Measuring Soil Properties to Assess Soil Quality

Charles W. Raczkowski
North Carolina A&T State University

Soil Quality

"The capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant, animal and human health."

Soil Quality Assessment

- **Choose indicators of soil quality based on the multiple functions of soil that maintain productivity and environmental health.**
- **Must include soil physical, chemical, and biological properties.**
- **Give importance to those soil functions that need to be improved.**

Choosing Soil Quality Indicators

Condition	Indicator Properties
Weak soil structure	Aggregate stability, slaking, qualitative assessment
Crust prone soil	Infiltration, aggregate stability
Low infiltration & high runoff rates	Infiltration
Low nutrient & water retention	CEC, organic matter content, water holding capacity
High erodibility	Aggregate stability

A “minimum set” of physical, chemical and biological properties is chosen to assess the overall function of soil.

Soil Properties		
Physical	**Chemical**	**Biological**
Bulk Density	Soil pH	Soil Respiration
Infiltration	Soil Nitrate	Earthworms
Aggregate Stability	Electrical Conductivity	
Soil Slaking		

Two Ways to Assess Soil Quality

1. **Measurements over time.**
2. **Comparisons.**

Examples:

1. **Measurements in the same field over time.**
2. **Problem areas versus non-problem areas.**
3. **Compare management systems.**

Soil Physical Properties

- ✓ Bulk Density
- ✓ Aggregate Stability
- ✓ Slaking
- ✓ Infiltration
- ✓ Morphological observations
- ❑ Porosity
- ❑ Pore-Size Distribution
- ❑ Soil Strength
- ❑ Water Retention

Bulk Density

- **The ratio of oven-dried soil (mass) to its bulk volume (g/cm^3).**
- **Range: 1.00 to 1.80 g/cm^3.**
- **Calculation:**

  BD = Oven-Dry Soil Weight / Core Sample Volume

  $$BD = \frac{\text{Oven-Dry Soil Weight}}{\text{Core Sample Volume}}$$

- **Indicator of: Compaction, Pore Space**
- **Related to: Water Dynamics, Root Growth**

Aggregate Stability (AS)

- **Measures the amount (%) of stable aggregates against flowing water.**

- **Calculation:**

  AS = 100 [(Weight of Stable Aggregates) ÷ (Weight of Aggregate Sample Used)]

- **Indicator: Soil erodibility, soil aggregation (structure).**

Infiltration

- **The entry of water into the soil (cm/hr).**
- **The height (cm) of water entering the soil surface per unit time (hr).**
- **Calculation:**

$Ir = (WV \div CA) \div T_{ir}$

where,

Ir = Infiltration rate (cm/hr)

WV = Volume of water (cm^3) infiltrating in time T_{ir} (hr)

CA = Cylinder area (cm^2)

Indicator: Water runoff, erosion, surface crusting.

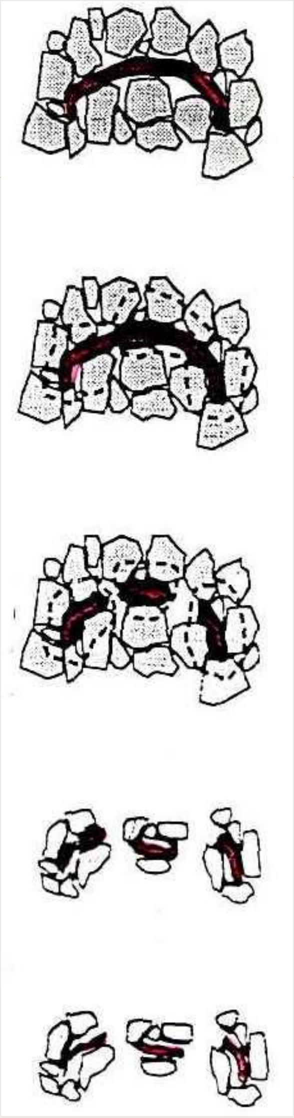
Increasing soil organic matter improves these soil properties.

AS ↑

Ir ↑

BD ↓

Soil aggregates form around organic residues



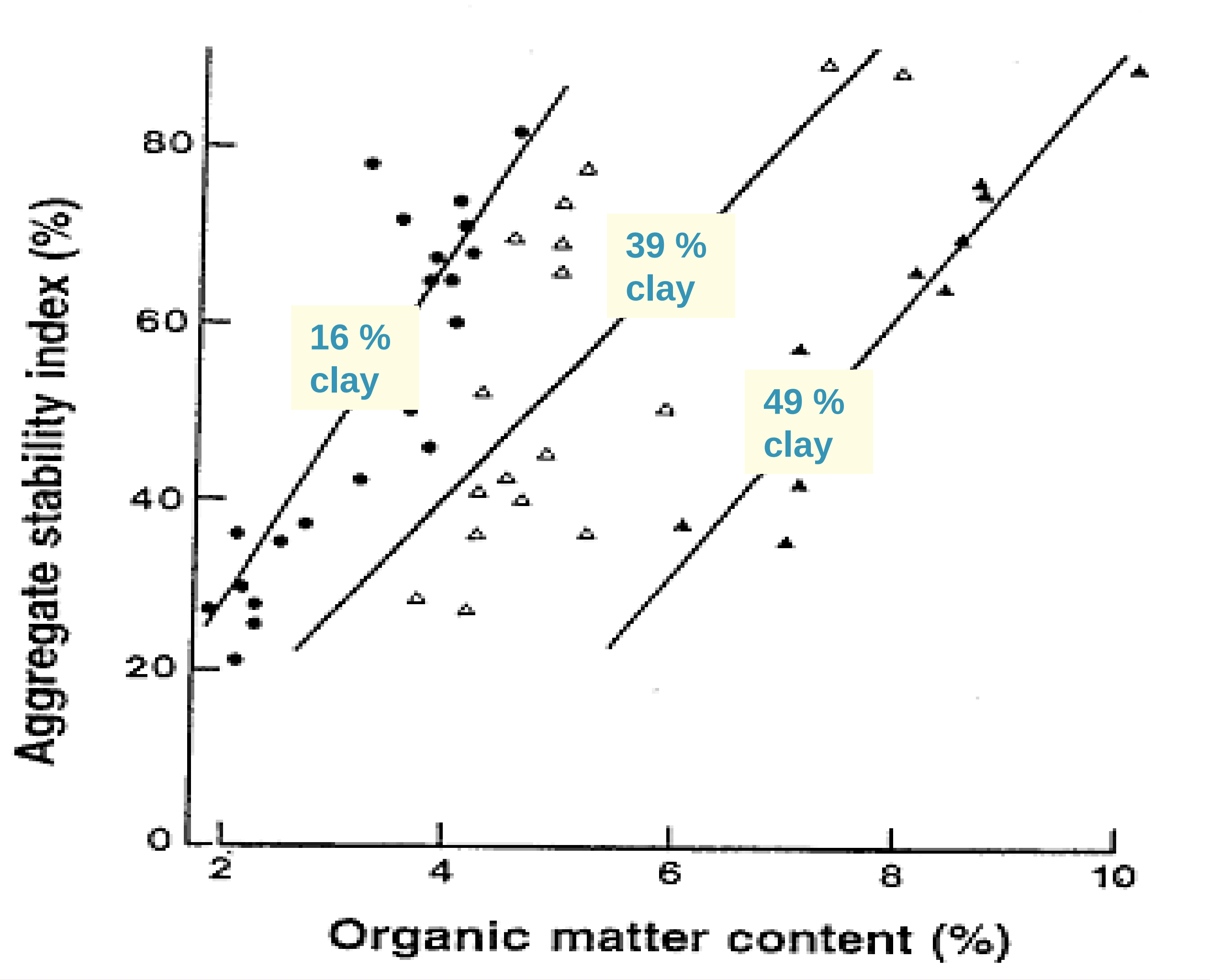
Processes that disrupt aggregates increase loss of SOM

AS ↓

Ir ↓

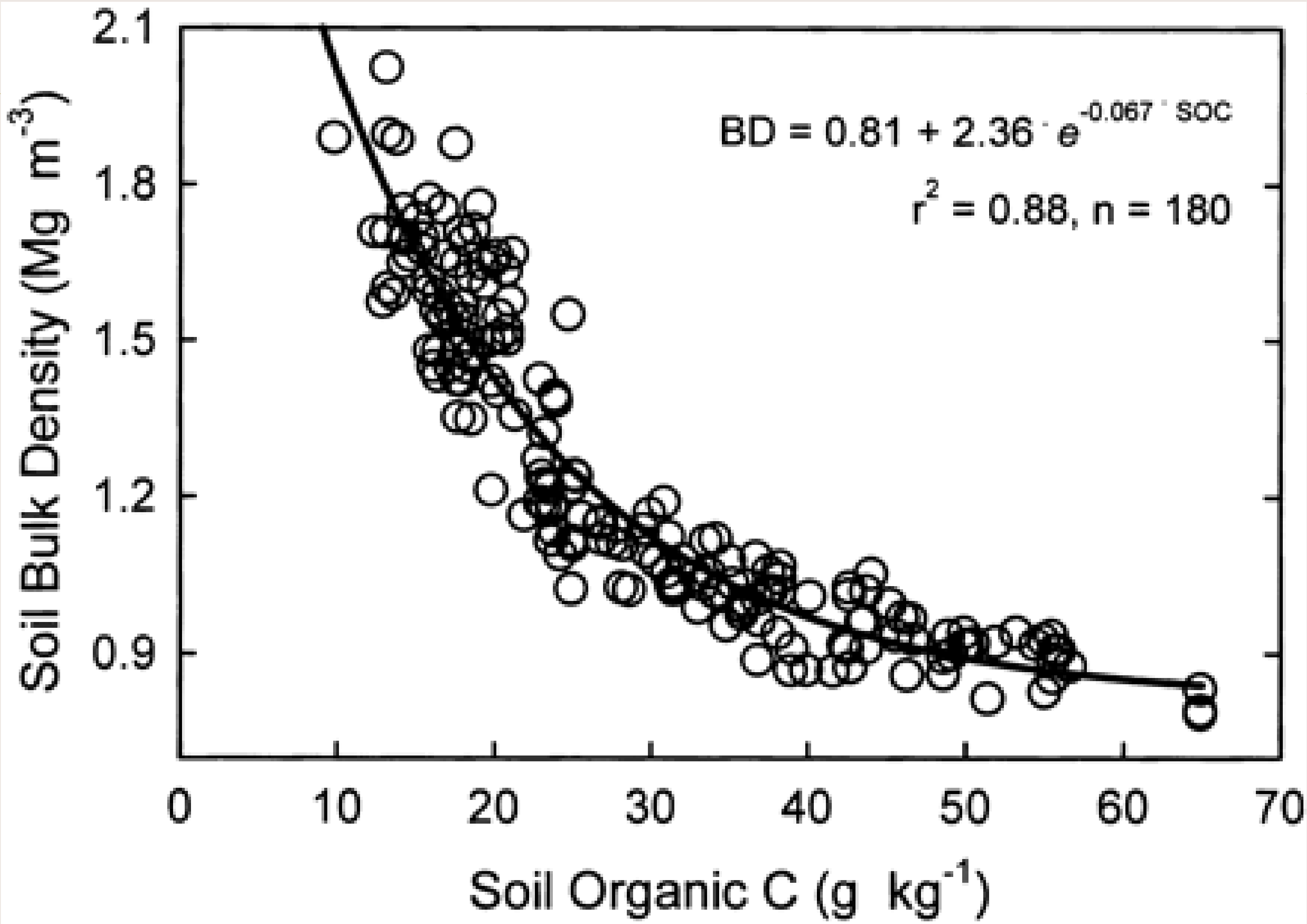
BD ↑

More OM is needed to stabilize fine textured soils



Adapted from Russell (1973)

Effect of long term sod on bulk density



http://soil.scijournals.org/cgi/content-nw/full/65/3/834/FIG3


25 yrs of
CT corn
20 yrs of
bluegrass,
then 5 yrs
CT corn
LOW
O.M.
HIGH
O.M.
photo by Ray Weil


"Slaking" after adding water
LOW
O.M.
HIGH
O.M.
photo by Ray Weil

Minimizing Tillage

Applying Soil Amendments

Managing Crop Residues