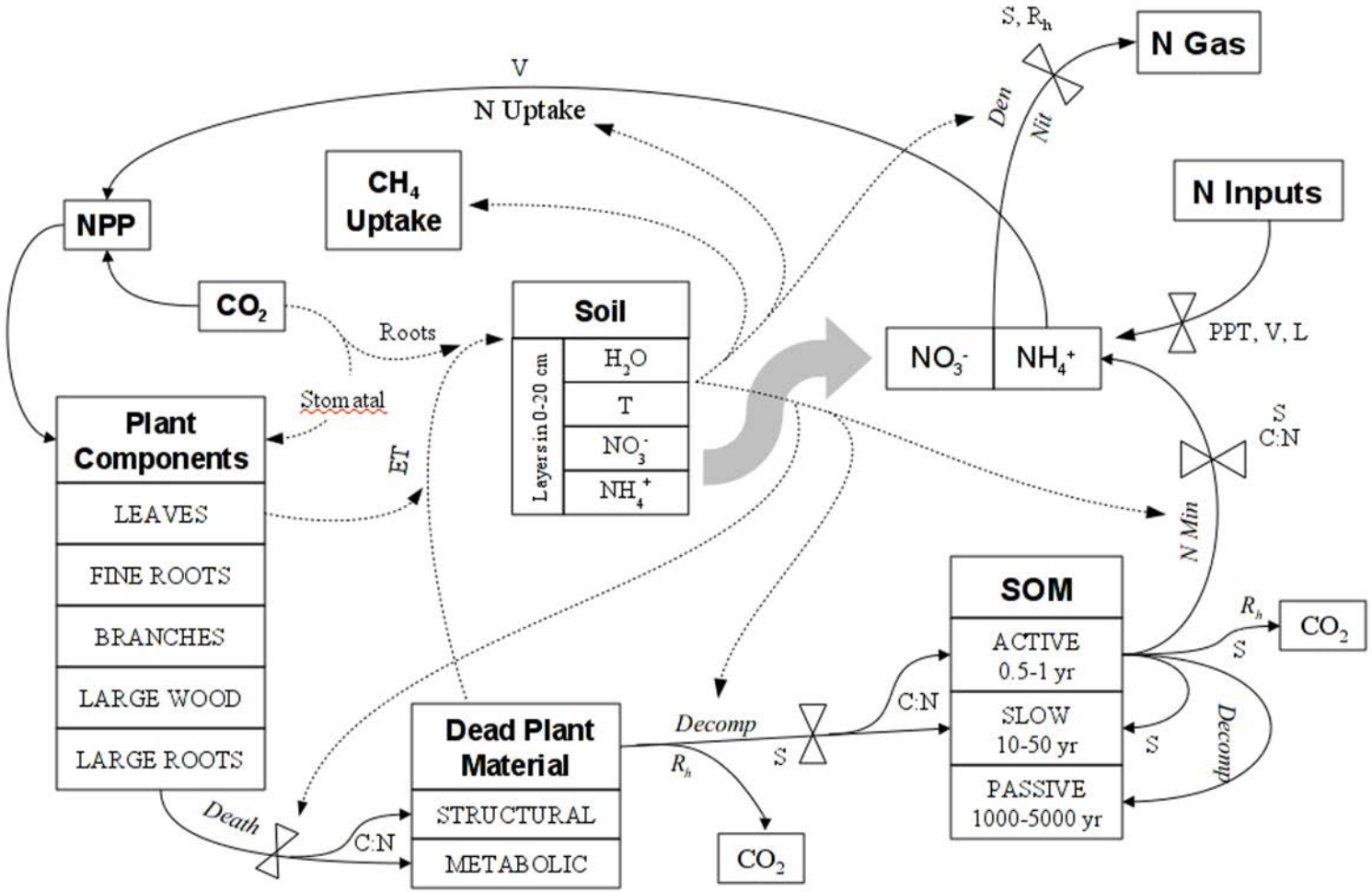
1. Soil health co-benefits
2. Increasing emphasis on C removal
3. Public perception of "naturalness"
4. Potential for optimization?



Sweet *et al.* (2021) *Climatic Change*

Process-based ecosystem models

- DayCent simulates C & N cycling during plant growth, death, decay, soil organic matter stabilization
- INTEGRATED modeling of:
  - Land quality
  - Mgmt. intensity
  - Yields
  - SOC response
  - Nitrous oxide (N_2O) emissions



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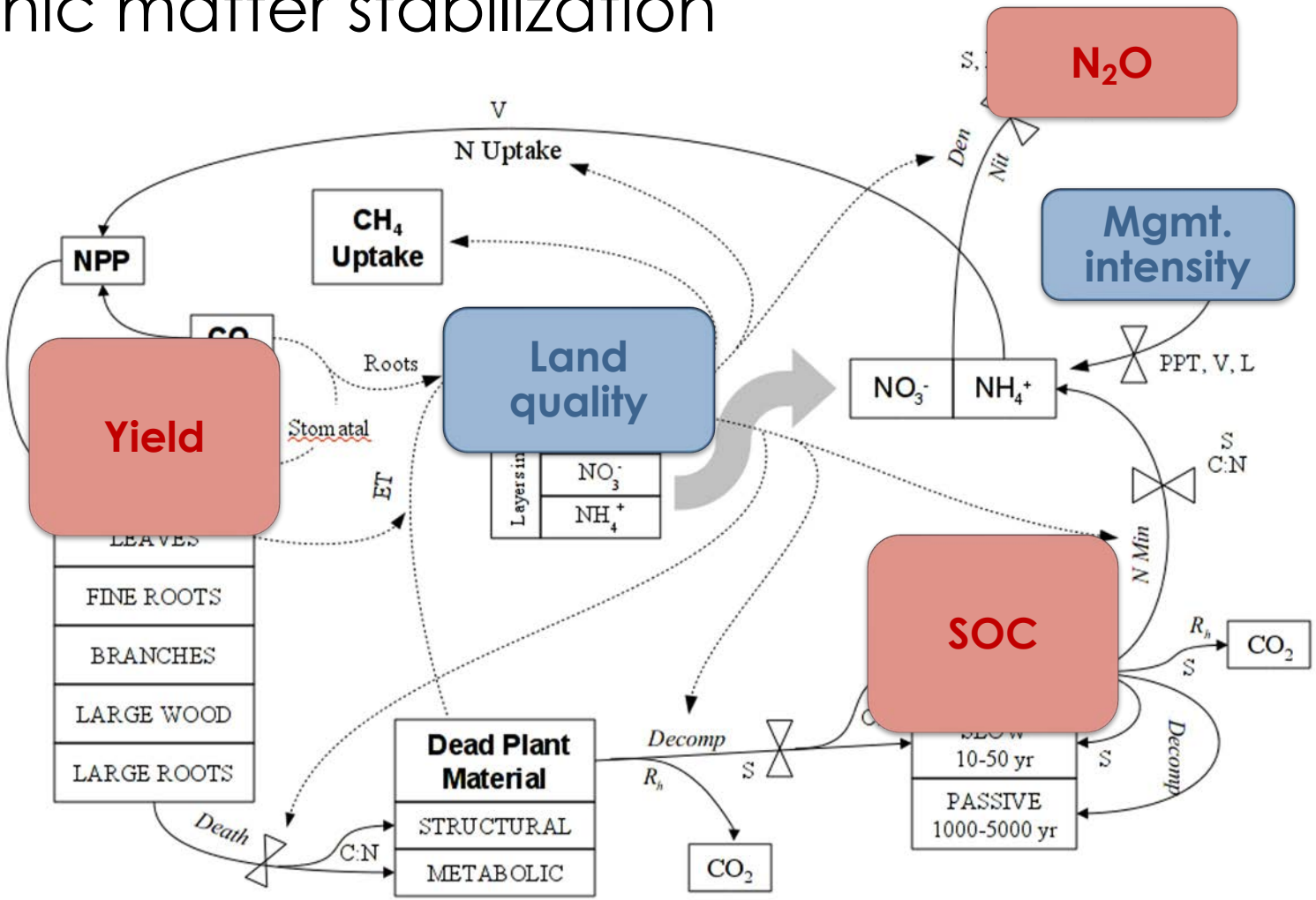


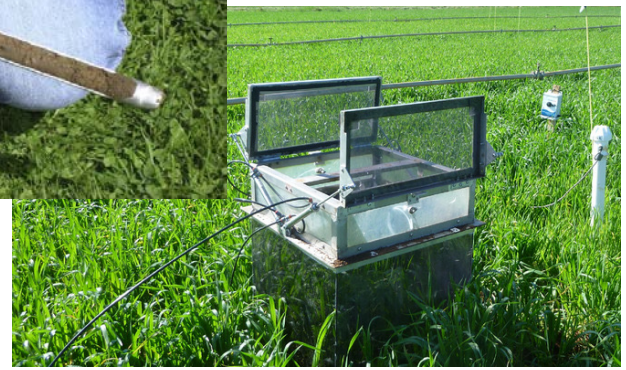
Modeling to establish GHG footprint *expectations*

- Sophistication of model-based assessment moves with data availability

exploratory evaluation → model improvement & validation → refined regional estimates, LCA, etc.

field trials

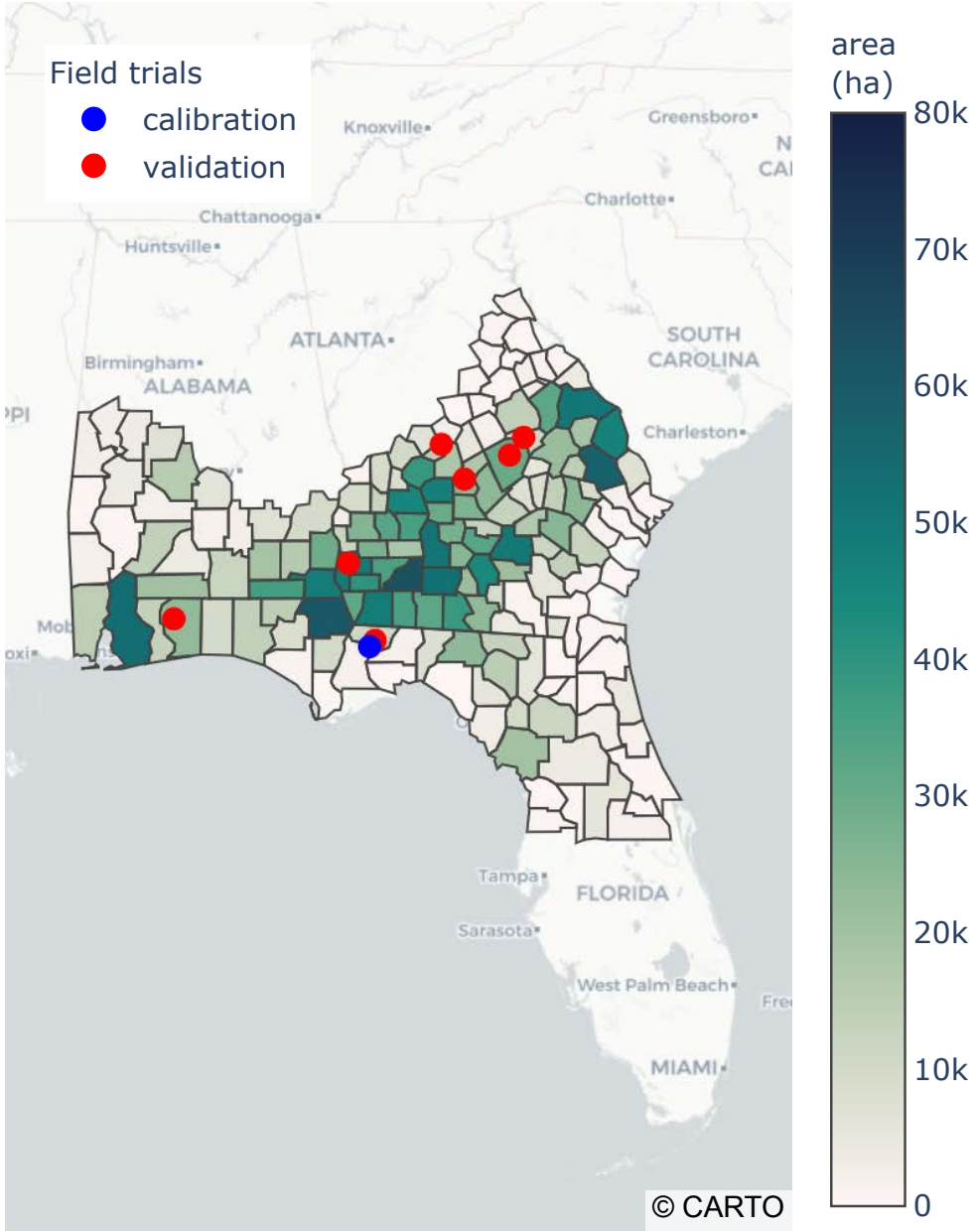
soil GHG measurements

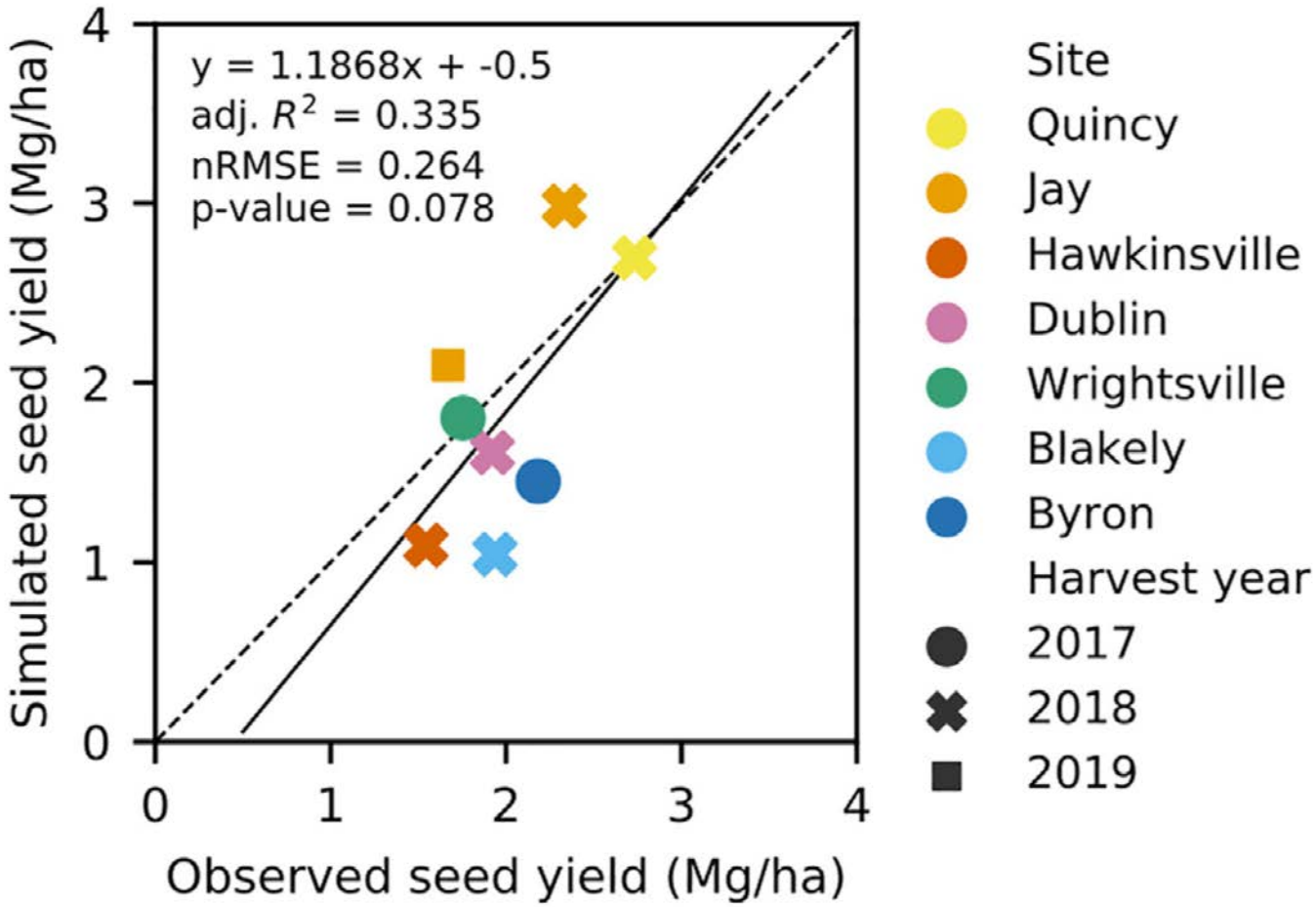


commercial experience

https://sparc-cap.org/sparc-plug-may-2018/
https://www.mustard21.com/research-summaries/carinata-development/

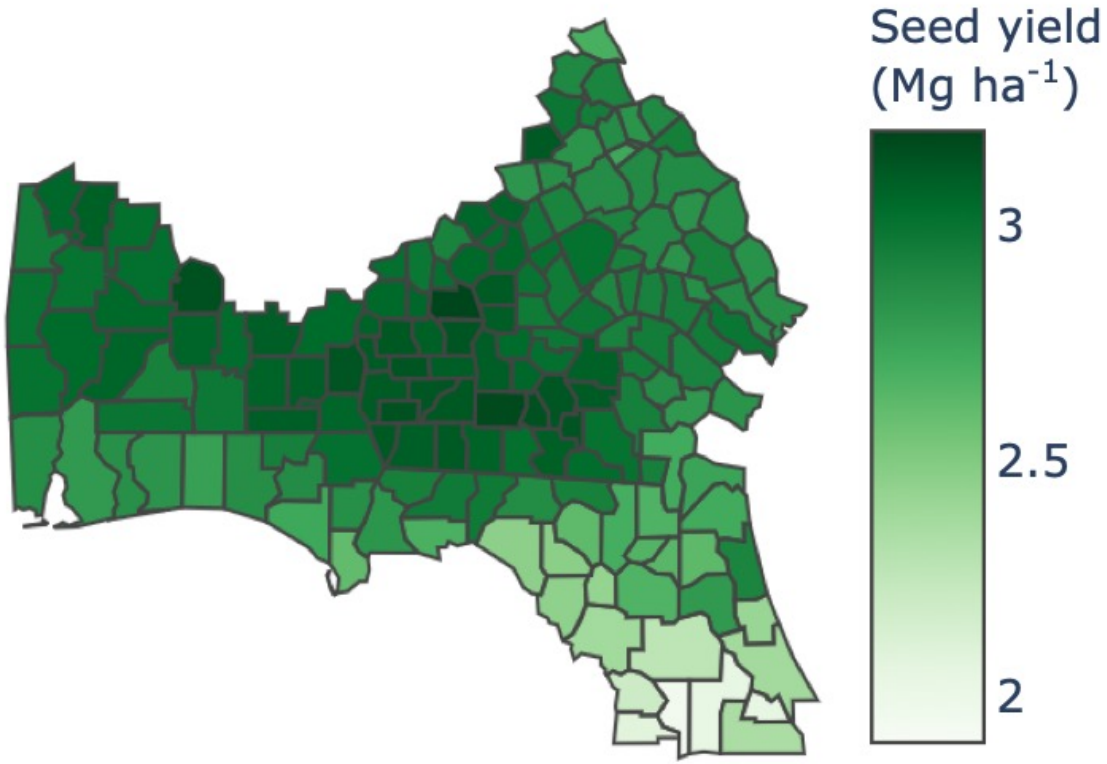
Study area & model calibration/validation

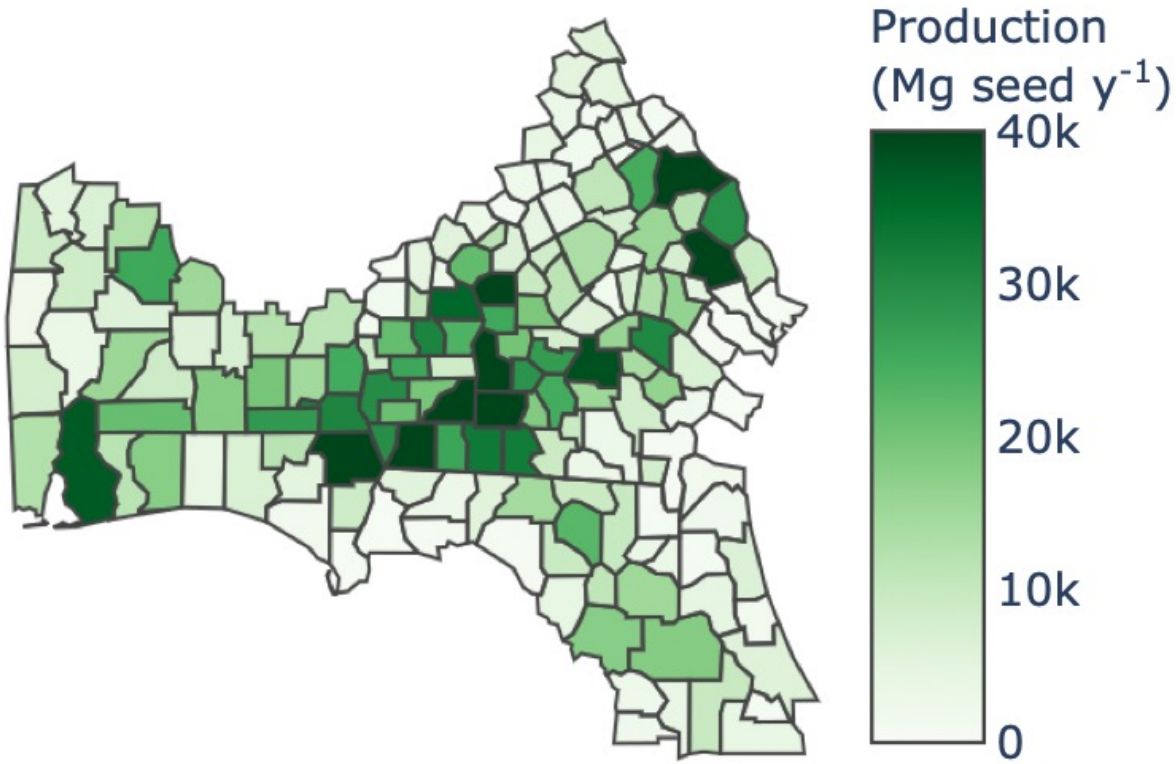




Simulated carinata yield & county-level production

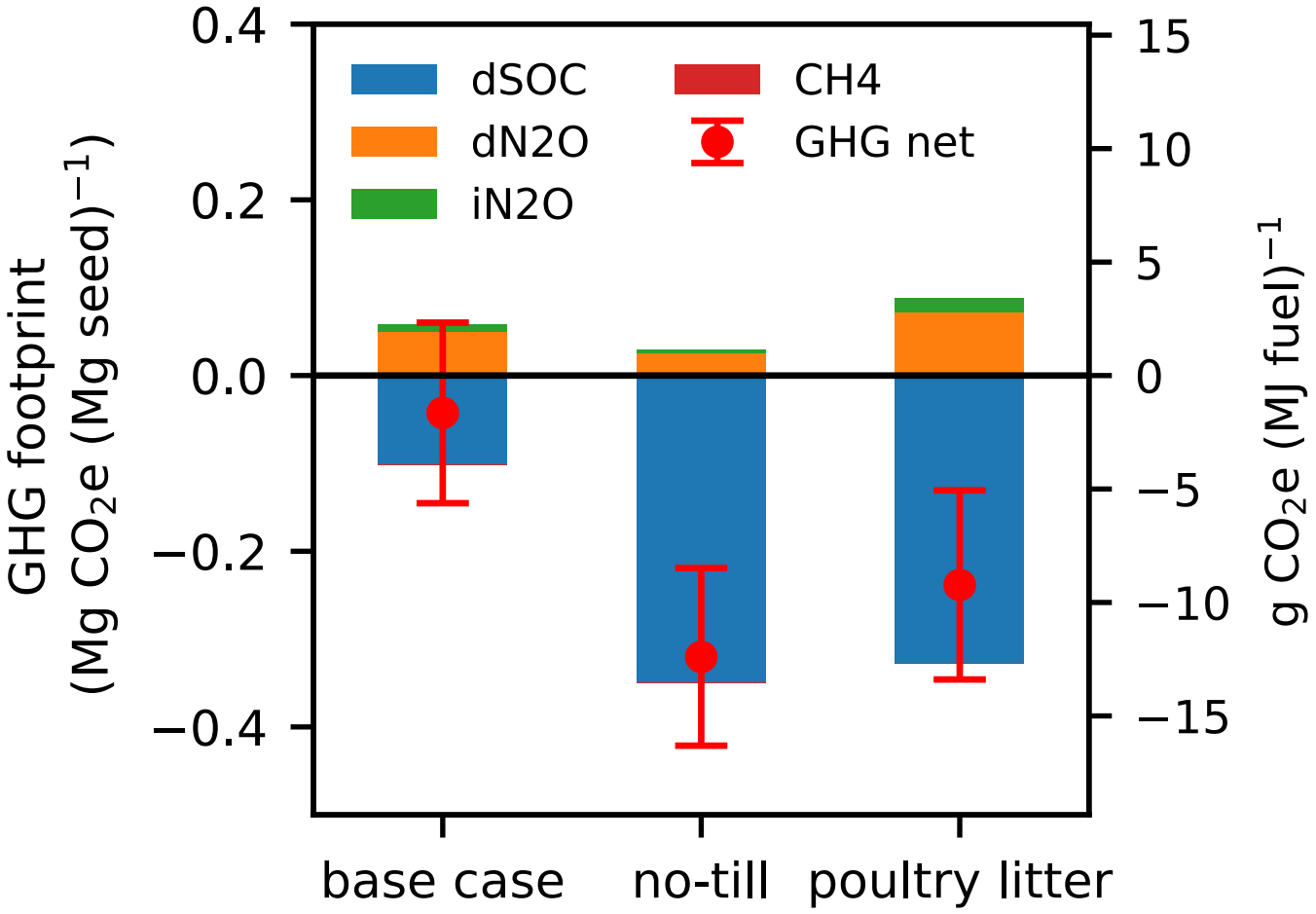
- Avg. yield of 3.0 Mg seed ha^{-1} y^{-1} simulated across study area
- Fairly sensitive to N rate & leaching in central FL





Regional scenario results

- All scenarios yield ~1.0 billion liters SAF annually
- Base case: slight net soil GHG sink
- Climate-smart mgmt. creates a more consistent GHG sink:
  - Only +0.1 Mg C ha^{-1} y^{-1}
  - 10–14% of the GHG footprint of conventional jet fuel



Future work: Soil GHG measurement & validation

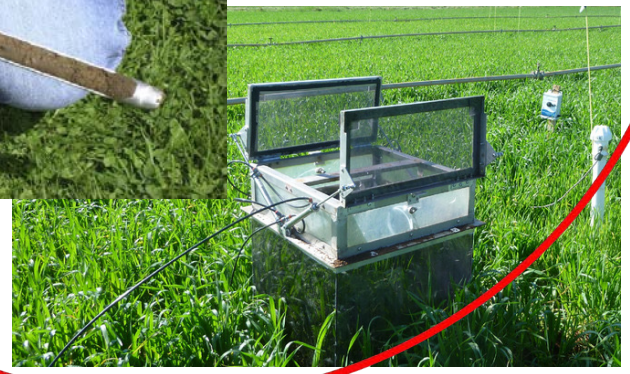
exploratory evaluation

model improvement & validation

refined regional estimates, LCA, etc.

field trials

soil GHG measurements



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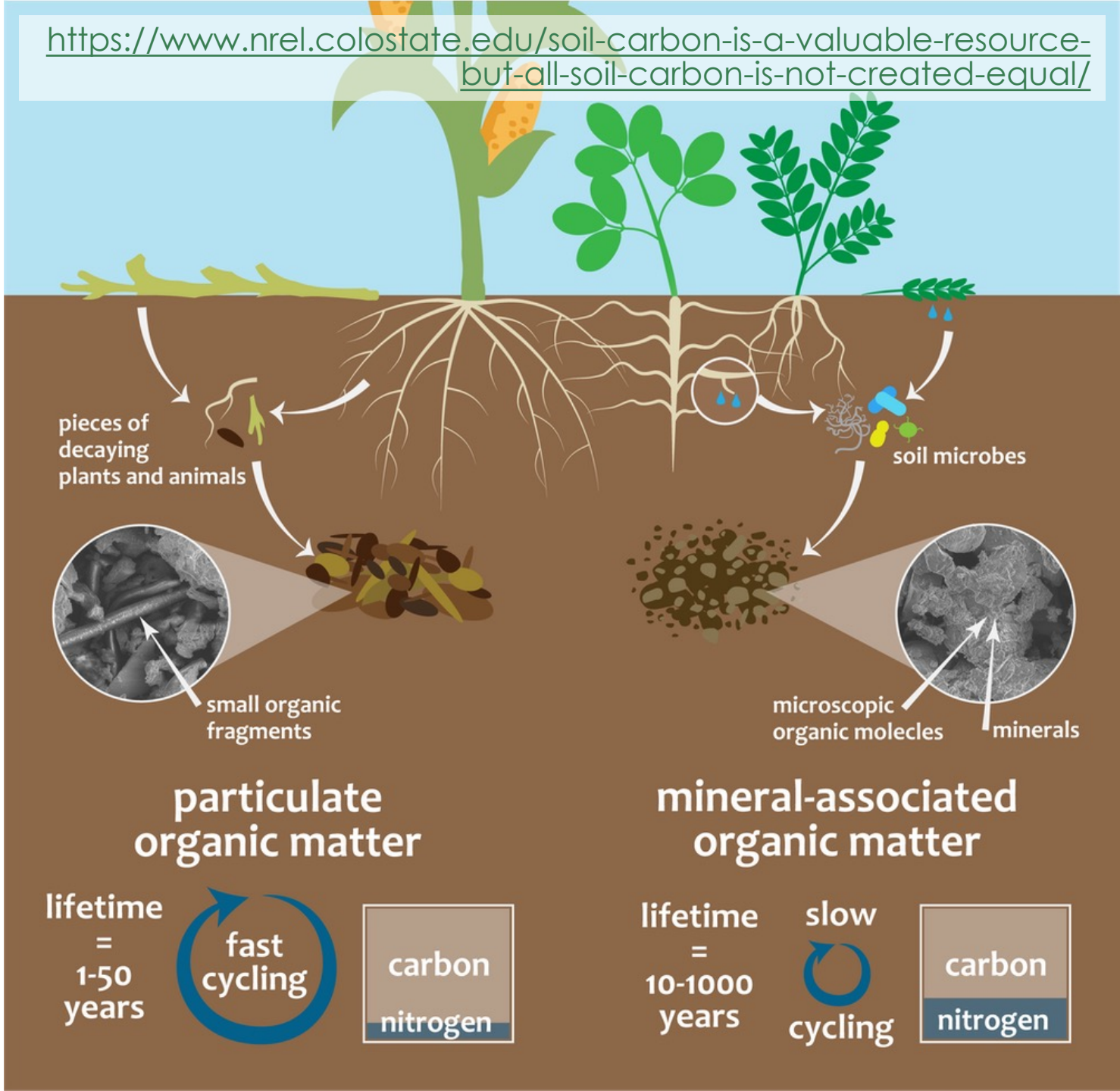
Future work: POM vs. MAOM

- Different sequestration potential, stability
- New models built on these physically-measurable soil C pools
  - Zhang et al. (2021). Simulating measurable ecosystem carbon and nitrogen dynamics with the mechanistically defined MEMS 2.0 model. *Biogeosciences*, *18*(10), 3147–3171.



Reference & acknowledgements

Field, J. L., Zhang, Y., Marx, E., Boote, K. J., Easter, M., George, S., Hoghooghi, N., Johnston, G., Masum, F. H., Mulvaney, M. J., Paustian, K., Seepaul, R., Swan, A., Williams, S., Wright, D., & Dwivedi, P. (2022). Modeling Yield, Biogenic Emissions, and Carbon Sequestration in Southeastern Cropping Systems With Winter Carinata. *Frontiers in Energy Research*, *10*, 837883. https://doi.org/10.3389/fenrg.2022.837883

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