Quantifying Soil Carbon: A Field and Laboratory Perspective

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Excellent discussion in Crops and Soils magazine (January-February 2022)

ASSESSING SOIL HEALTH SERIES

Sampling Design for Quantifying Soil Organic Carbon Stock in Production Ag Fields

By Cristine L. S. Morgan, Chief Scientific Officer, and Jason P. Ackerson, Research Soil Scientist, Soil Health Institute

The following article kicks off a new five-part series on assessing soil health. It seeks to provide a brief and practical review about measuring soil organic carbon (SOC), especially SOC stock. It is part of a larger Soil Science Society of America webinar series produced in partnership with The Soil Health Institute and sponsored by The Walton Family Foundation. Earn 0.5 CEUs in Soil & Water Management by reading the article and taking the quiz at https://web.sciencesocieties.org/Learning-Center/Courses.

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Soil carbon marketplace

- Ever growing and changing landscape
- New and old companies alike, buying and selling carbon to meet ESG goals
- Opportunity for farmers and landowners to sell sequestered organic carbon in soil
- Most require some farm practice change
- Each program has specific and defined rules on soil sampling intensity and frequency
  - Soil sample core diameter and depth
  - Number of soil cores per site/zone/field
  - Soil analysis requirements

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Quantifying soil organic carbon

- Bulk density: soil mass per unit volume
  - convert %SOC (concentration) to tonne C/ha (mass/area), needed for carbon sequestration calculations
  - correction for coarse fragments
  - difficult to collect soil samples, special equipment and care is required
- Total organic carbon: total carbon minus inorganic carbon (carbonate)
  - measure organic carbon in soil organic matter and inorganic carbon in carbonate minerals

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Collecting soil cores for bulk density

- Among the hardest soil sampling tasks
- Critical components are soil mass and volume
  - No loss of soil mass
  - No compression or compaction of soil core
- Error here leads to error later

AMS split-core soil sampler

- 12-inch length
- 2-inch diameter

- Allows collection of large-diameter bulk density soil core
- Attaches to AGVISE Quicktach collars with adapter

The hand method: slide-hammer and shovel

The hydraulic method

https://www.youtube.com/watch?v=c5JftYpV7j8

A nice and clean soil core

Soil organic carbon determination

Total carbon (TC)

- dry combustion
- combusts all carbon @ 1,000-1,200 °C
- includes organic C and inorganic C (carbonate)

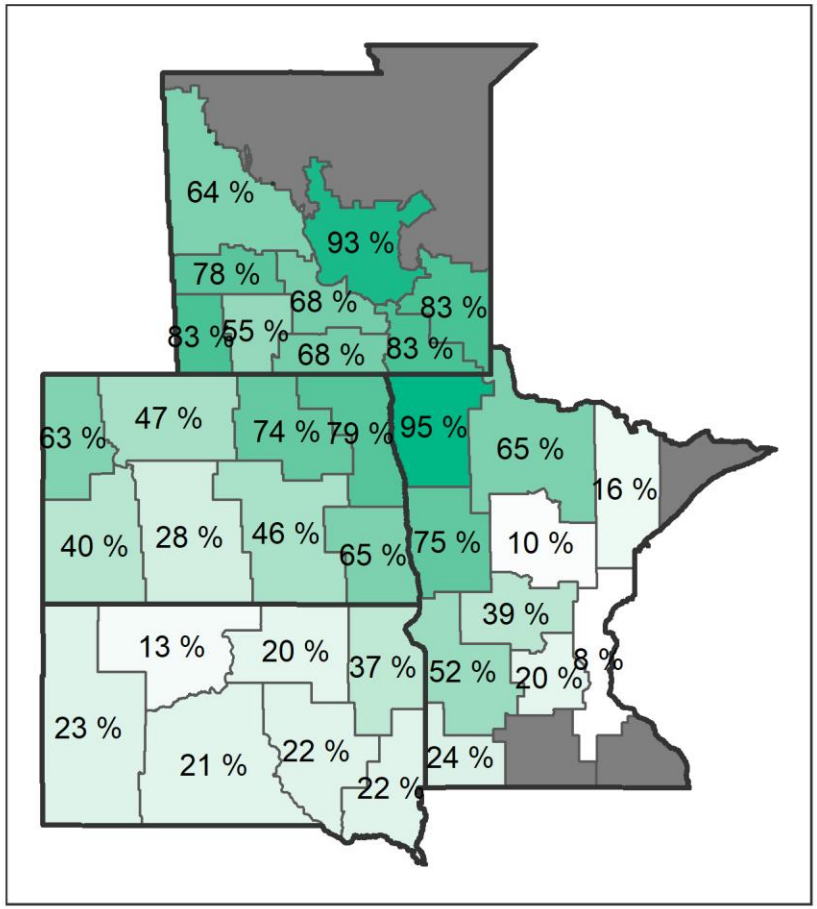
Inorganic C (IC)

- pressure calcimeter
- react carbonate with hydrochloric acid, measure CO_2 evolution

Organic C = TC - IC

Elementar vario MAX cube CN analyzer

Soil samples with soil pH above 7.3 in 2021



Data not shown where n< 100
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Any soil with pH > 7.3 will contain some calcium carbonate

Percent of samples (0-6 inch)

75
50
25

Calculating soil organic carbon stock

- SOC stock (Mg C ha^{-1}) = organic C [g C 100 g^{-1} soil] × bulk density [g cm^{-3}] × (1 - CF) × thickness of soil sample [cm]
  - SOC stock = soil organic C mass per unit area
  - organic C = organic carbon concentration
  - bulk density = soil mass per unit volume (soil core)
  - CF = coarse fragment fraction, aka rocks (> 2 mm)
  - soil thickness = length of soil core

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A fun day in the soil sampling truck

- Using AMS split-core soil probe and in-cab hydraulic system
- Collected 0-12 inch (0-30 cm) soil cores for bulk density and soil carbon
  - 12-inch soil cores (r=3)
  - 2-inch increments

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Soil carbon stock results
0-30 cm soil depth

Soil series	Bulk density	Total organic carbon	SOC stock
	g/cm^3	g C 100 g $soil^{-1}$	Mg C ha^{-1}
Hecla fine sandy loam	1.37	0.71	29.2
Embden fine sandy loam	1.33	1.80	71.7
Barnes loam	1.27	1.89	67.2
Bearden silty clay loam	1.19	2.70	93.9

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Soil carbon stock variability

Three (3) soil cores taken within 10 feet, 0-30 cm soil depth mean +/- standard deviation

Soil series	Bulk density	Total organic carbon
	g/cm^3	g C 100 g $soil^{-1}$
Hecla fine sandy loam	1.27 – 1.48	0.64 – 0.78
Embden fine sandy loam	1.32 – 1.34	1.76 – 1.84
Barnes loam	1.18 – 1.35	1.79 – 1.99
Bearden silty clay loam	1.14 – 1.24	2.52 – 2.88

Coefficient of variation = 8-10%

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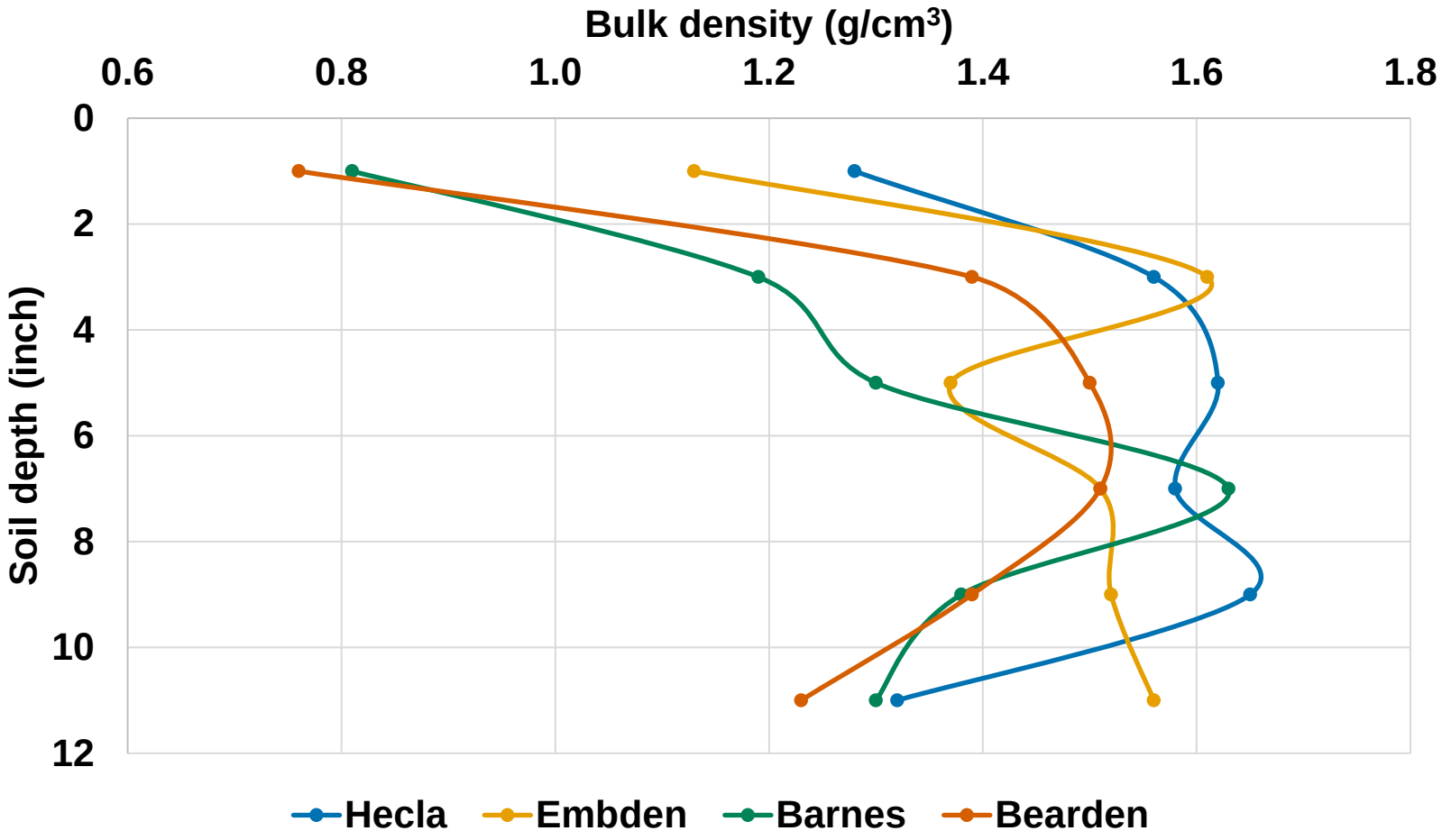
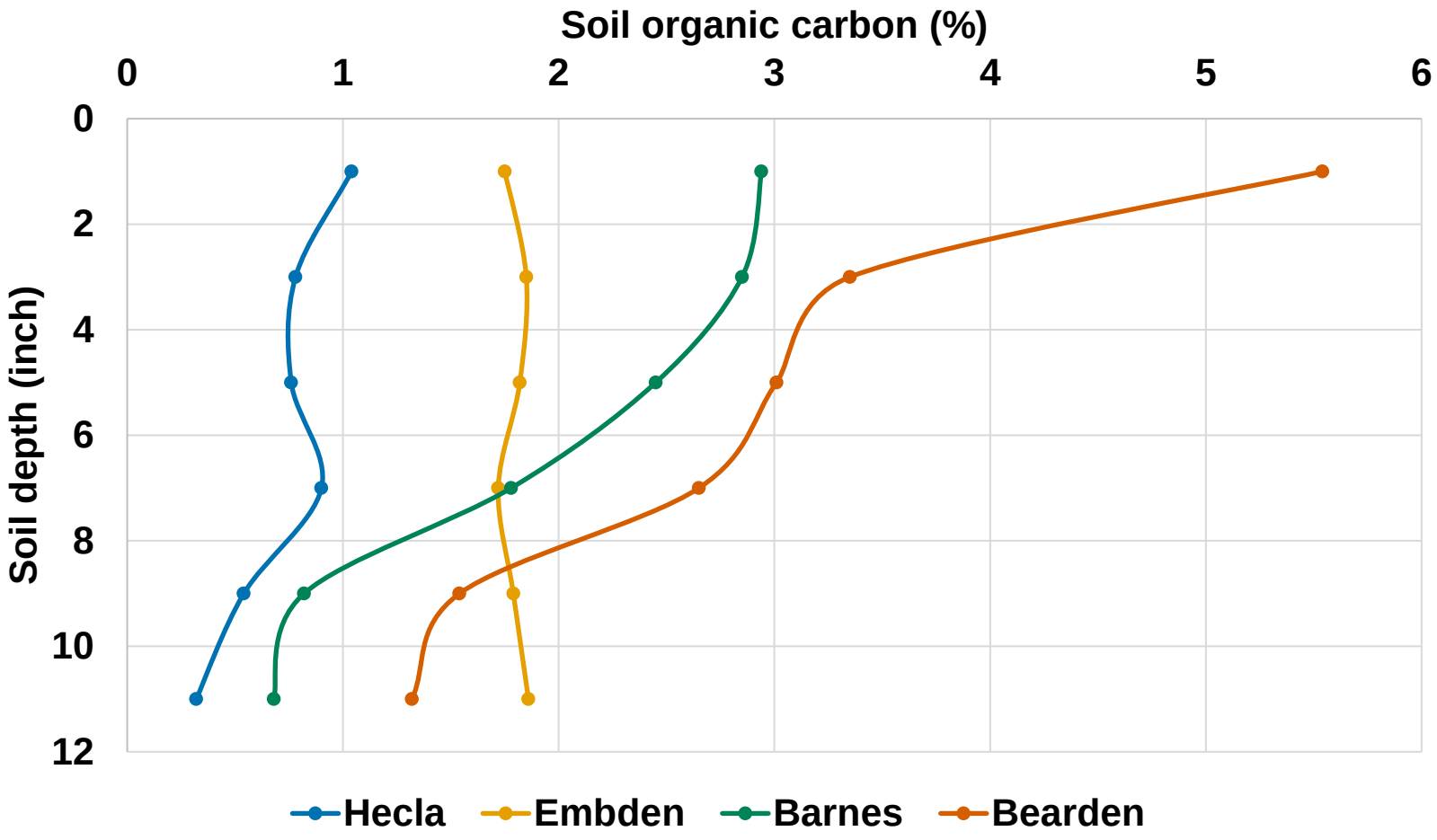
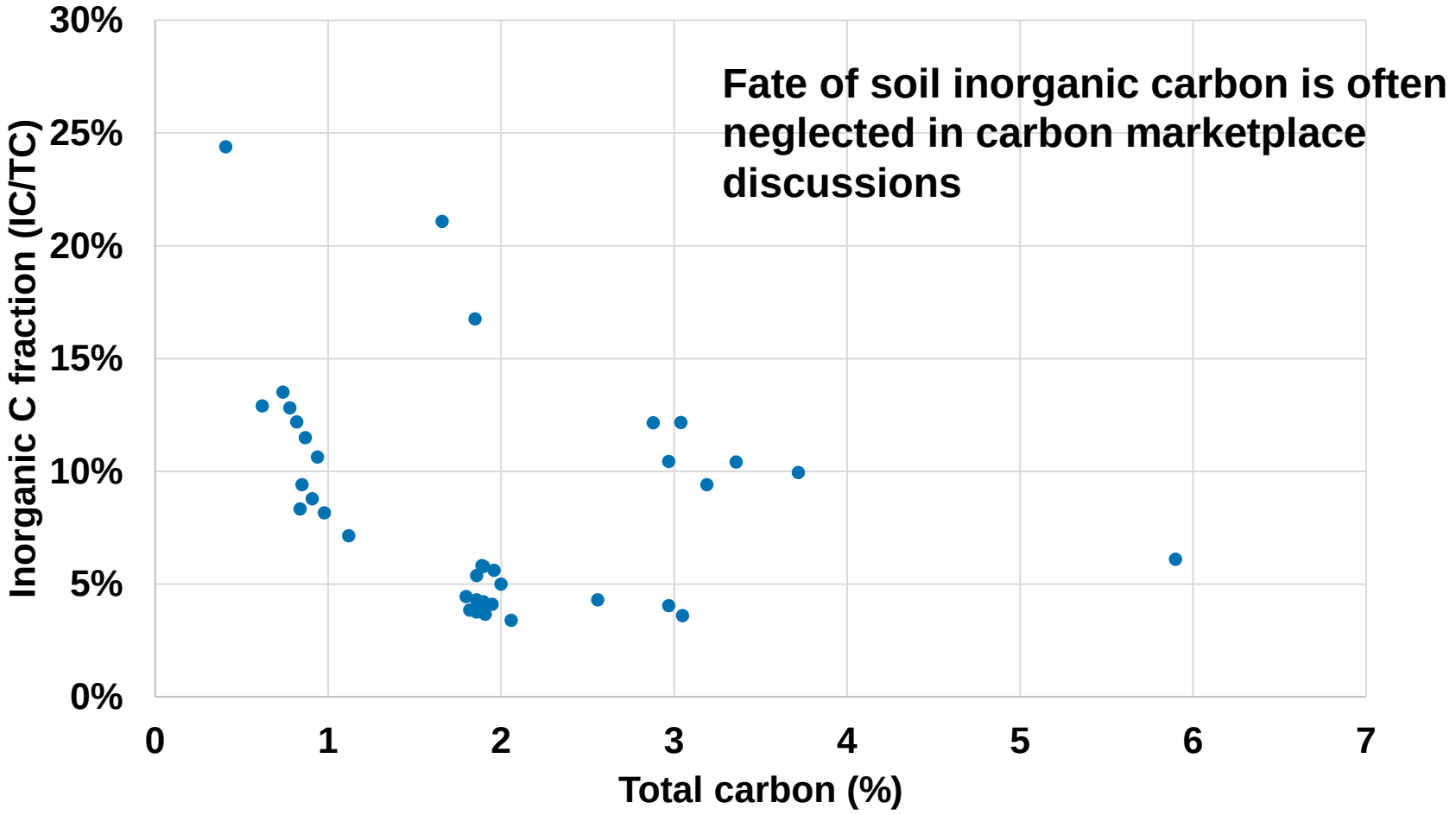
Bulk density changes with depth

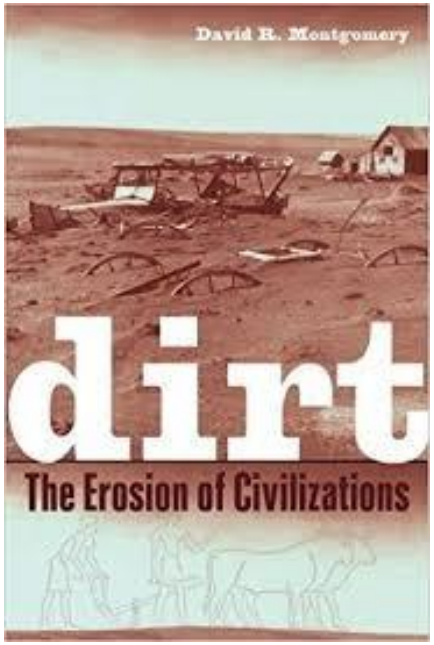


Soil organic carbon changes with depth



How important is inorganic carbon (carbonate)?





If you want to learn more about humankind's long struggle with soil erosion…

Thank you for your kind attention!

Are there any questions?

Remember: Your soil test is only as good as the soil sample.

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