Soil Health in Iowa Soils
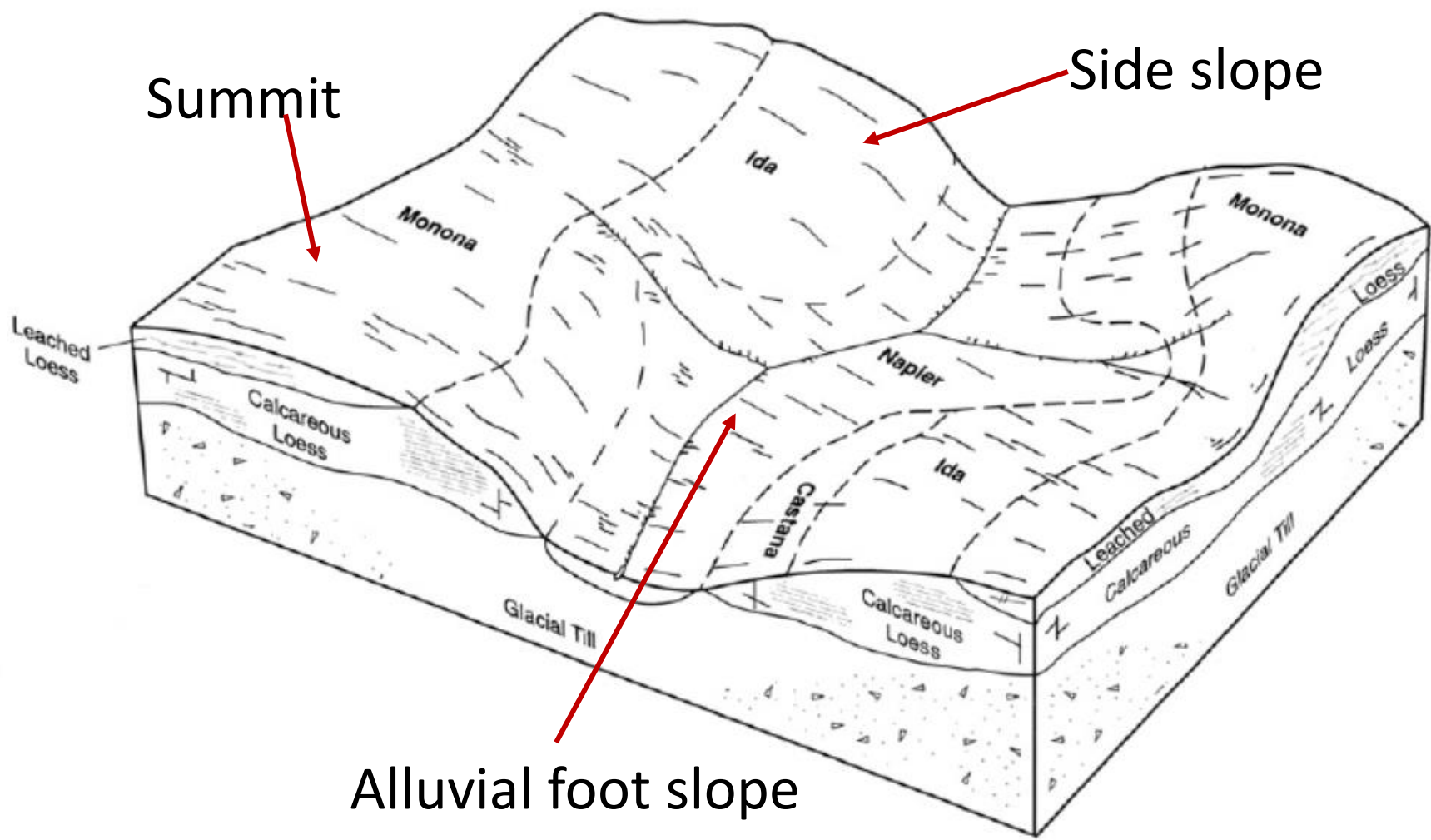
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Summit

Side slope

Alluvial foot slope
and toe slope

Monona (summit) ~40 cm of topsoil

- The Monona series consists of very deep, well drained soils formed in loess.

- These soils are on interfluves and side slopes on loess hills and on risers and treads on stream terraces in river valleys. Slope ranges from 0 to 40 percent.

- Mean annual air temperature is about 10 degrees C (51 degrees F).

- Mean annual precipitation is about 710 millimeters (29 inches).

- TAXONOMIC CLASS: Fine-silty, mixed, superactive, mesic Typic Hapludolls

https://www.extension.iastate.edu/soils/page/soil-series-photos-and-descriptions

Ida (side slope)
~30 cm of topsoil

- The Ida series consists of very deep, well drained soils formed in calcareous loess.

- These soils are on side slopes and crests on dissected till plains and on risers on stream terraces. Slopes range from 2 to 60 percent.

- Mean annual air temperature is about 9 degrees C (49 degrees F).

- Mean annual precipitation is about 74 centimeters (29 inches).

- TAXONOMIC CLASS: Fine-silty, mixed, superactive, calcareous, mesic Typic Udorthents

Judson (alluvium) ~100 cm of topsoil

- The Judson series consists of very deep, well drained soils formed in silty colluvium derived from non-calcareous loess.

- These soils are on foot slopes, upland drainageways, and alluvial fans. Slope ranges from 0 to 12 percent.

- Mean annual air temperature is about 10 degrees C.

- Mean annual precipitation is about 810 millimeters.

- TAXONOMIC CLASS: Fine-silty, mixed, superactive, mesic Cumulic Hapludolls

https://www.extension.iastate.edu/soils/page/soil-series-photos-and-descriptions

1 mm
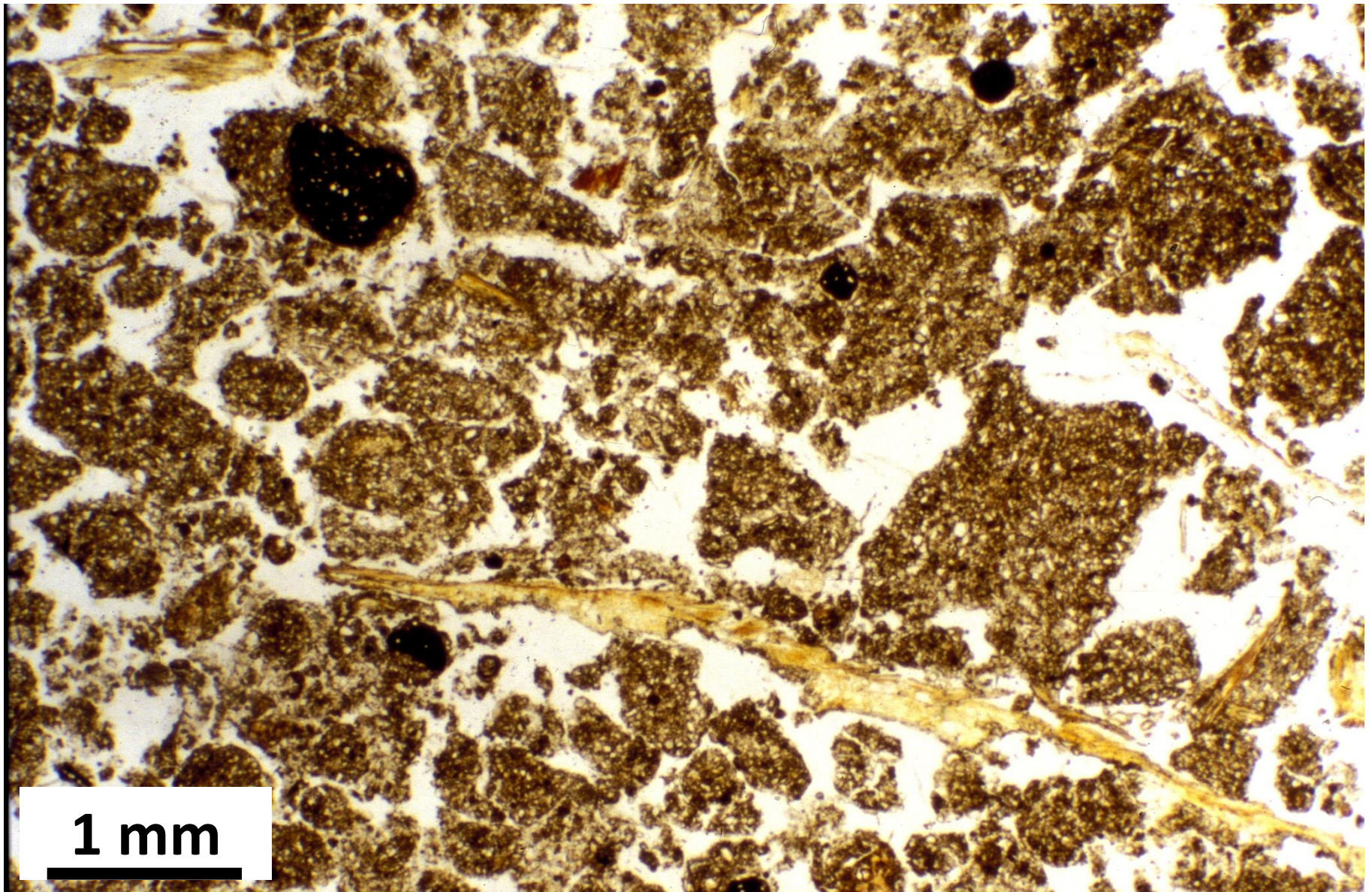
Granular structure: Soil organic matter aggregates particles to create pore spaces – for water, air, and roots.

0.5 mm
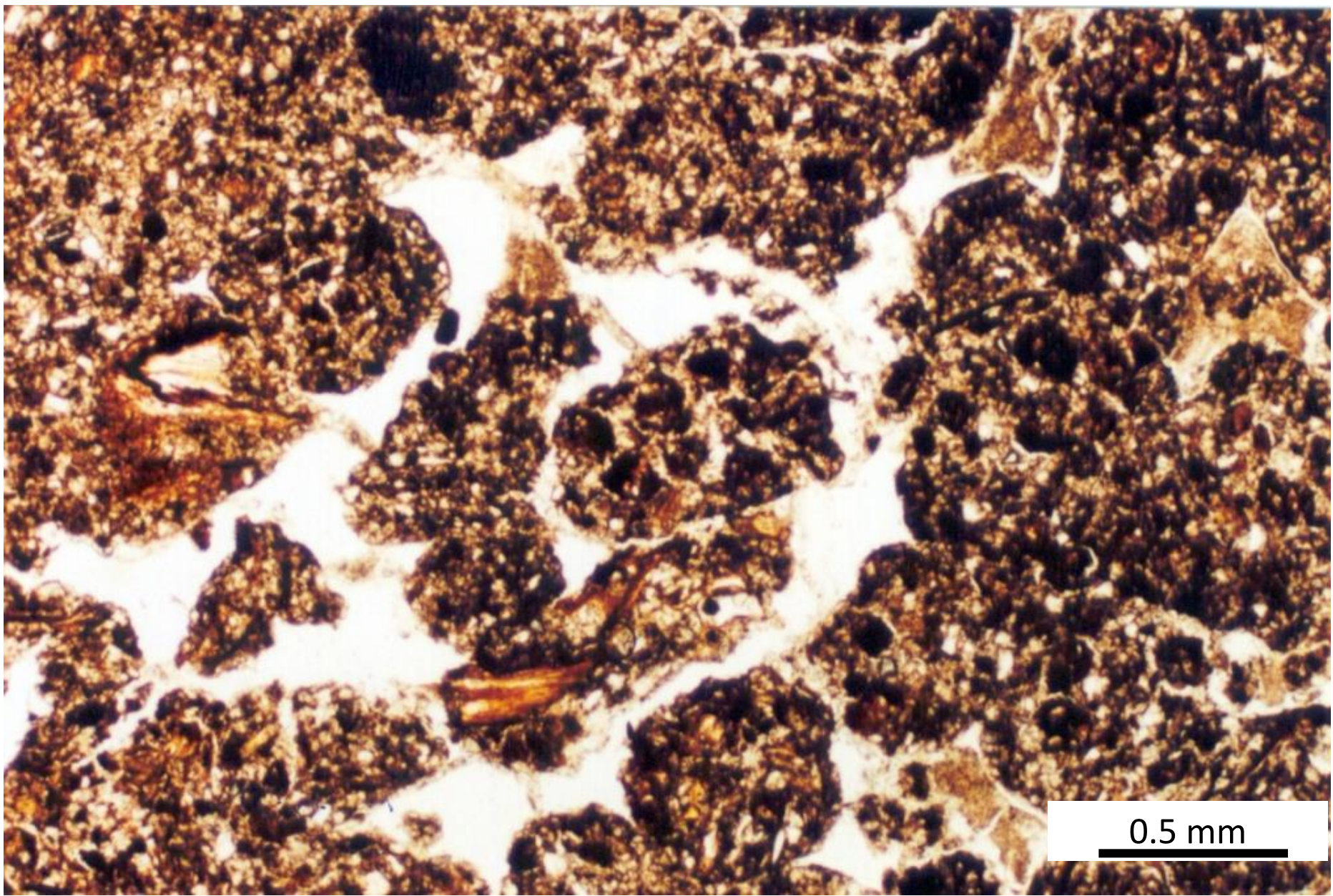
Granular structure:
Microaggregates held together with soil organic matter

Soil Health

- The term *soil health* refers to a holistic perspective on how a soil functions in the ecosystem, with particular emphasis on biological processes.

- Healthy soils are *resilient* to external impacts that might negatively affect the productivity and stability of the soil's ecosystem.

Soil health is soil- and site-specific.

Soil health depends on many factors, including

- inherent soil characteristics

- environmental influences such as climate

- human values such as land use, management goals, and environmental protection.

Why are assessments soil health valuable?

- (1) to provide quantitative values that allow the **comparison** of one soil with another and

- (2) to help make **predictions** about the impact of management decisions on soil behavior.

Soil Health Assessments

- Physical properties

- Chemical properties

- Biological properties

Physical properties

- **Measurement**
  - bulk density
  - infiltration rate
  - soil structure and macropores
  - depth
  - water-holding capacity

- **Significance**
  - availability of water and nutrients to plants
  - prediction of water movement
  - habitat for soil microbes
  - estimates of potential crop productivity
  - compaction

Chemical properties

- **Measurements**
  - electrical conductivity
  - soil nitrate
  - soil pH
  - extractable phosphorus and potassium

- **Significance**
  - biological and chemical activity thresholds
  - plant and microbial activity thresholds
  - plant-available nutrients
  - potential for N and P loss

Biological properties

- **Measurements**
  - earthworms and other animals
  - microbial biomass C and N
  - particulate organic matter
  - potentially mineralizable N
  - soil enzyme potentials
  - soil respiration rate
  - total organic carbon

- **Significance**
  - microbial catalytic potential
  - potential repository for C and N
  - N-supplying potential
  - microbial activity indices

Soil organic matter

- **Measurements**
  - Organic carbon
  - Organic nitrogen
  - Particulate organic matter
  - Oxidizable organic matter

- **Impacts**
  - nutrient retention
  - soil fertility
  - soil structure and porosity
  - soil stability and soil erosion
  - carbon storage

Why is soil organic matter important?

- **Cation exchange capacity** of soil organic matter: Retains nutrients like Ca, Mg, K.

- Source of **plant nutrients** – especially N, P, and S

- **Carbon storage** in soils

- Retention / binding of **pesticides**

- Retention / binding of **organic contaminants**

- Retention / binding of important **metals**

- **Structure and bulk density**: SOM binds clay and silt particles into aggregates, preventing *erosion*, increasing *water-holding capacity*, providing space for *root growth*, promoting *gas movement* in soil

Soil Health in Iowa: Treatments and Plots

- **Continuous corn** (grain and stover): *with* rye cover crop (**CCW**) or *no* cover crop (**CC**)
- Multi-species, **reconstructed prairie**: *with* annual N fertilizer (**PF**) or *no* fertilizer (**P**)

Representative suite of till-derived soils
Four replicate blocks per treatment, no tillage
Each of the 24 plots is 27 m x 61 m

Treatments (Cropping systems)

Continuous corn (CC)

Continuous corn with rye cover crop (CCW)

Reconstructed multispecies prairie without N fertilizer (P)

Reconstructed multispecies prairie with N fertilizer (PF)

Soil (surface horizon) characteristics

Cropping system	Soil pH	Soil organic carbon	Clay
		$g\ kg^{-1}$	$g\ kg^{-1}$
Continuous corn	6.9	25	282
Continuous corn *with* cover crop	6.9	26	244
Prairie – *no* N	6.8	26	269
N-fertilized prairie	6.8	30	282

Soil Health Parameters

- CO_2 respiration using the "Solvita" technique

  ➤ 24-h incubation at uniform water content

- Water-extractable organic carbon (WEOC) and organic nitrogen (WEON)

- NH_4-N, NO_3-N, extracted with both **water** and **H3A**

  The "H3A" extraction uses a composite of low-molecular-mass organic anions (lithium citrate, citric acid, malic acid, and oxalic acid) at pH 4.4.

Soil CO$_2$ respiration
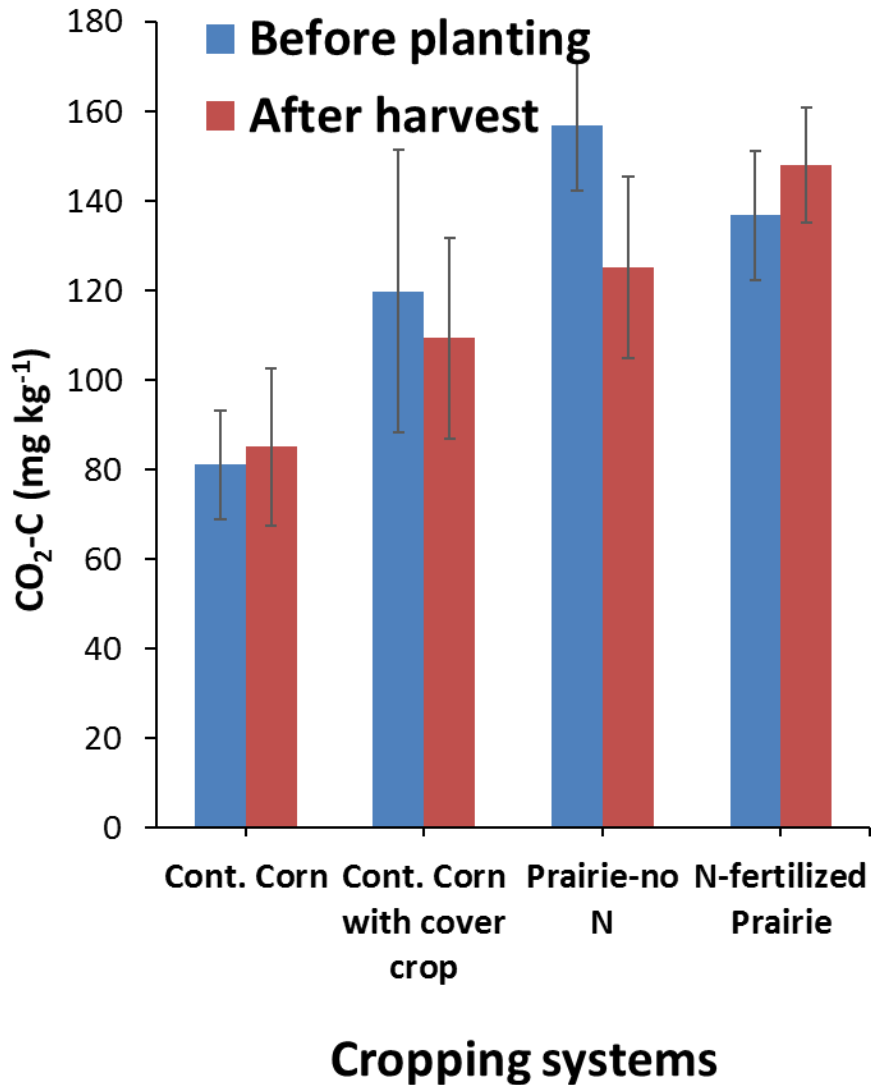
Water-extractable OC
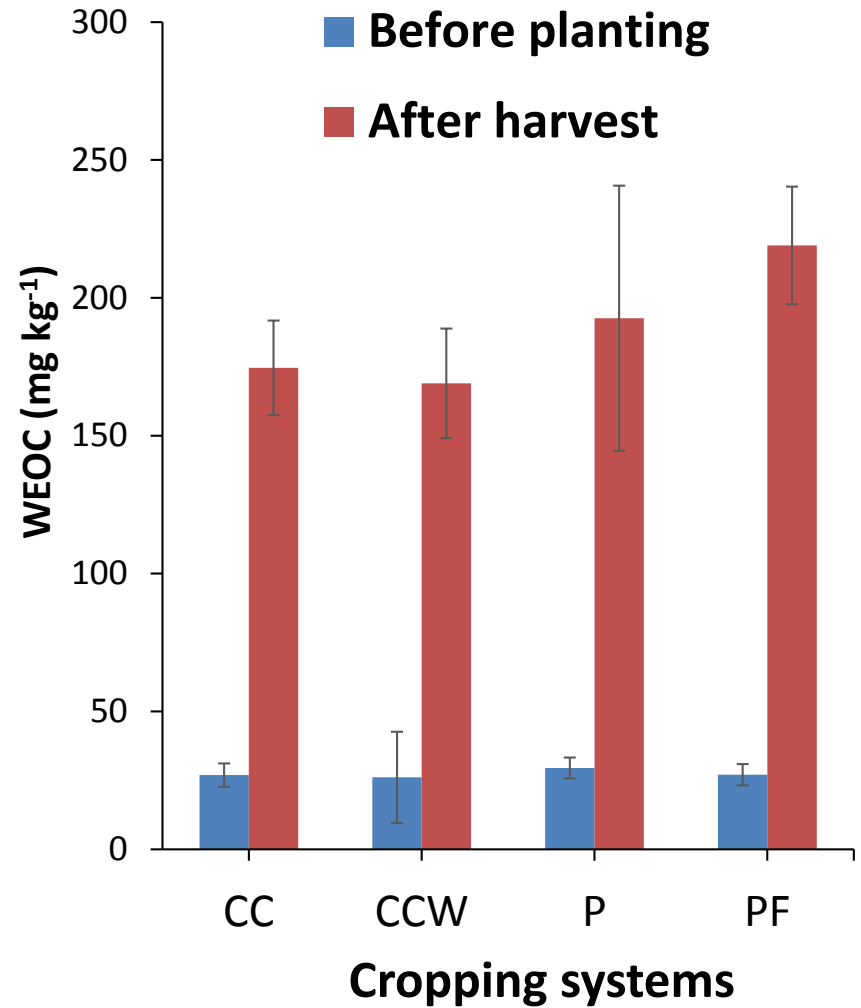
Calculated Soil Health Index

Haney Soil Health Index =

(CO_2-C / 10) + **(WEOC / 100)** + **(WEON / 10)**
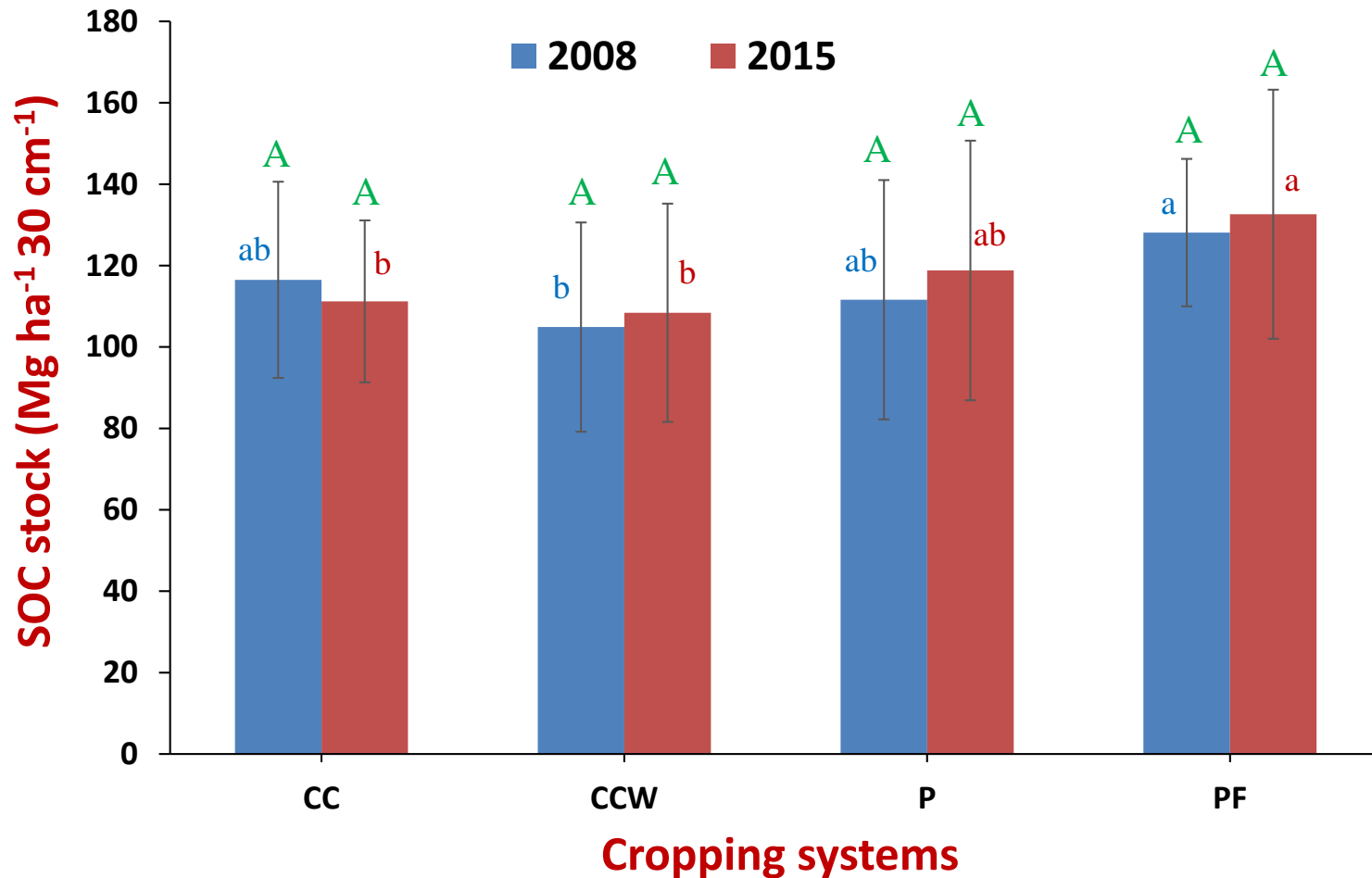
Water-extractable organic carbon

Soil CO_2 respiration
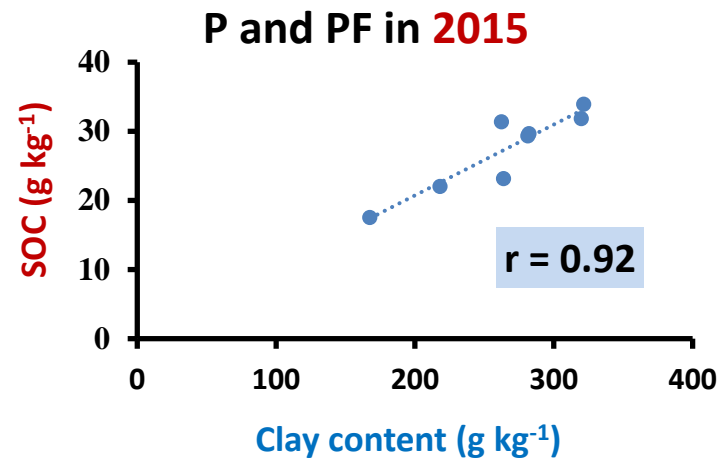
Water-extractable organic nitrogen
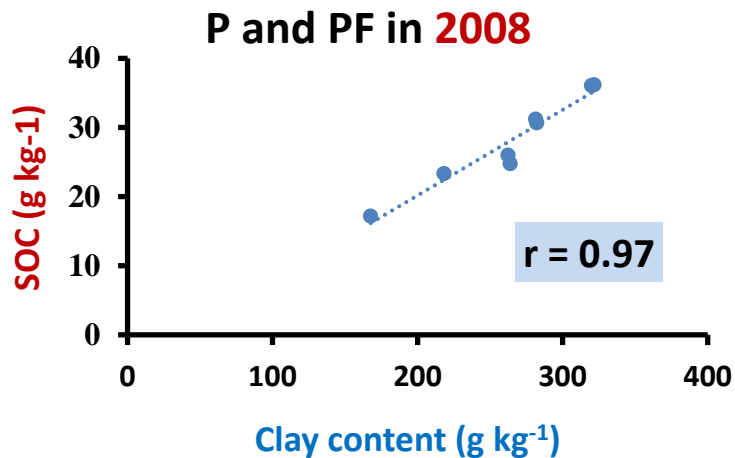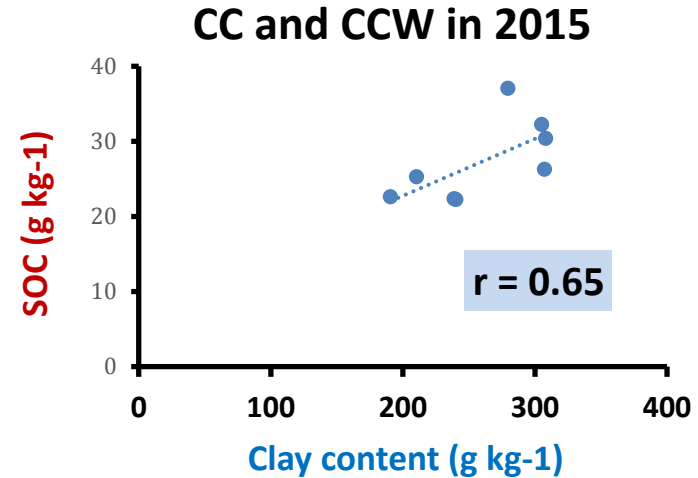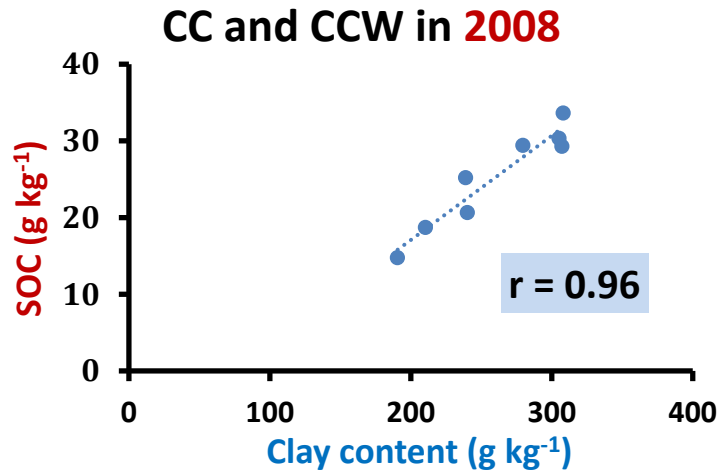
Haney Soil Health Index
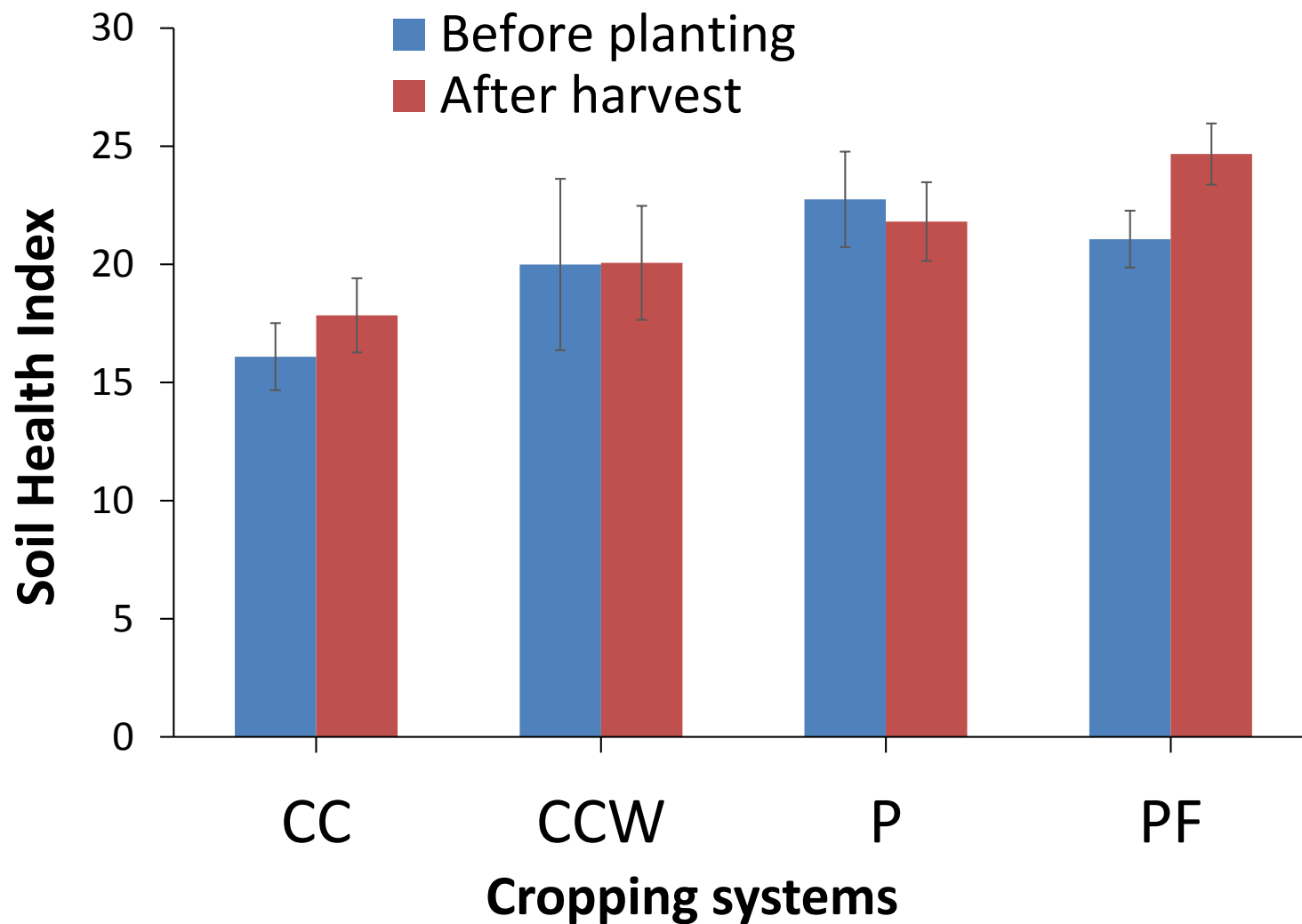
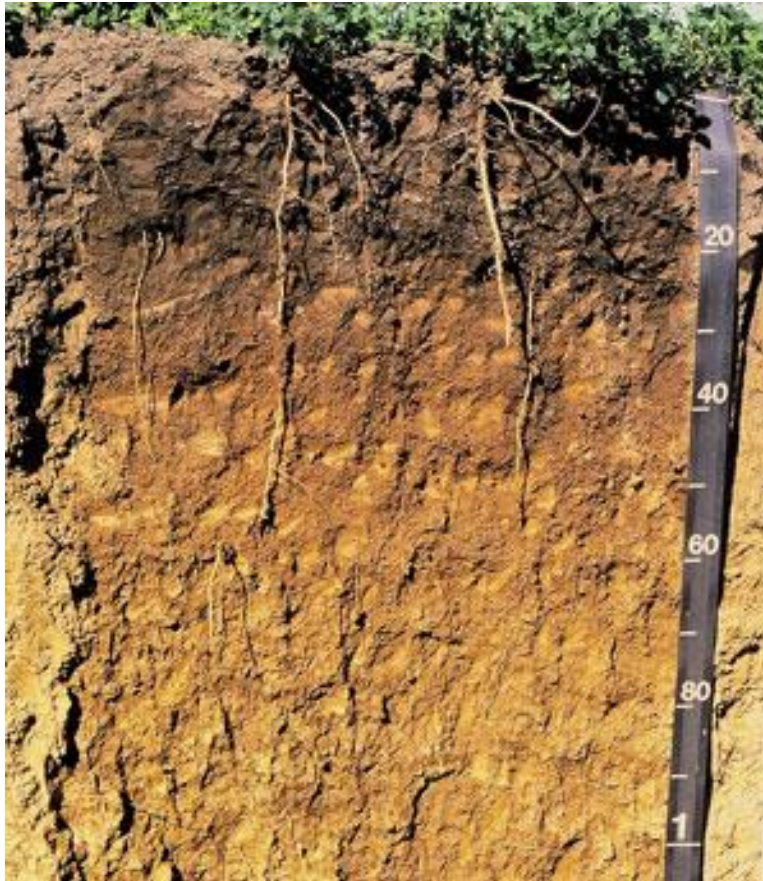# Soil organic carbon stock in annual and perennial cropping systems (*equivalent soil mass*)

Integrated Soil Health Assessments

- Soil functions and behaviors arise from the integration of physical, chemical, and biological processes.

- It is important to measure these properties over time.

- We can compare soils to one another more consistently.

- We can assess the value of our management approaches more consistently.

- We can make better predictions about the future of soil functioning in the ecosystem.

Correlation between clay content and soil organic carbon

CC and CCW in 2008

r = 0.96

(SOC (g kg^{-1}) vs Clay content (g kg^{-1}))

CC and CCW in 2015

r = 0.65

(SOC (g kg-1) vs Clay content (g kg-1))

P and PF in 2008

r = 0.97

(SOC (g kg-1) vs Clay content (g kg^{-1}))

P and PF in 2015

r = 0.92

(SOC (g kg^{-1}) vs Clay content (g kg^{-1}))

Marshall

- The Marshall series consists of very deep, well drained soils formed in loess.

- These soils are on interfluves and hill slopes on uplands and on risers and treads on stream terraces. Slope ranges from 0 to 25 percent.

- Mean annual air temperature is about 11 degrees C. Mean annual precipitation is about 765 millimeters.

- TAXONOMIC CLASS: Fine-silty, mixed, superactive, mesic Typic Hapludolls

Primghar

- The Primghar series consists of very deep, somewhat poorly drained soils formed in loess on uplands and high stream benches. Slope ranges from 0 to 5 percent.

- Mean annual air temperature is about 8 degrees C (47 degrees F), and mean annual precipitation is about 690 millimeters (27 inches).

- TAXONOMIC CLASS: Fine-silty, mixed, superactive, mesic Aquic Hapludolls

Nira

- The Nira series consists of very deep, moderately well drained soils formed in loess. These soils are on short, convex to linear side slopes on interfluves on dissected till plains and on risers on loess-covered stream terraces in river valleys. Slope ranges from 2 to 18 percent.

- Mean annual air temperature is about 10 degrees C. Mean annual precipitation is about 900 millimeters.

- TAXONOMIC CLASS: Fine-silty, mixed, superactive, mesic Aquic Argiudolls
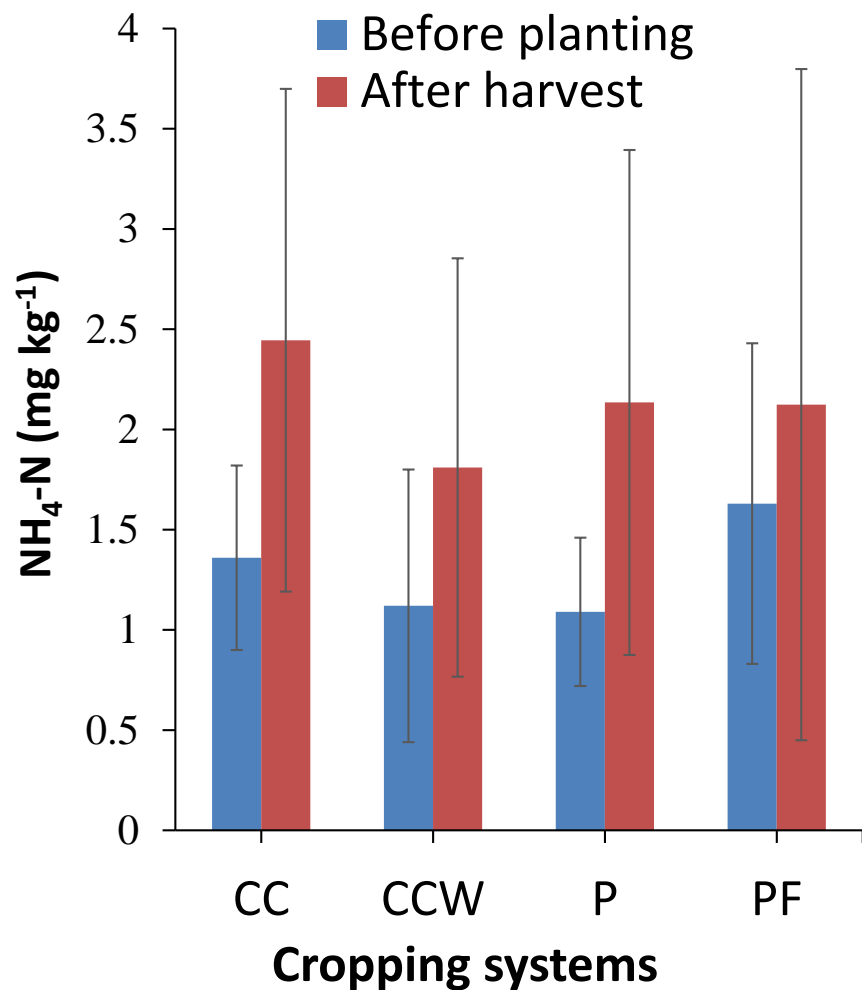
Sharpsburg

- The Sharpsburg series consists of very deep, moderately well drained soils formed in loess. These soils are on interfluves and hill slopes on uplands and on treads and risers on stream terraces in river valleys. Slope ranges from 0 to 18 percent.

- Mean annual air temperature is about 13 degrees C (55 degrees F). Mean annual precipitation is about 900 millimeters (35 inches).

- TAXONOMIC CLASS: Fine, smectitic, mesic Typic Argiudolls
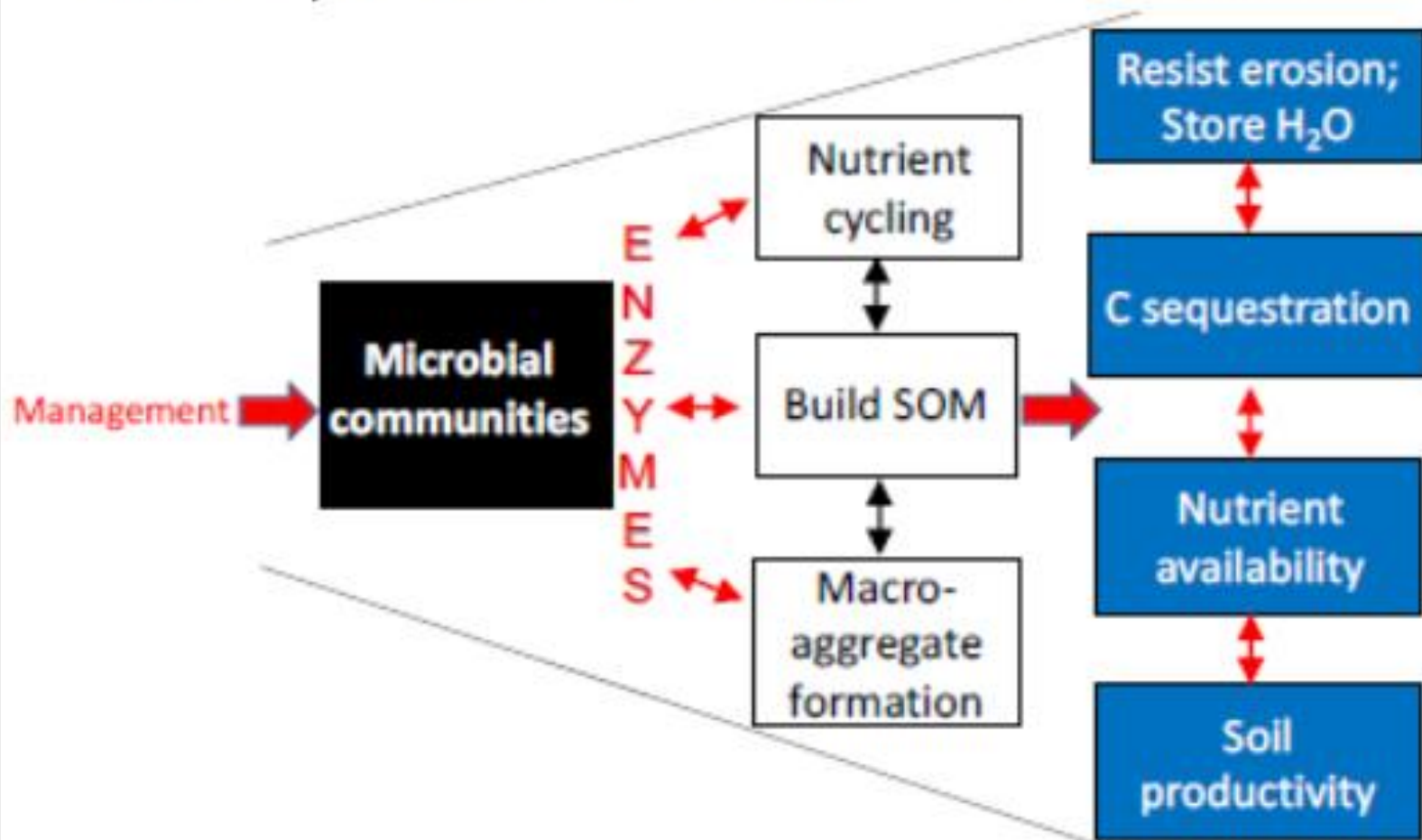
Courtesy of Veronica Acosta-Martínez

NH₄-N (extracted with H3A)

NH$_4$-N (extracted with H3A)

NO₃-N (extracted with H3A)

NO$_3$-N (extracted with H3A)