Soil Health and Soil Carbon Sequestration in Arid and Semi-Arid Regions

Presented by
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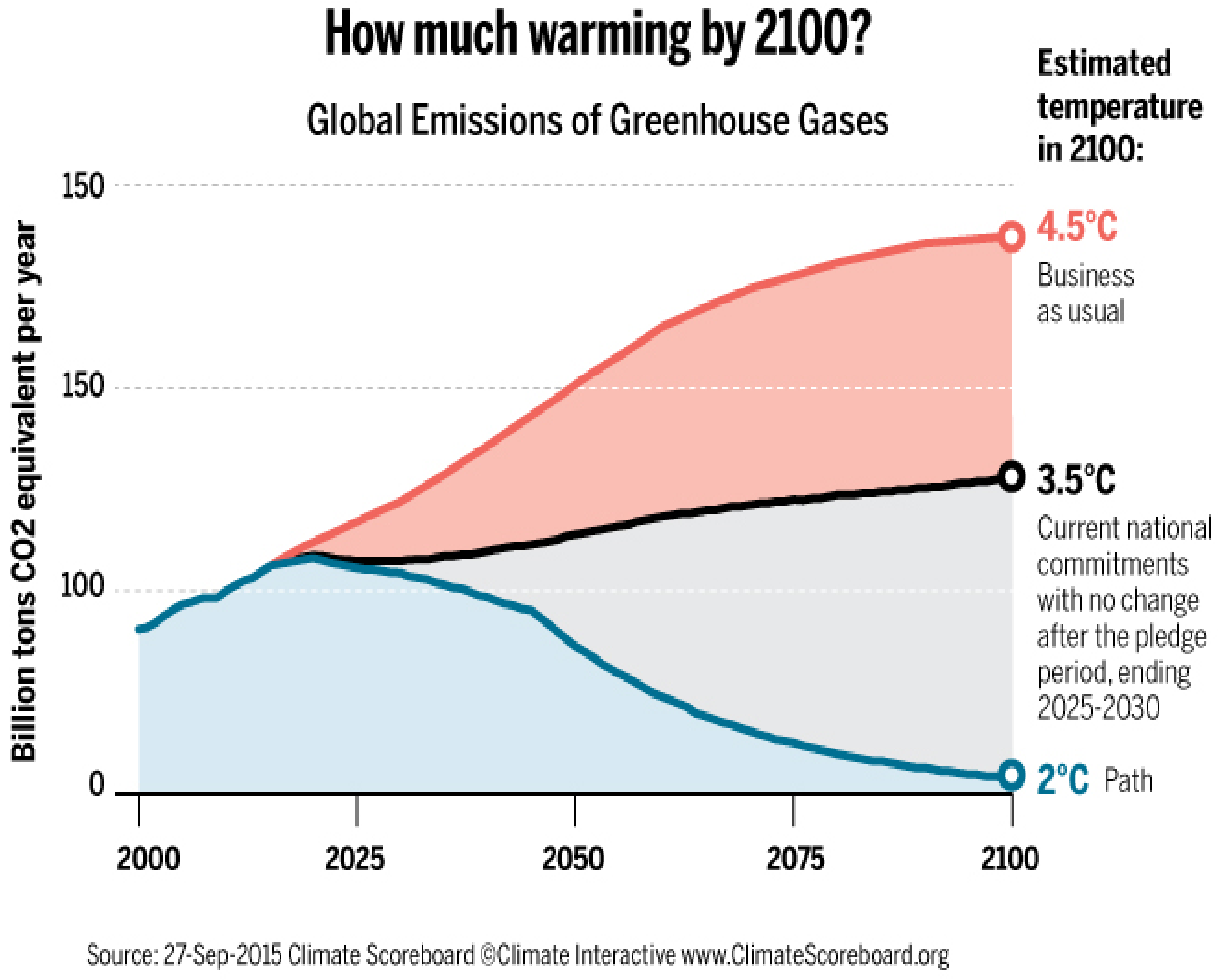
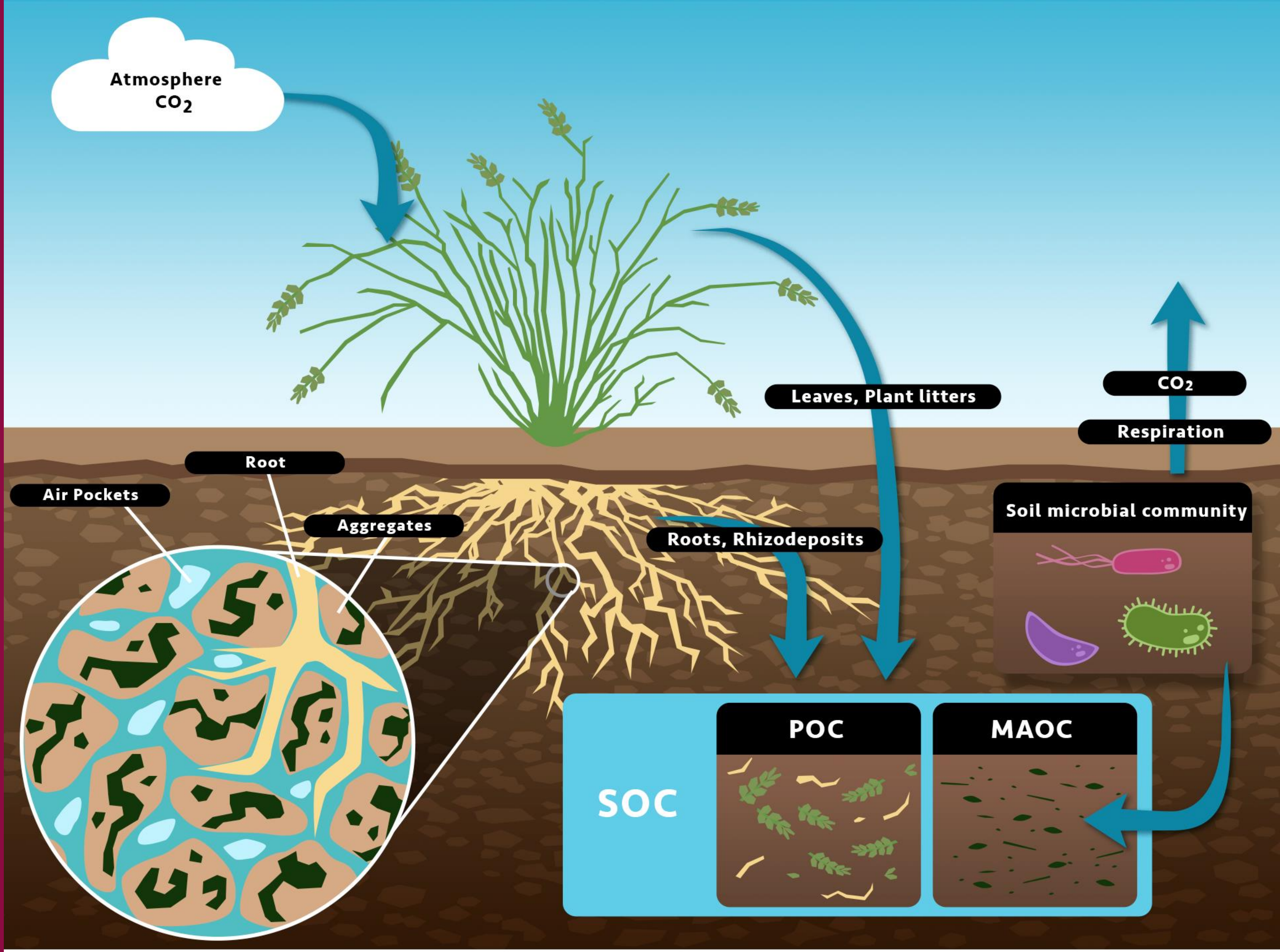
The need

As the wildfires raging in New Mexico and episodic droughts demonstrate, there is a need to find tools to reduce the impacts of climate change in agriculture

Achieving the goal of Paris Climate Agreement to limit global warming below 2°C requires a large-scale implementation of climate smart practices across crops and land uses



One approach to mitigate climate change is soil carbon sequestration, which involves capture and storage of carbon in soils

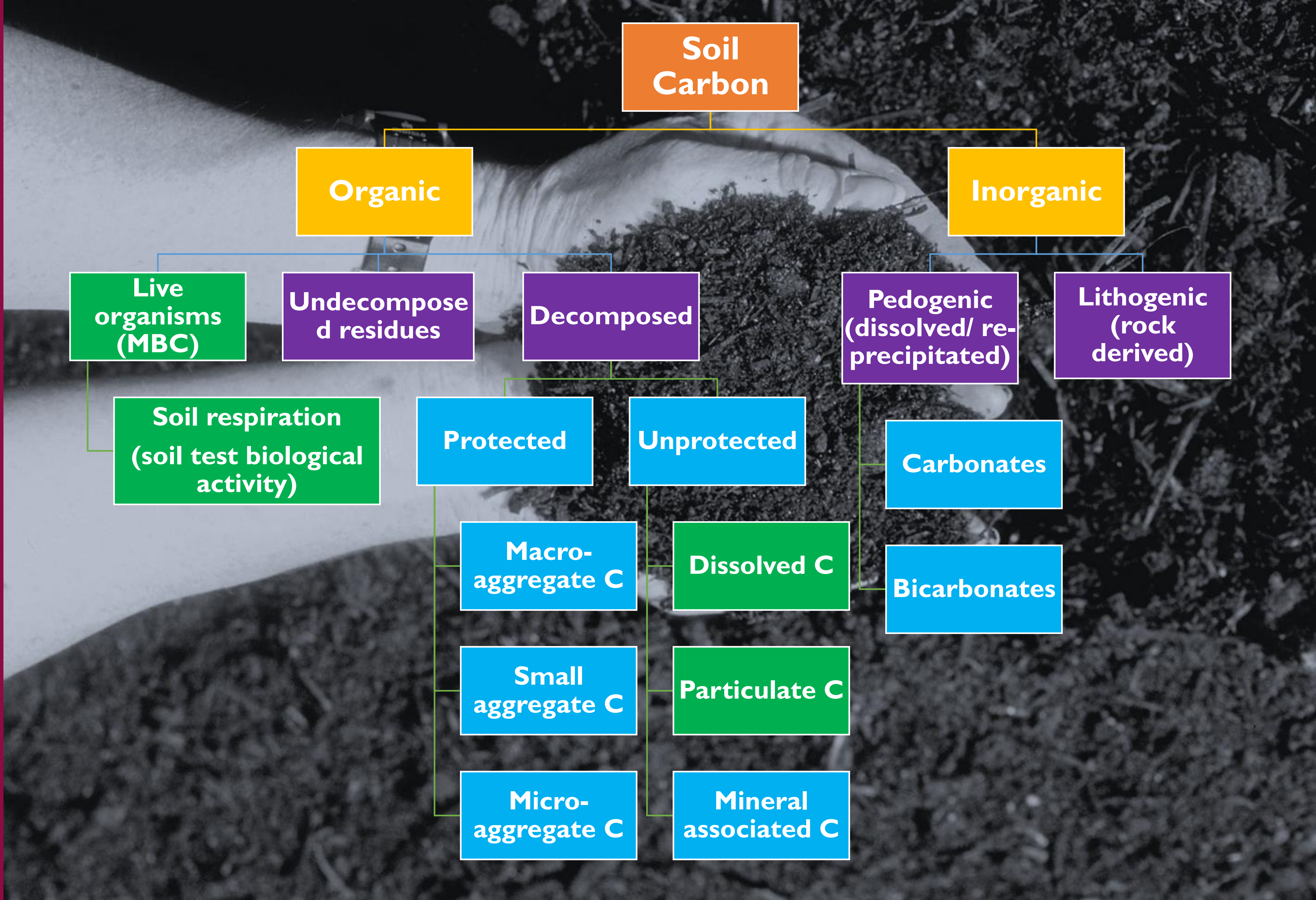


Soil microbial community regulates soil organic matter cycling and soil health.

SOC = soil organic carbon.
POC = particulate organic carbon.
MAOC = mineral associated organic carbon.

Thapa et al., 2022, Geoderma

Soil carbon pools

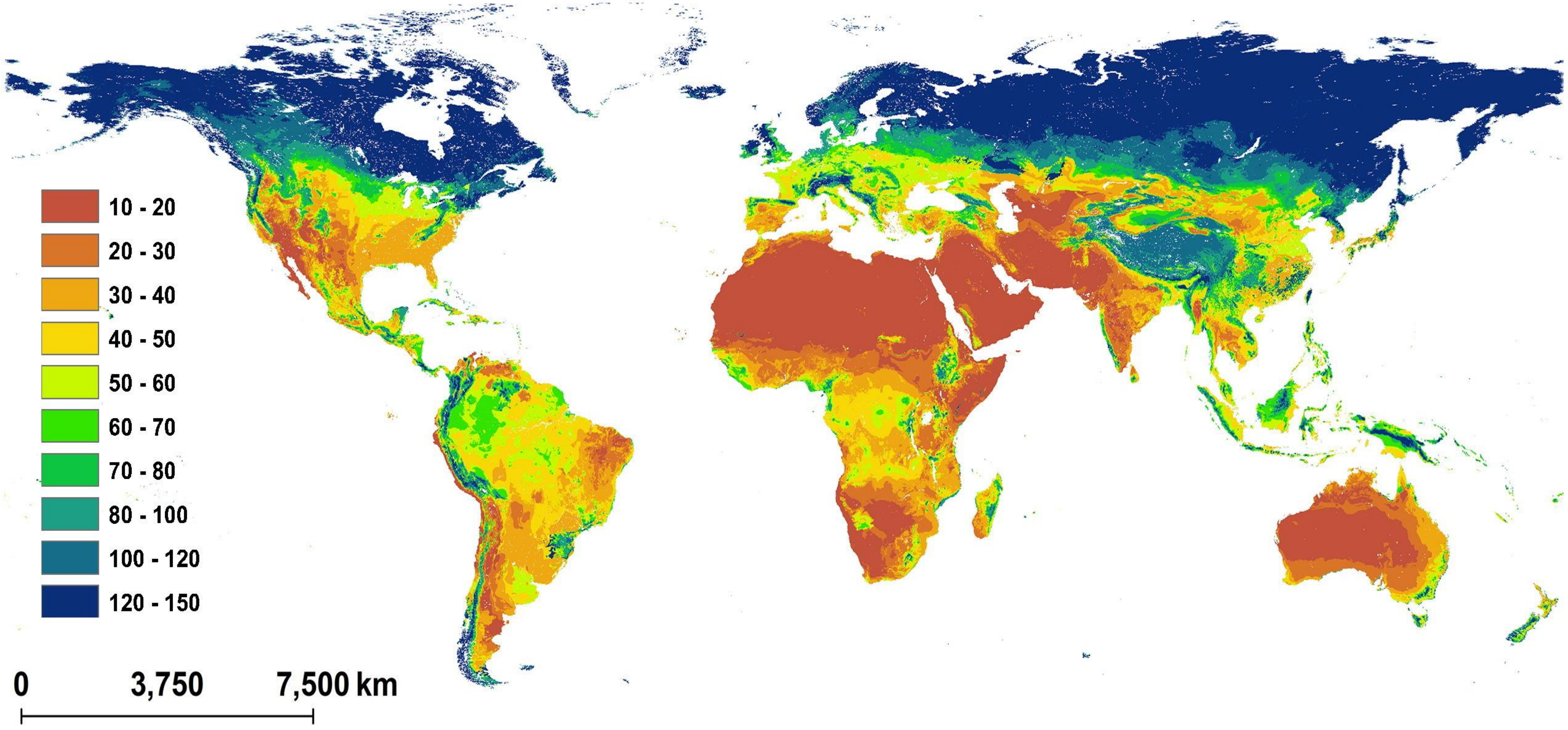


Soil has enormous potential to sequester carbon to provides a natural climate solution

(Soil C stock in world's top-soil: 0–0.3 m, Mg C ha^{-1})

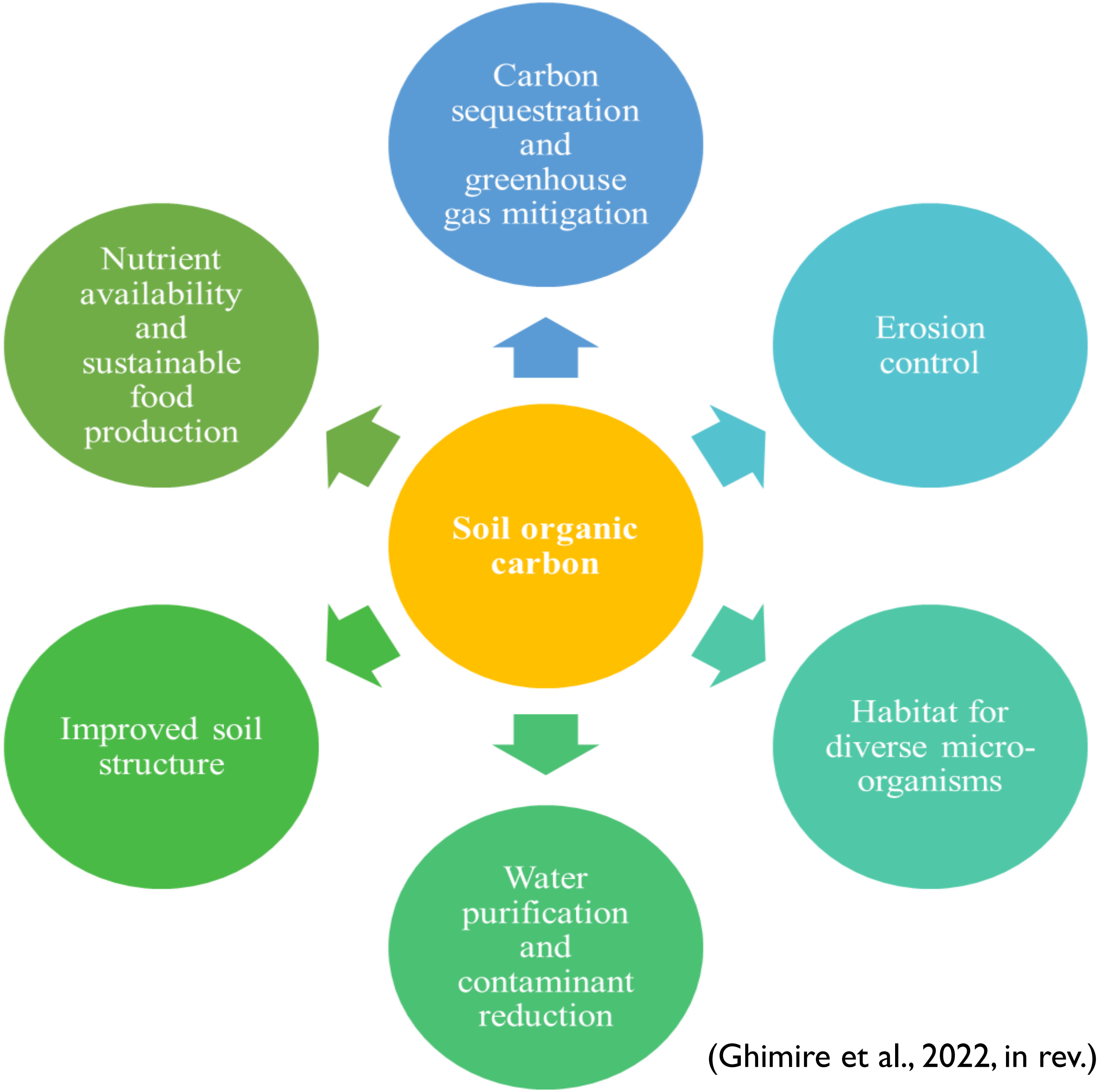
Soils store 550 GT (billion MT) of organic carbon and 950 GT inorganic carbon

Soils organic carbon sequestration potential (0.79-1.54 GT C yr^{-1}) (Fuss et al., 2018)



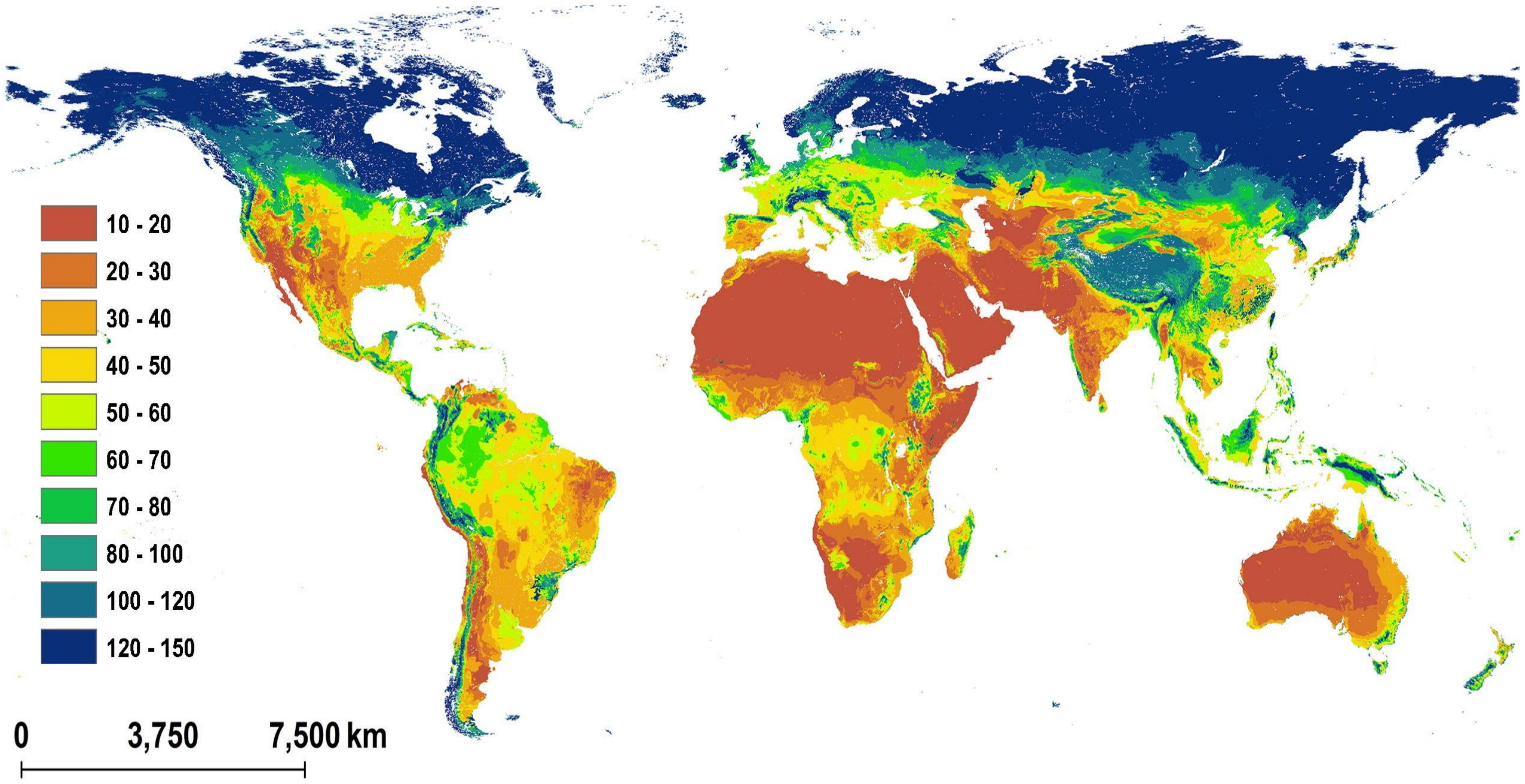
Source: Stockmann et al. (2015)

Soil organic carbon and ecosystem services



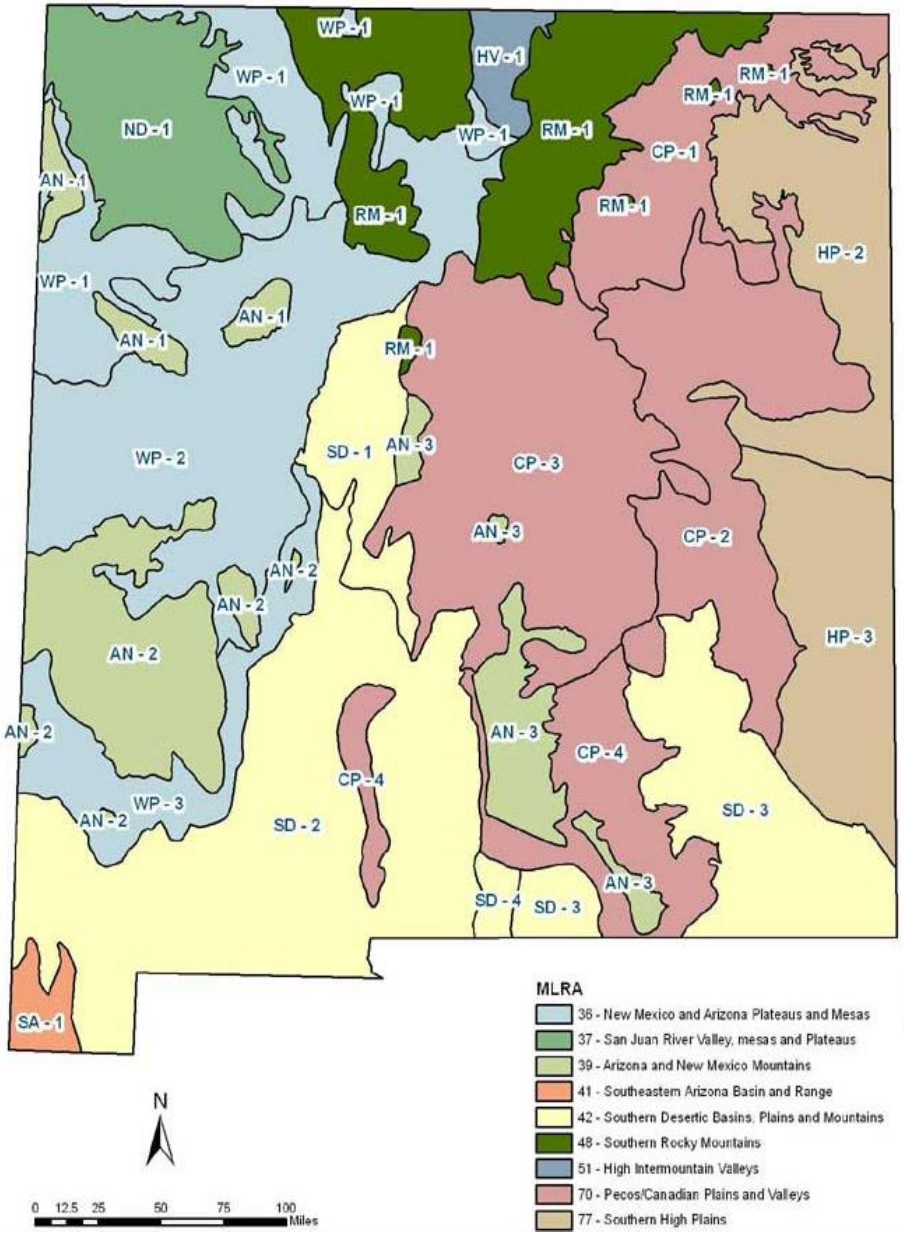
(Ghimire et al., 2022, in rev.)

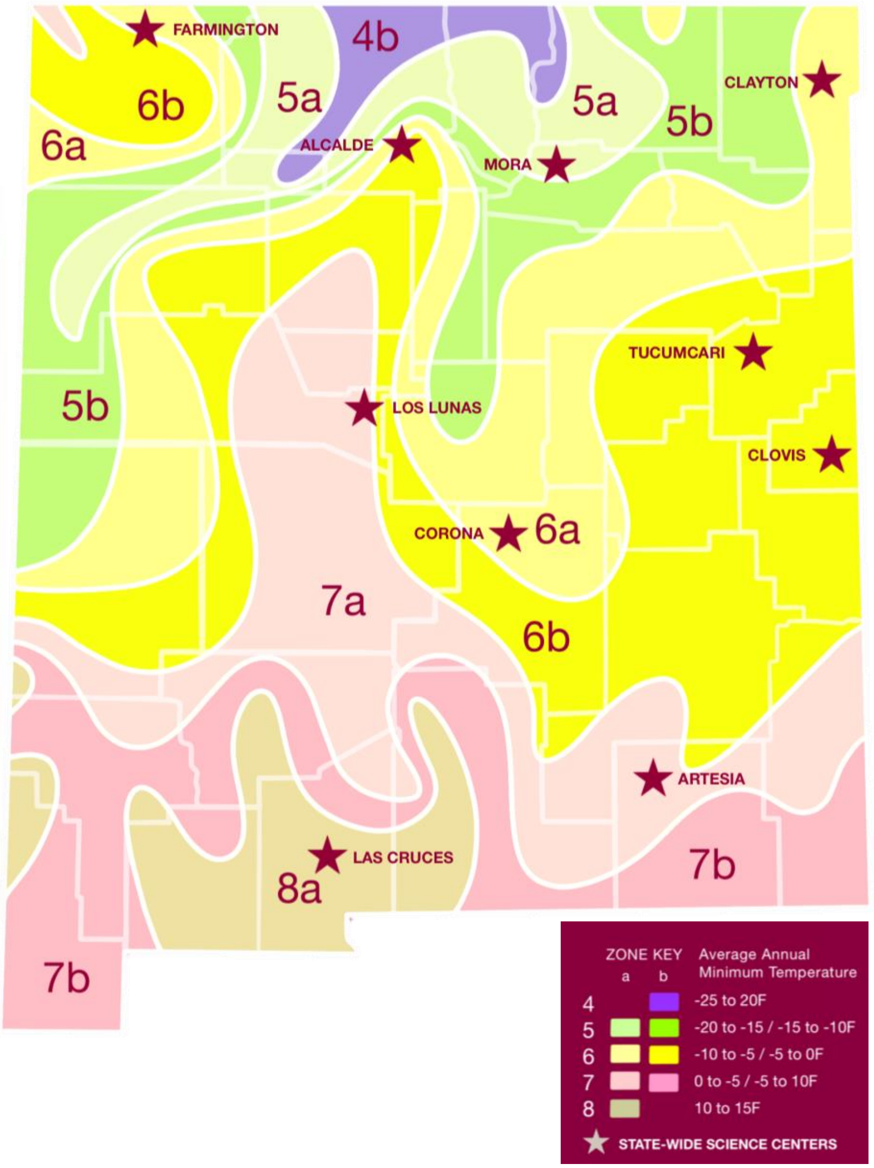
Principal impediments to large-scale implementation of soil carbon sequestration practices in arid and semi-arid lands



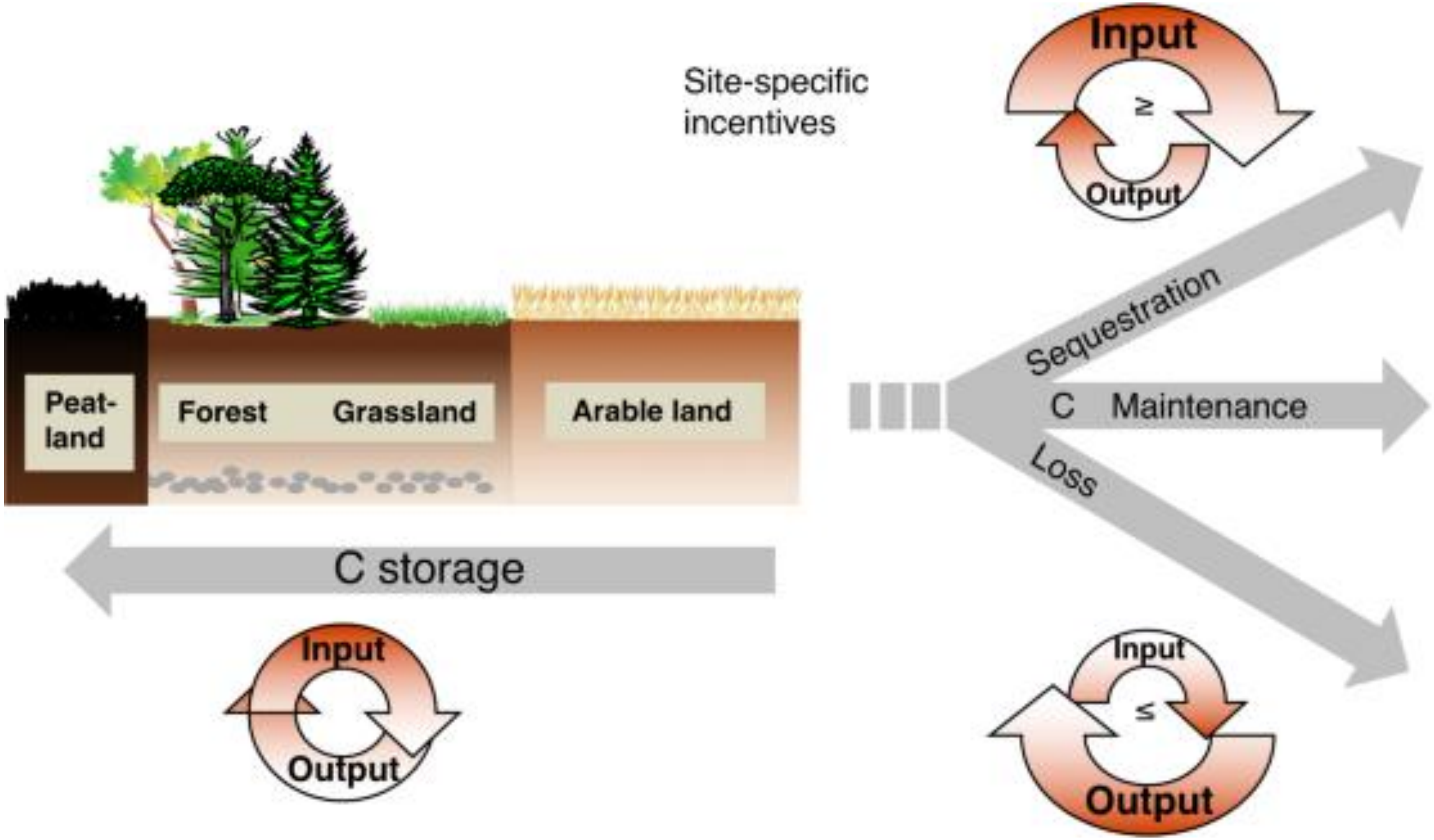
- **Lack of technologies** to enable C sequestration in water limited environments
- **Absence of quantifiable and verifiable benefits** of sequestering atmospheric C to guide the changes in existing land management practices
- **Lack of policy and economic incentives** to drive the needed changes in land management

New Mexico provides unique opportunity to study soil carbon in water limited areas





Soil management and SOC Sequestration



- BMPs
- Conservation practices
- Cropping intensification

- Optimum irrigation
- Optimum fertilization

- Intensive tillage
- Bare fallow
- Deficit irrigation
- Deficit fertilization

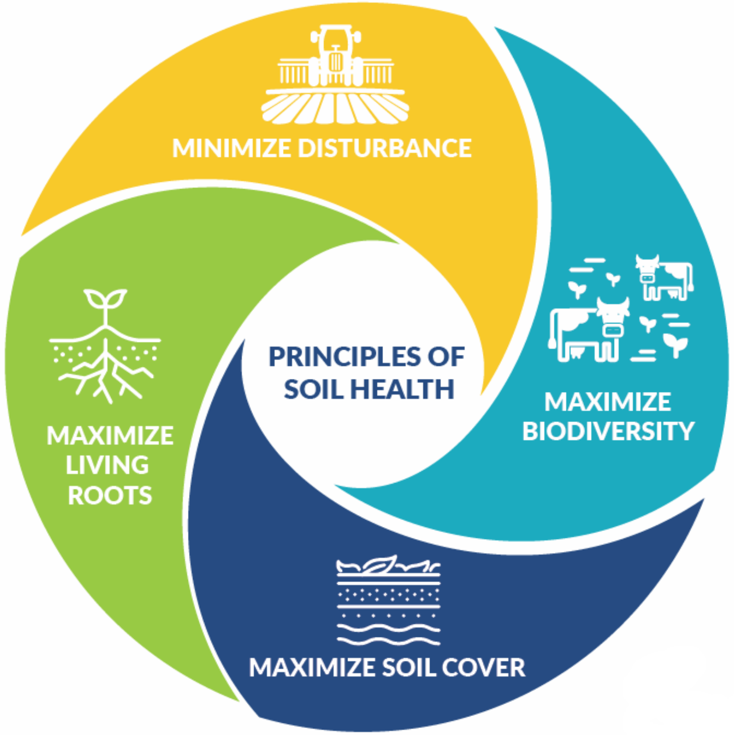
Soil organic carbon sequestration practices can improve soil health

Carbon sequestration

Minimizing soil disturbance	Maximizing carbon inputs	Increasing cropping intensity and diversity
• No-tillage • Reduced tillage • Perennial cropping	• Crop residue retention • Nutreint management • Soil amendments (compost and biosolid application)	• Cover cropping • Diverse crop rotations • Mixed cropping • Perennial cropping

(Ghimire et al., 2022, in rev.)

Soil health principles



Soil health management practices: cover crops carbon sequestration

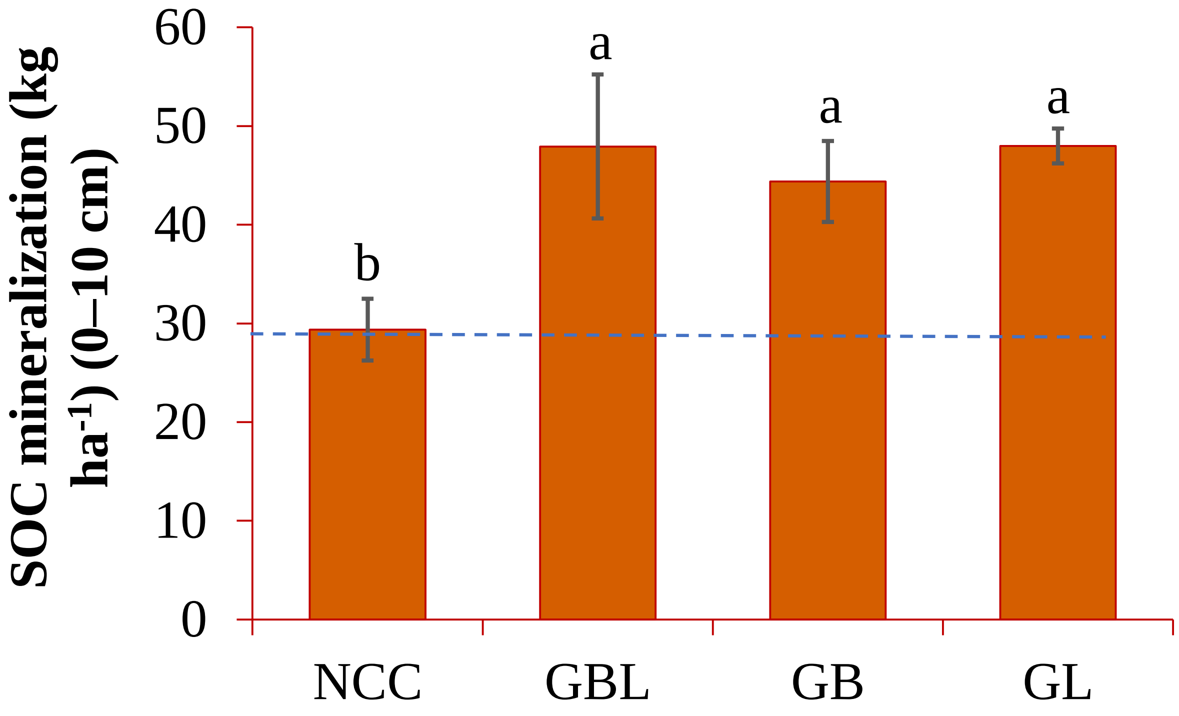
- Study site: NMSU ASC, Clovis, NM

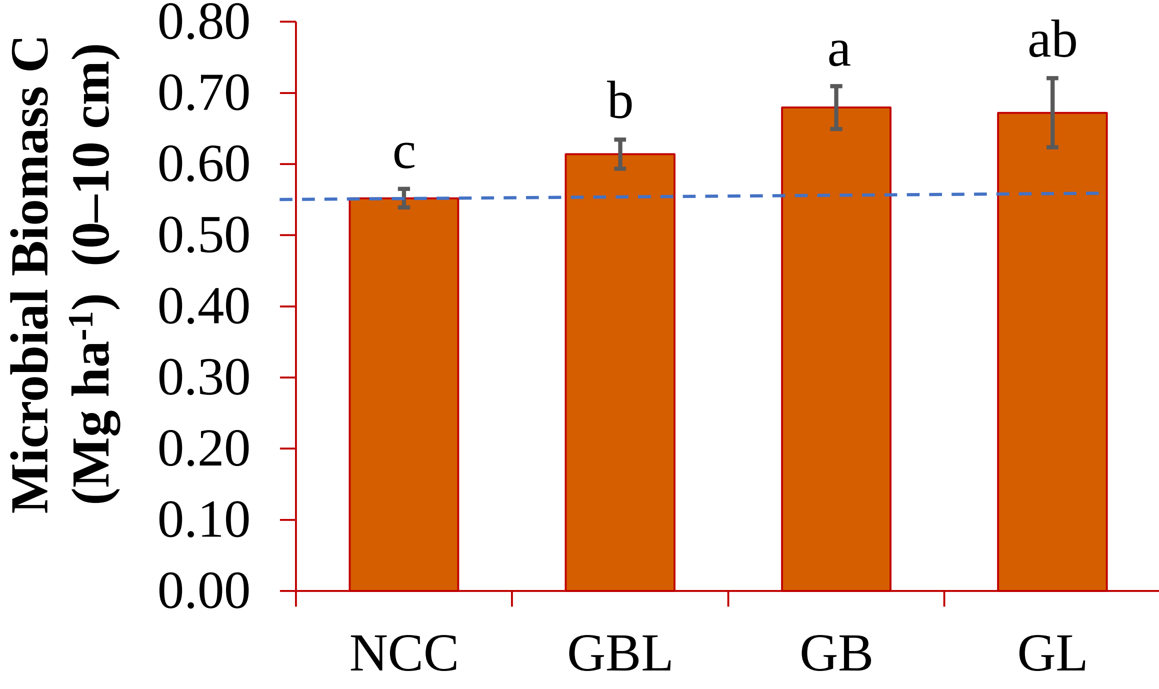
- Treatments in corn-sorghum rotation
  - NCC = No cover crops
  - GBL = Grass +brassica + legume
  - GB = Grass + brassica
  - GL = Grass + legume

  where,
  G- grasses (annual ryegrass + winter triticale)
  B- brassica (daikon radish + turnip)
  L- legumes (berseem clover + Austrian winter pea)

Labile carbon components

Third year of cover cropping

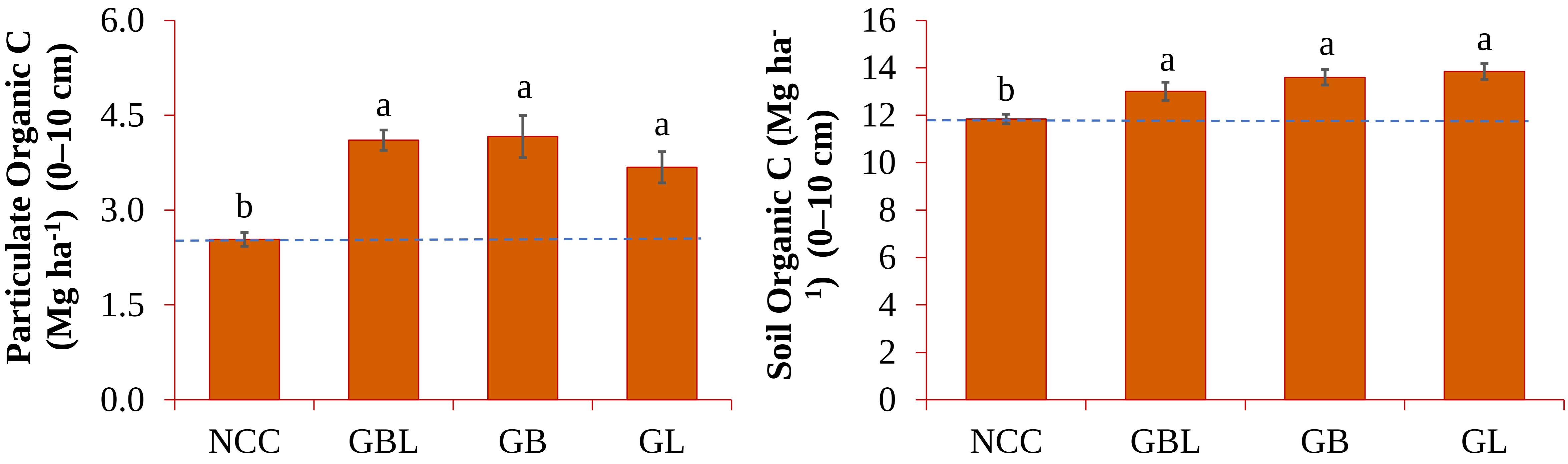




NCC = No cover crops, GBL = Grass + brassica + legume, GB = Grass + brassica, GL = Grass + legume

Particulate and total organic carbon

Third year of cover cropping



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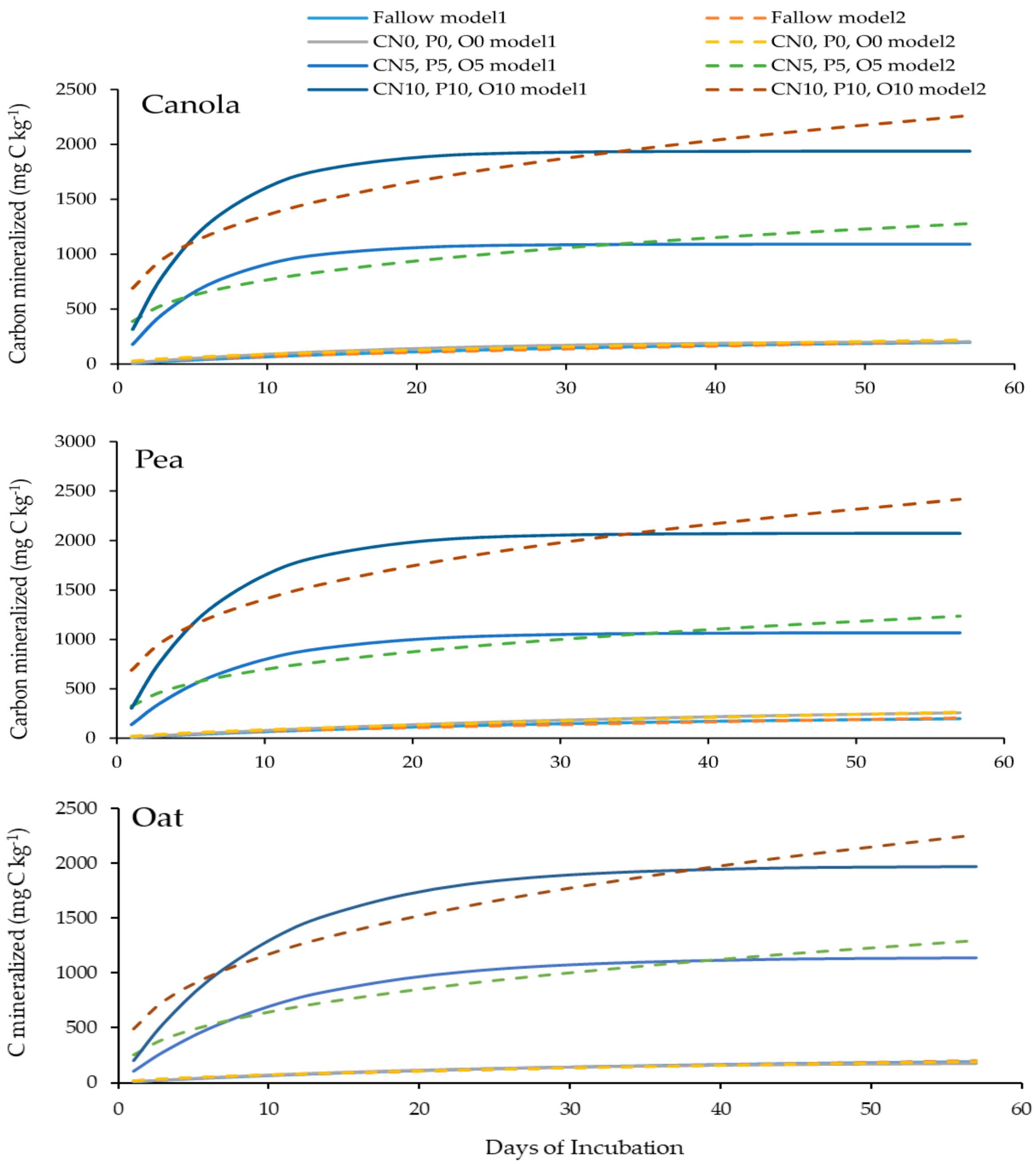
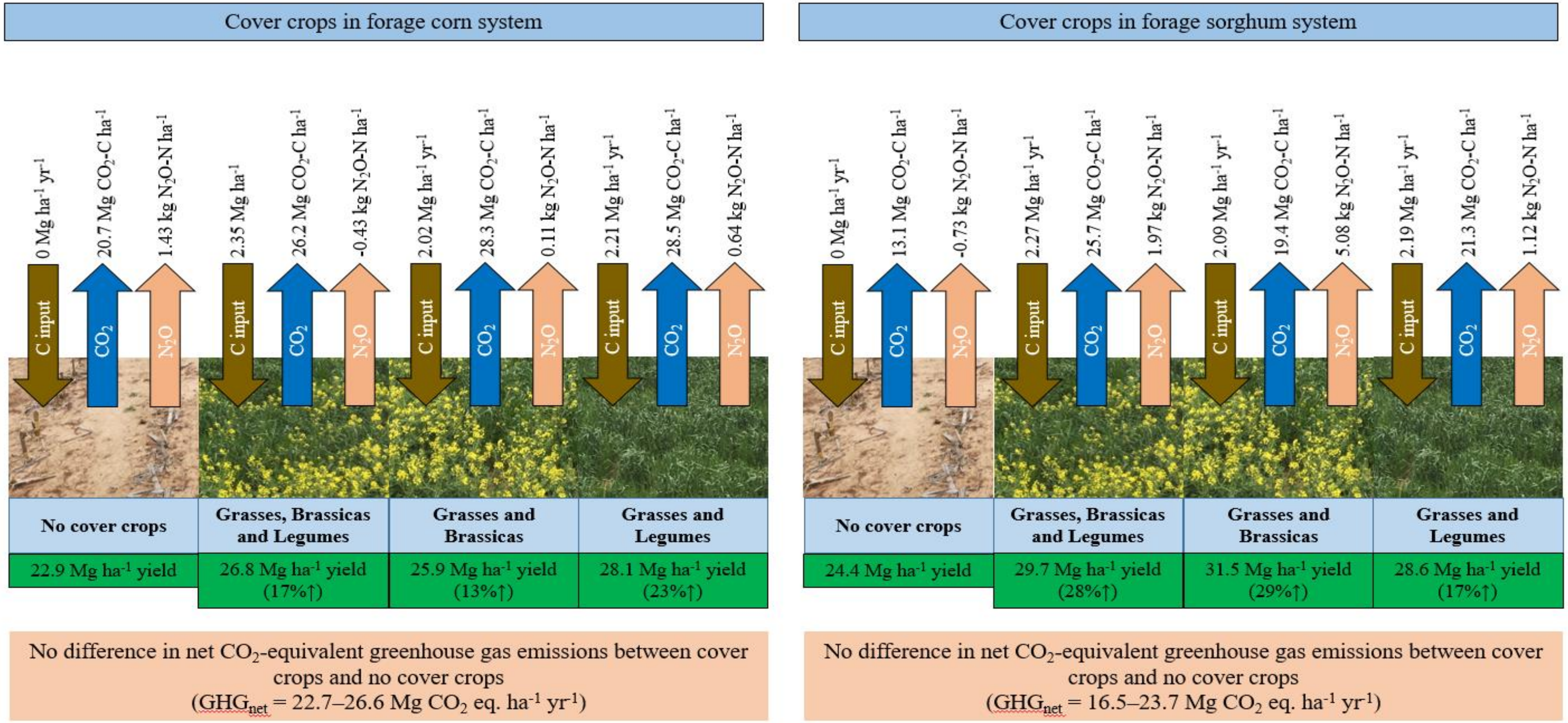
How much C input is need to enhance SOC sequestration in semi-arid soils



(Ghimire et al., 2017, Sustainability)

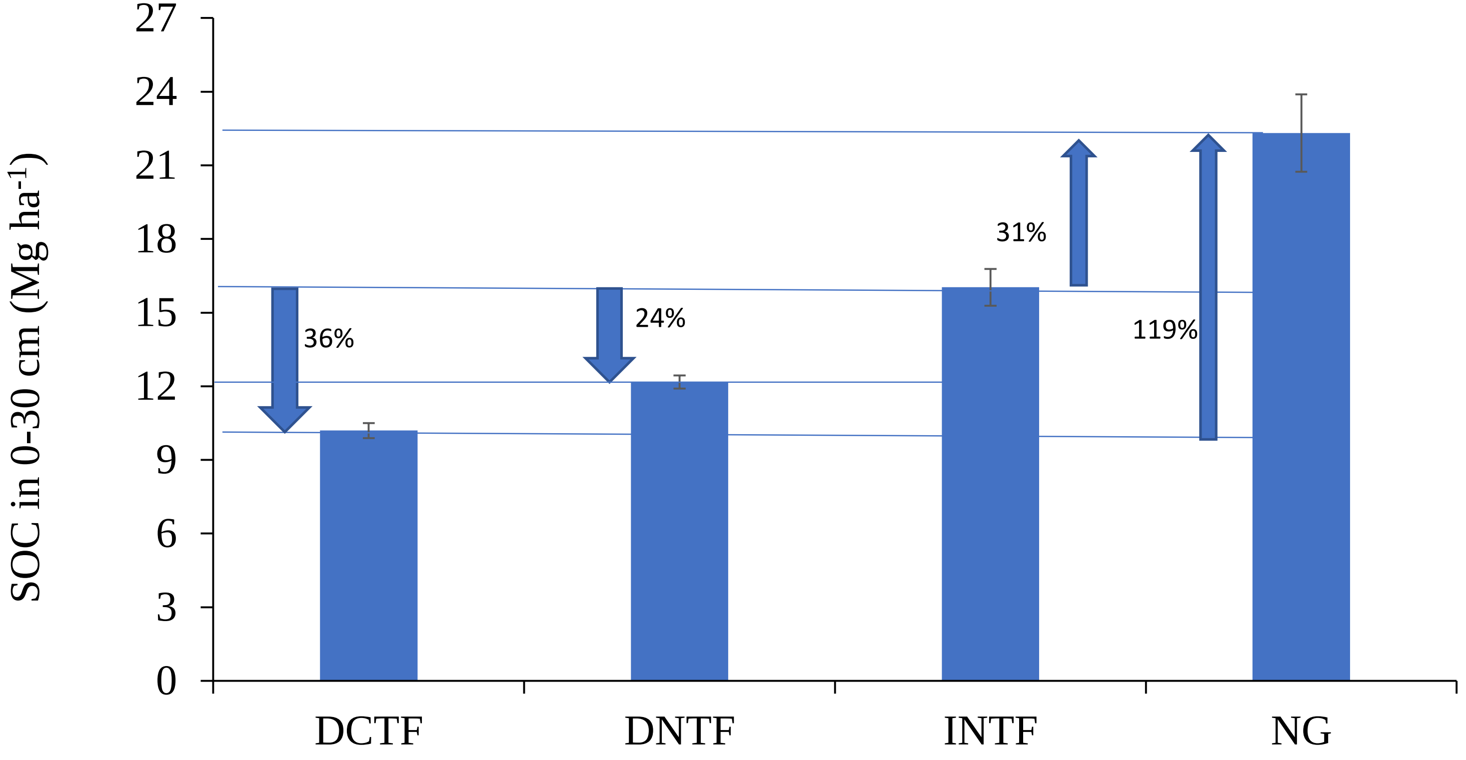
>5 Mg ha^{-1}

Increased SOC sequestration should have net zero (or negative) greenhouse gas emissions



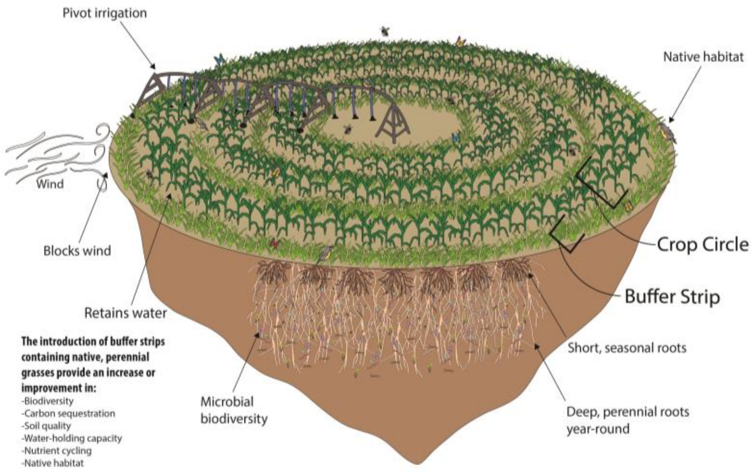
(Acharya et al., 2022, in rev.)

Landscapes facing transition respond differently depending on management choices



(Ghimire and Khanal, 2020, PeerJ)

Grass buffer in a center pivot

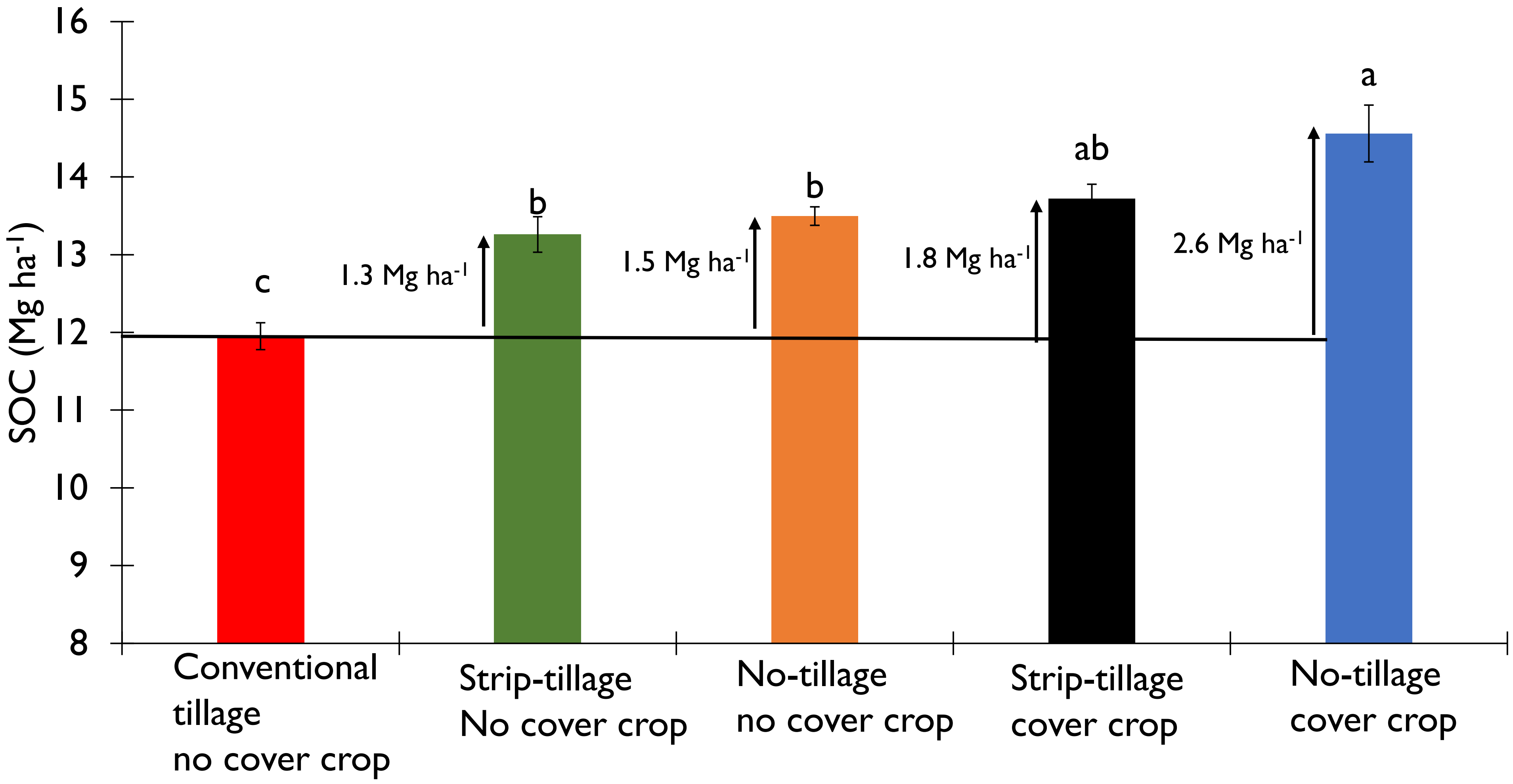


Perennial and Pasture Cropping

SOC sequestration in Ogallala Aquifer region:

1. Conservation farming- 32 MT y^{-1}
2. Grassland restoration: 126 MT yr-1

No-tillage and cover cropping complement each other

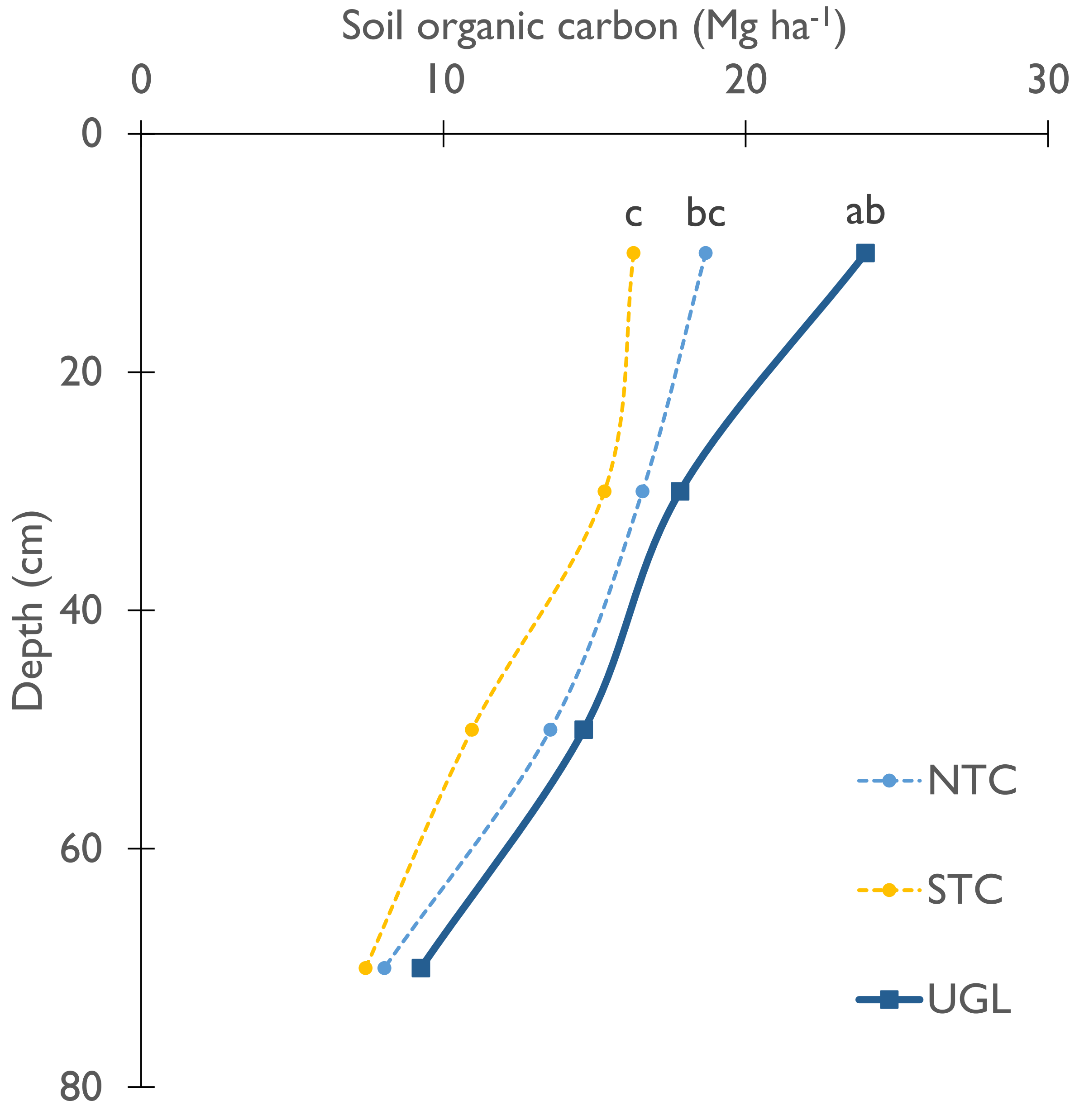


(Thapa et al., 2019, Agrosyst. Geo. Sci. & Envt.)

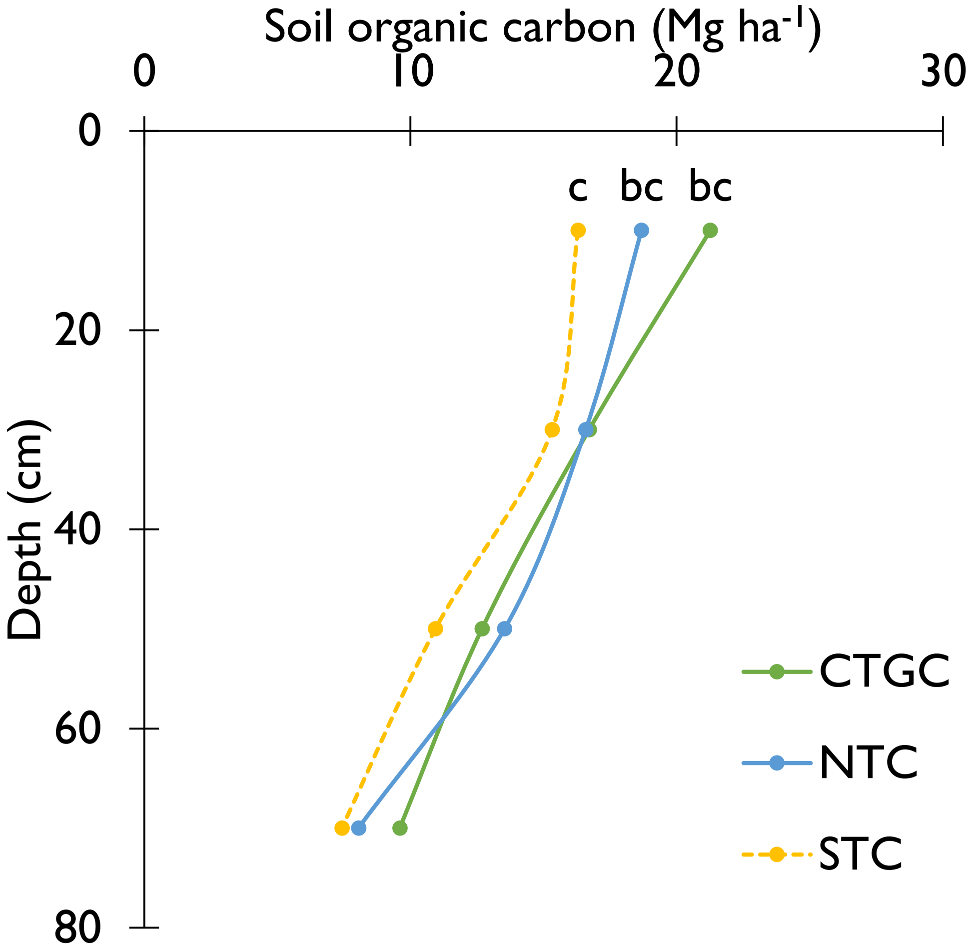
Grassland restoration for soil profile carbon sequestration

Grassland soils sequestered 10 Mg ha^{-1} (18%) more SOC than cropland soils in the 0–80 cm profile

NTC = no-till cropland
STC = strip till cropland
UGL = undisturbed grassland



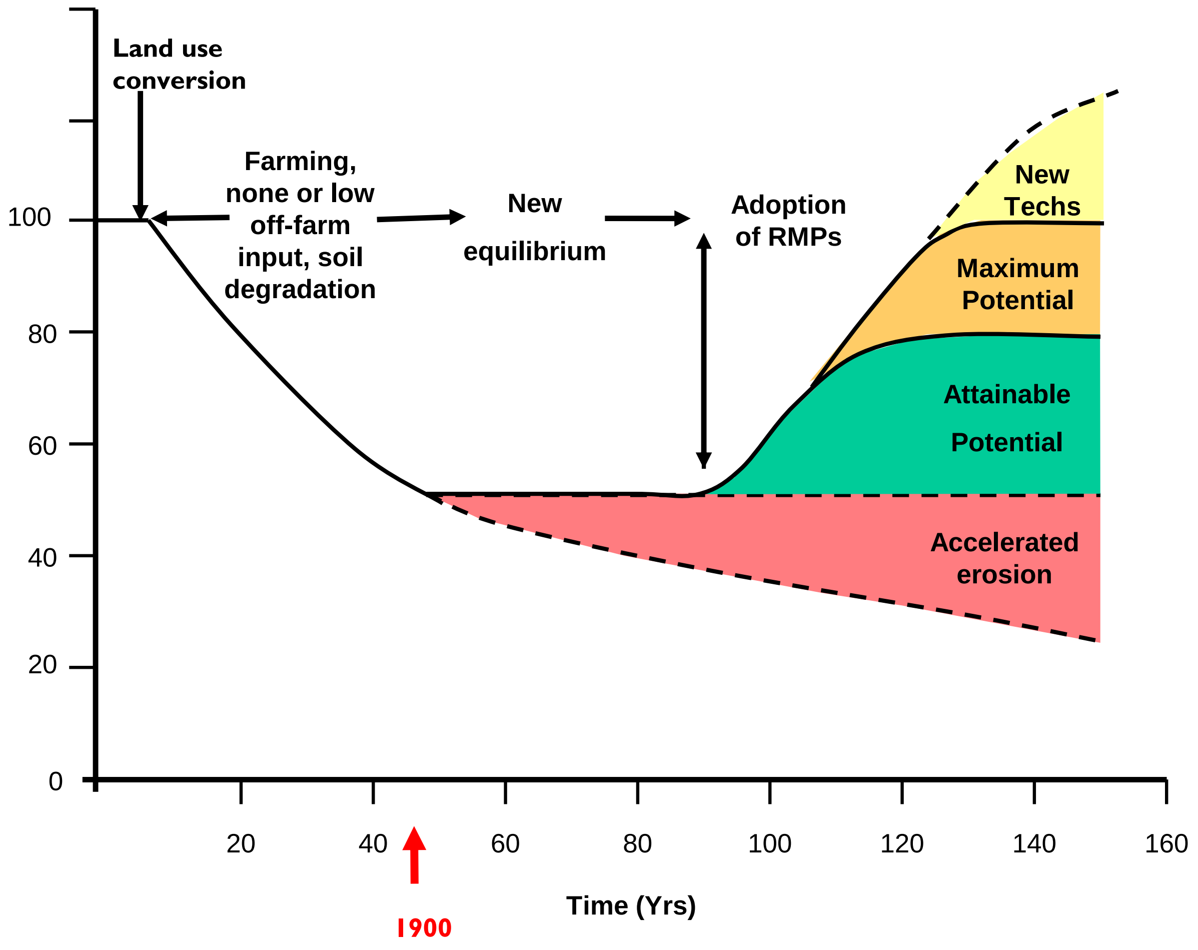
Role of livestock on soil carbon accumulation



Compost addition and root carbon

Considerations

- Carbon sequestration in arid and semiarid southwest is a slow process, often constrained by low precipitation and high temperature
- Integration of multiple conservation tools complement each other to increase carbon accrual



Thank You

USDA NIFA

ARID
Agroecosystem Resilience In Times of Drought

NRCS
Natural Resources Conservation Service

Graduate Students and Postdoctoral Scholars

Unique position of NMSU