Soil Health:

A Holistic Approach to Managing Soil for Resilience

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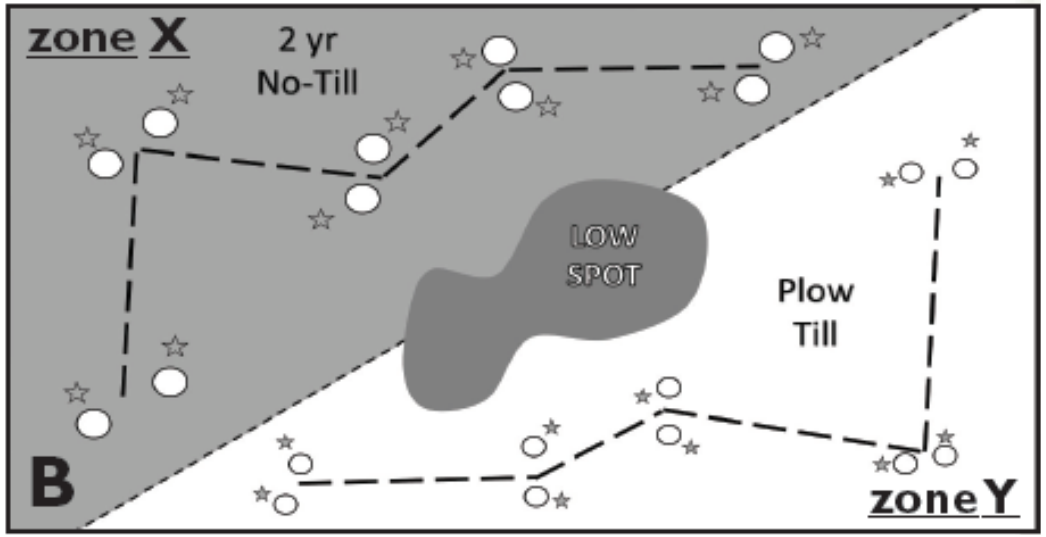
NY Soil Health Training 10-22-20

CornellCALS College of Agriculture and Life Sciences

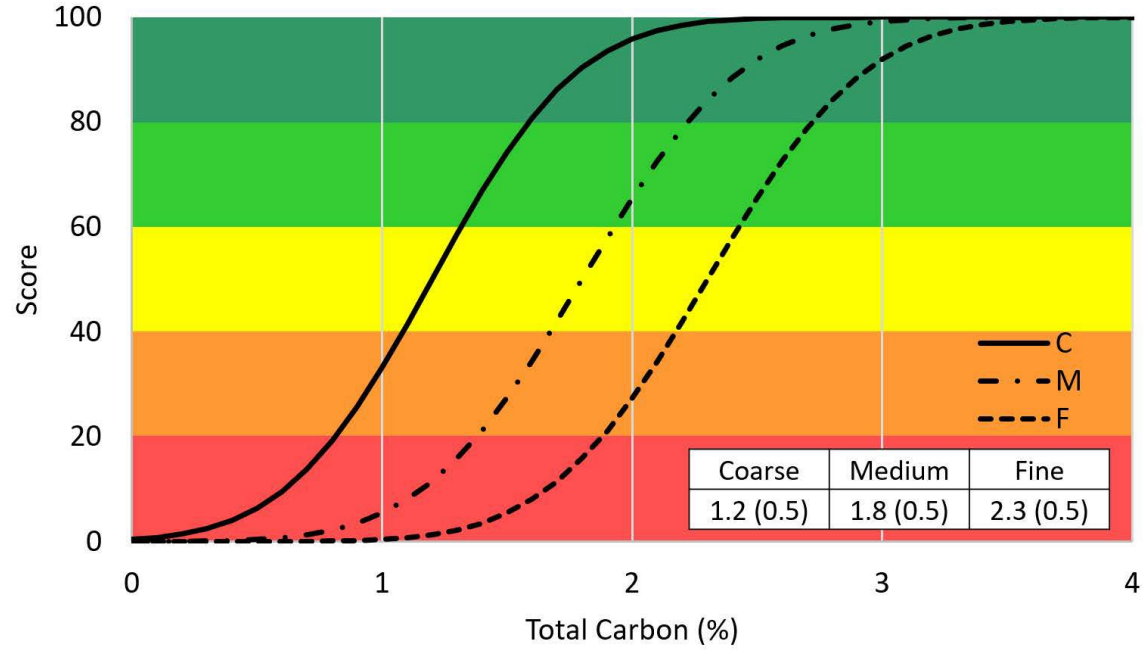
Sampling Considerations

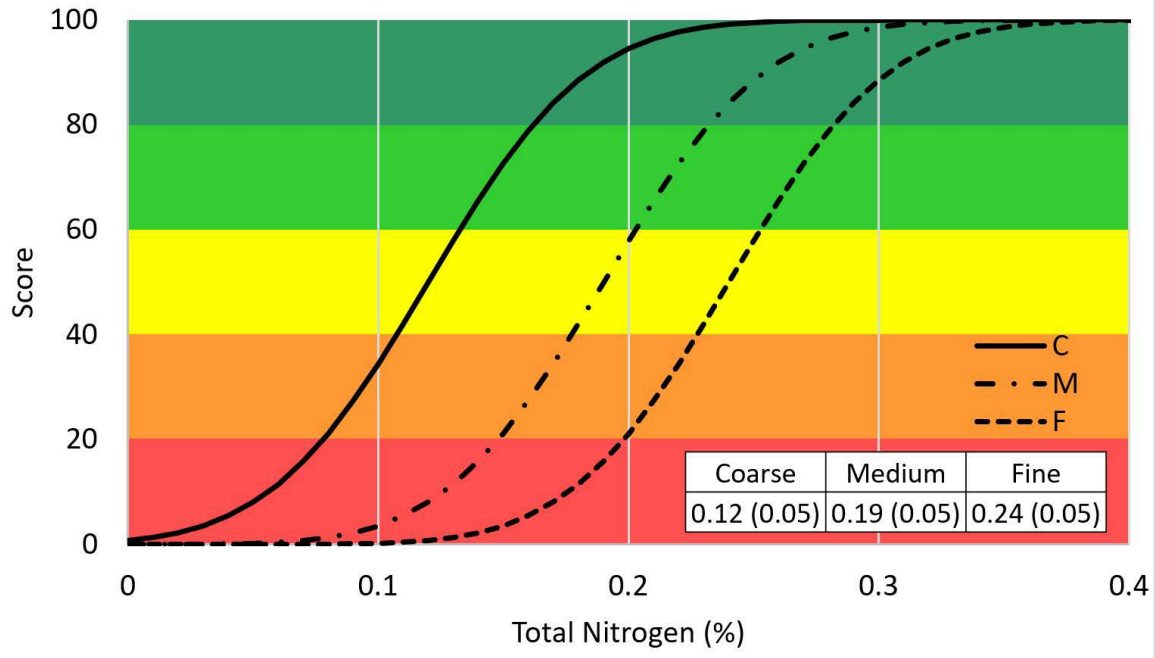
“Ask your Best Question”



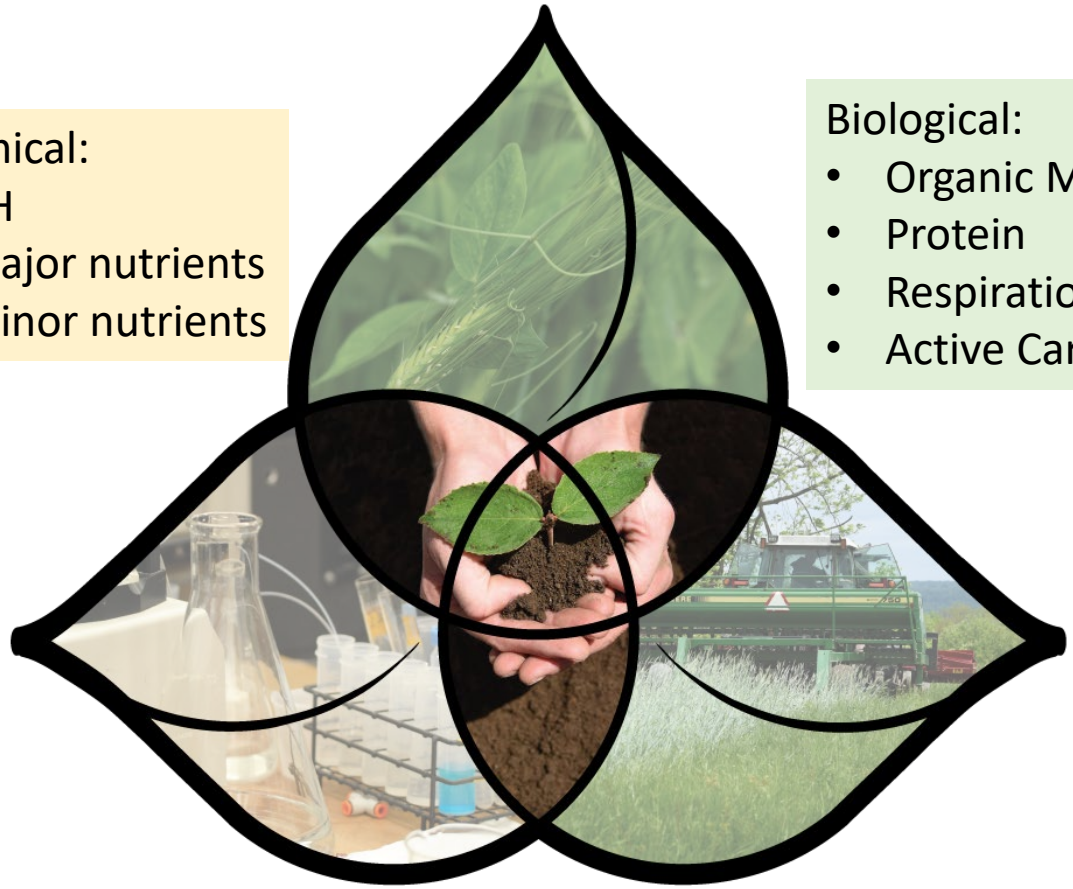
Video link: https://soilhealth.cals.cornell.edu/testing-services/collecting-samples/

Quantifying Soil Health





Chemical:
- pH
- Major nutrients
- Minor nutrients



Biological:
- Organic Matter
- Protein
- Respiration
- Active Carbon

Physical:
- Texture
- Aggregate Stability
- Surface/sub-surface hardness

Biological Indicators:

(The life of the soil)

- Organic Matter
- Protein
- Respiration
- Active Carbon
- Total Carbon, Total Nitrogen

Soil Organic Matter (SOM):

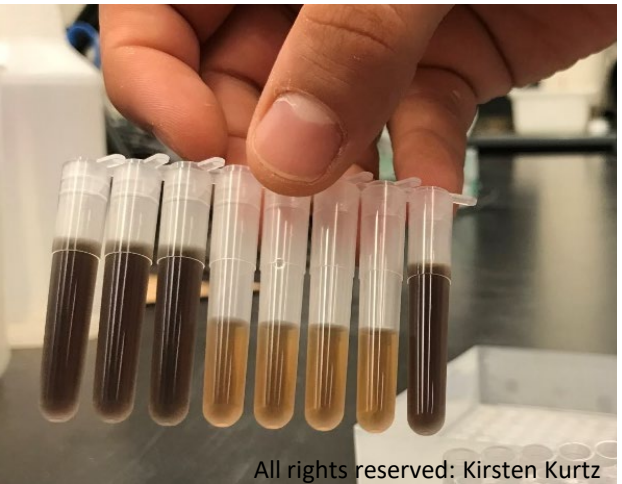
Measure of carbon-containing material that is, or is derived from living organisms including plants and other soil dwelling organisms.

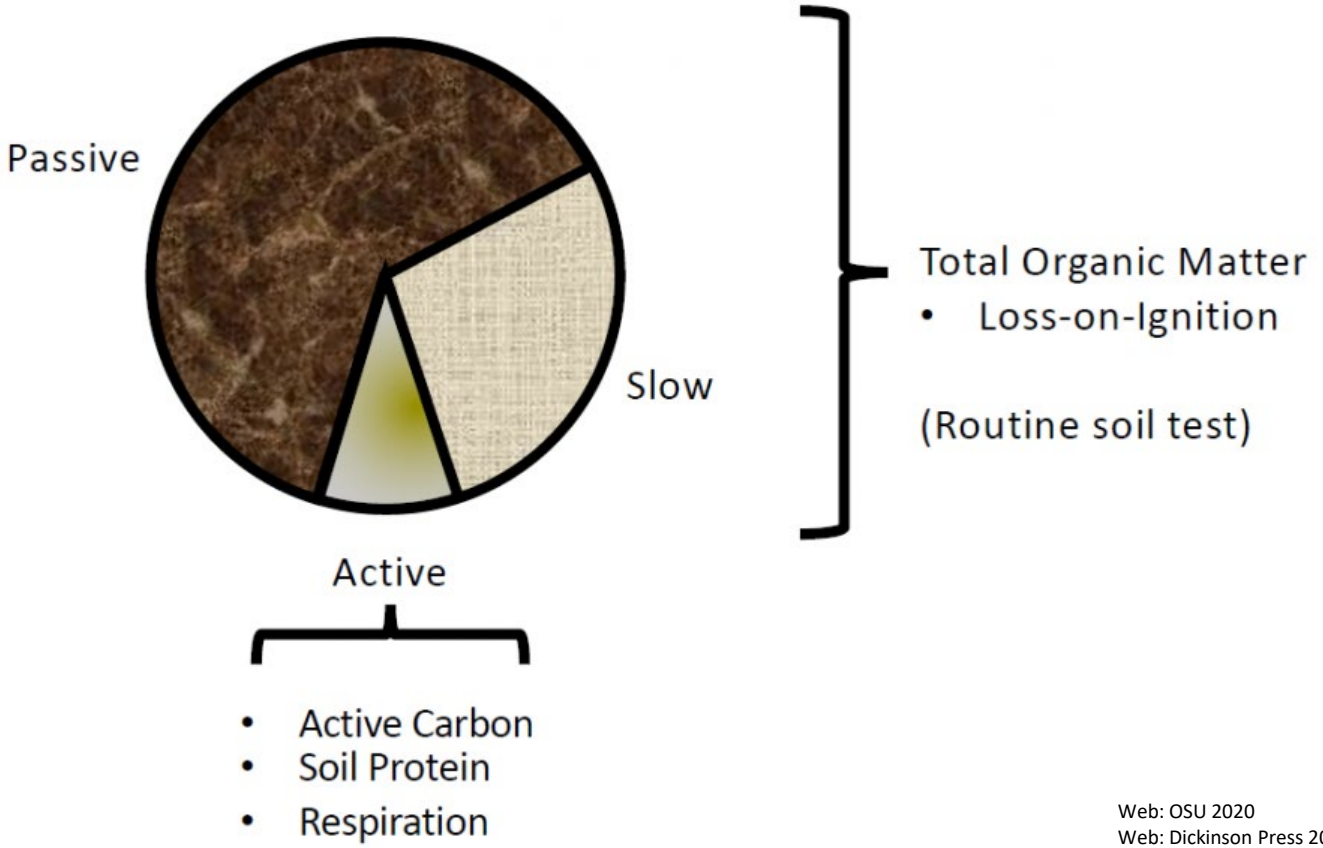
Basic protocol:

- Measured by Loss on Ignition at 500C
- % OM = (%LOI * 0.7) – 0.23
- Reported as % SOM

Soil Protein Index:

- Derived from plant residues in soil
- Indicator of protein-like substances present in SOM. Represents the large pool of organically bound N in SOM, which microbial activity can mineralize and make available for plant uptake



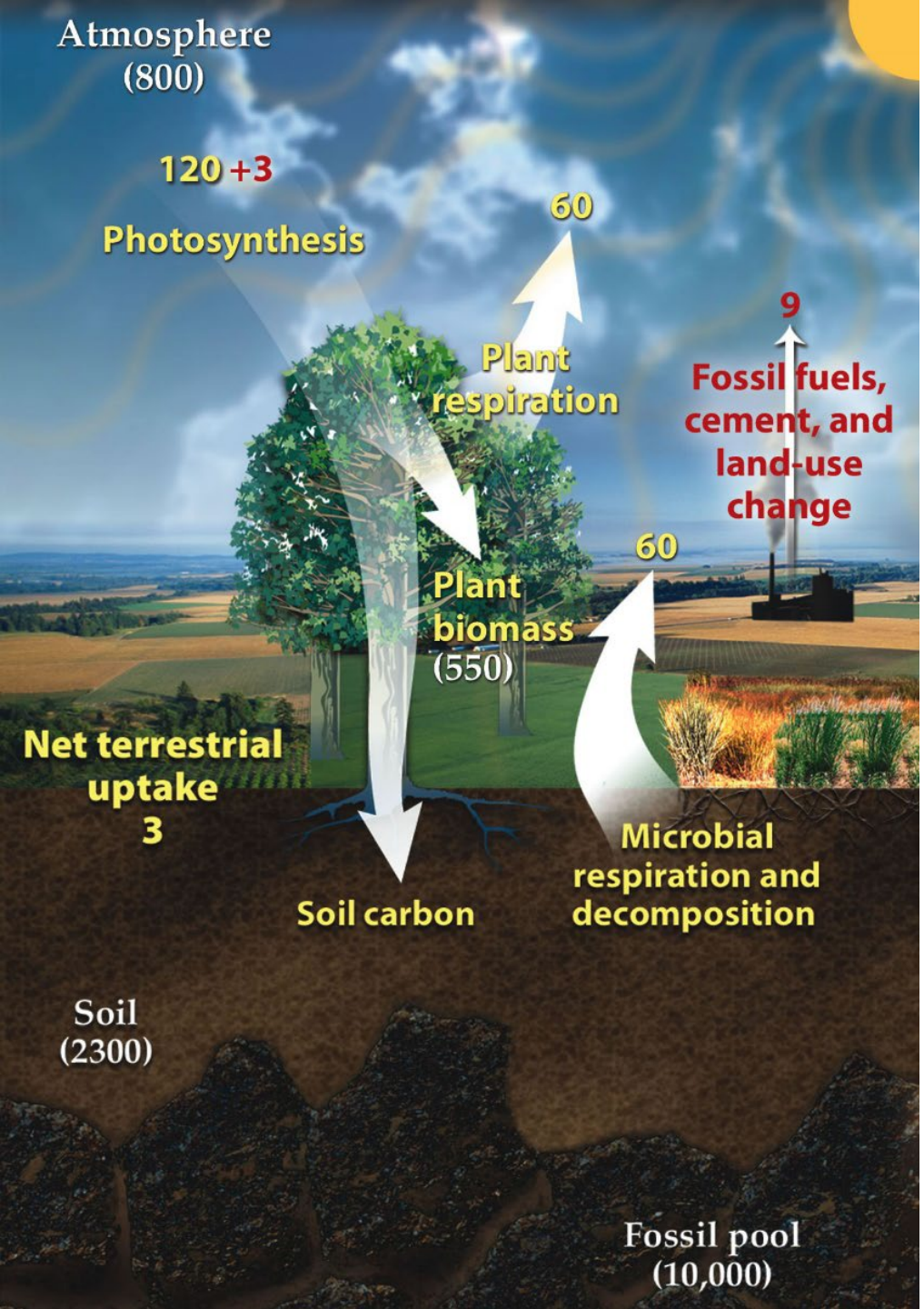


Web: OSU 2020
Web: Dickinson Press 2020

Soil Protein Index

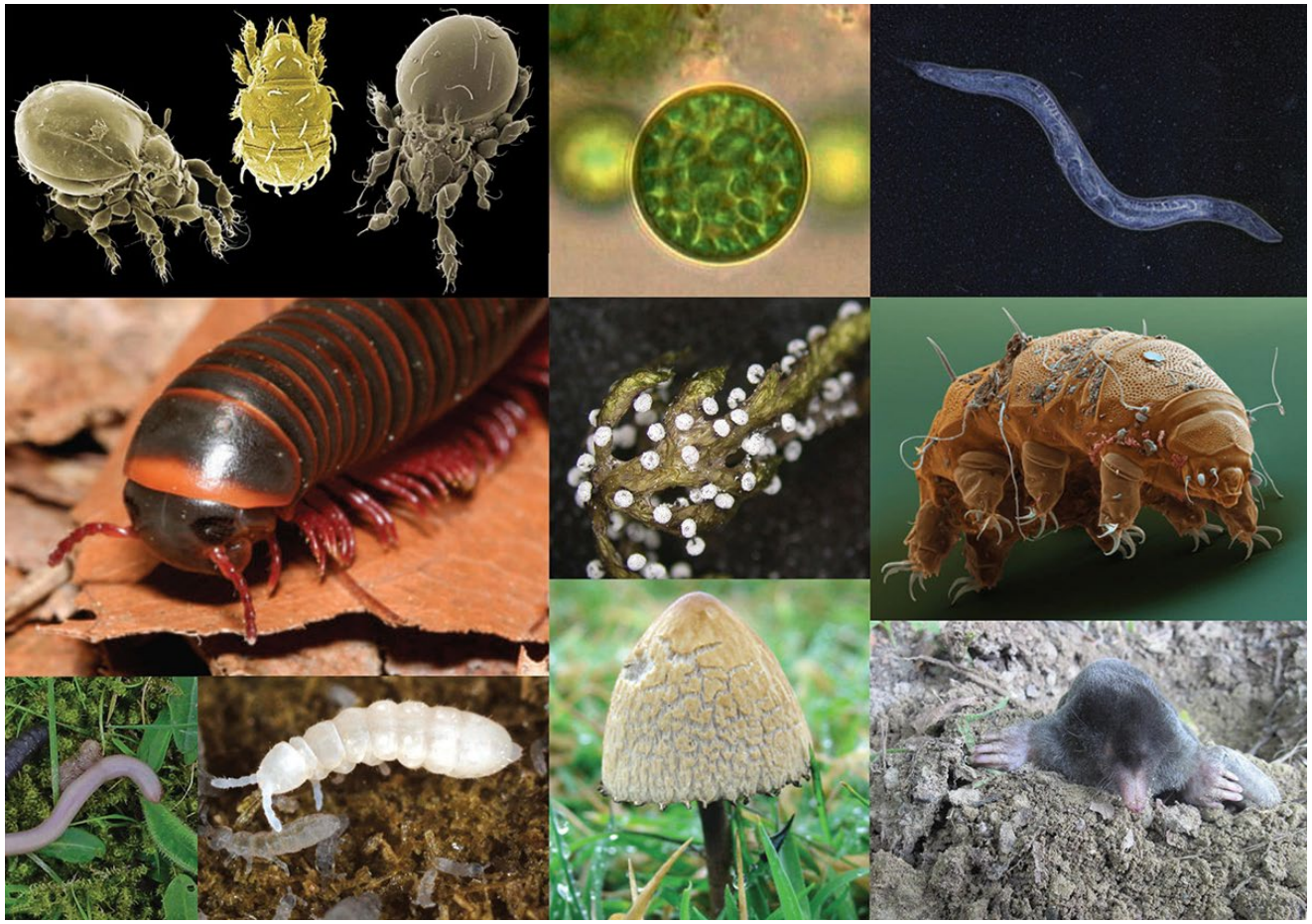
Basic Protocol:

- Proteins are extracted from soil
- Aggregates are dispersed using sodium citrate buffer
- Solution autoclaved, 2 ml slurry centrifuged
- Extract analyzed in standard colorimetric protein quantification assay (Thermo Pierce BCA Protein Assay)
- Read for color with spectrophotometric plate reader



Soil Respiration

- Measure of metabolic activity of soil microbial community



Source: Global Soil Biodiversity Atlas and Joint Research Centre.

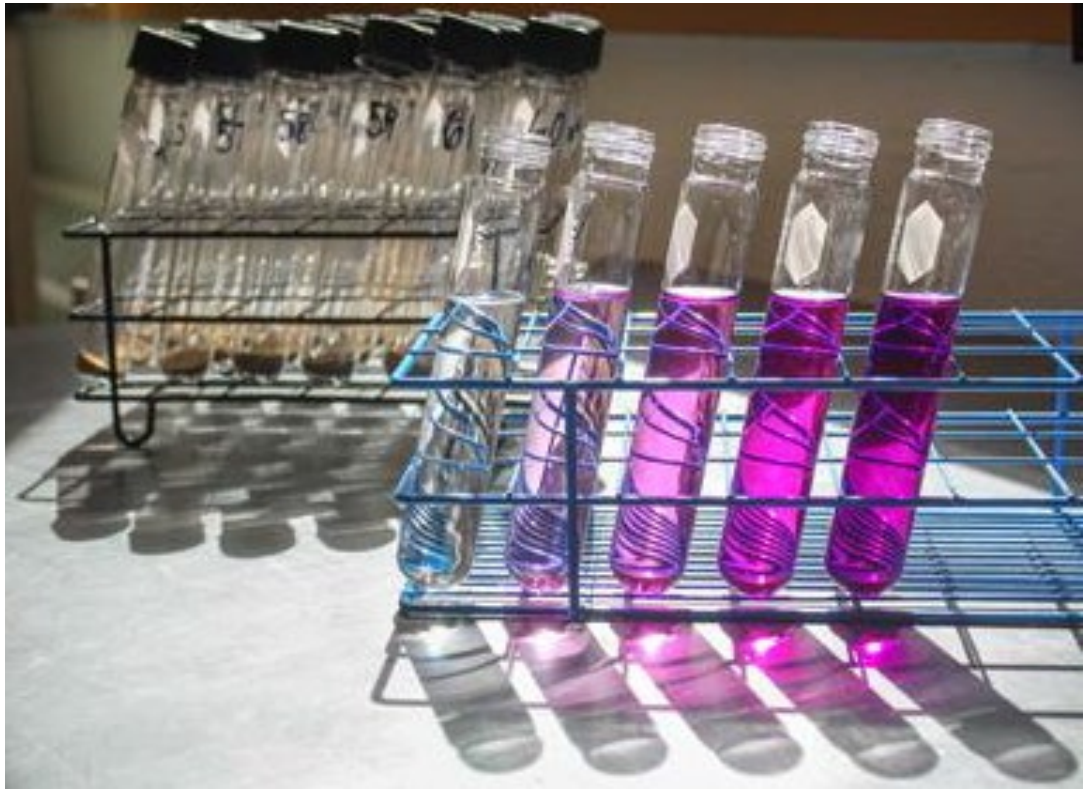
Soil Respiration

Basic Protocol:

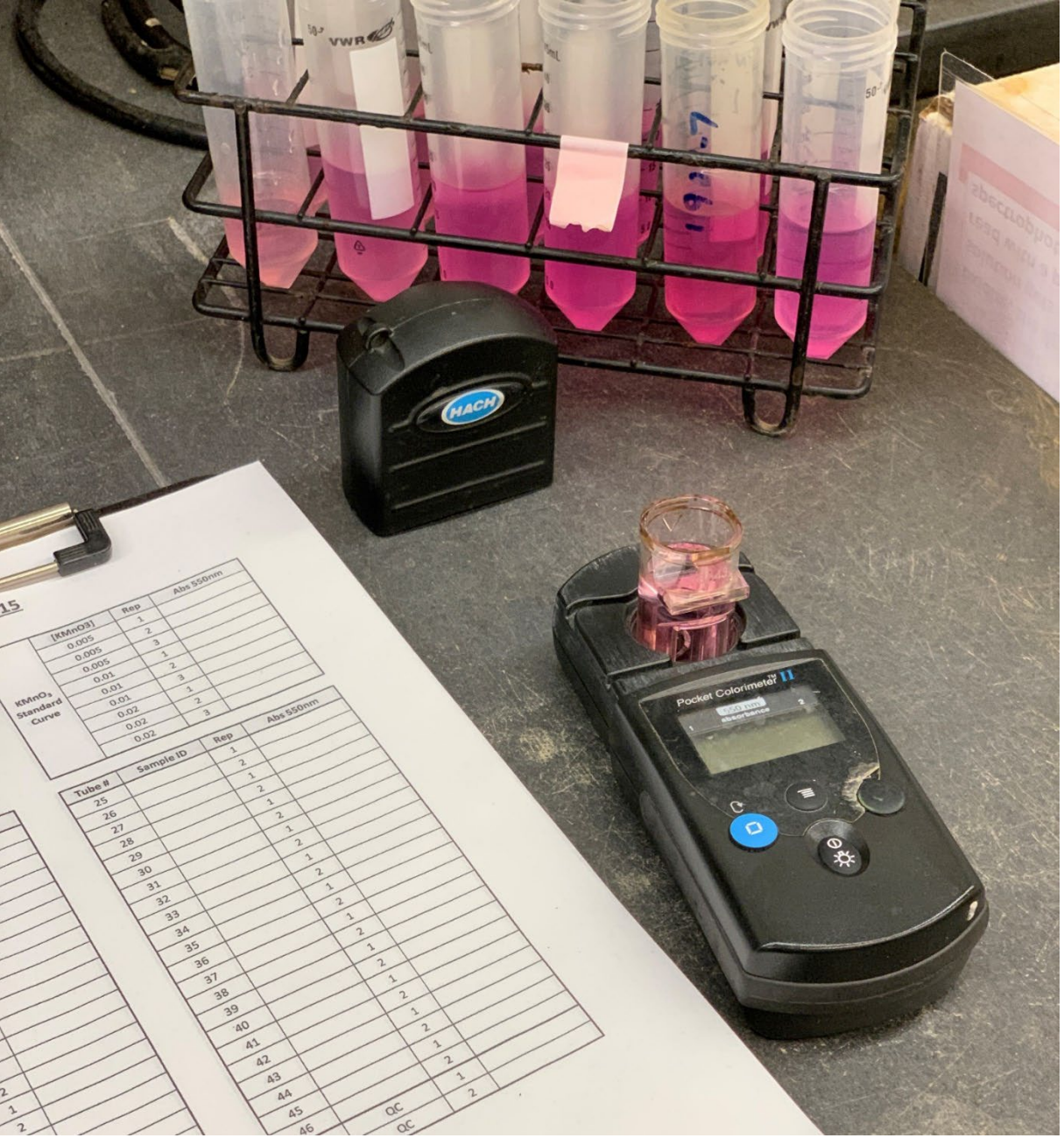
- 20g air-dried soil
- Rewetted and placed in jar with 9ml of 0.5 M Potassium Hydroxide (KOH) and 7ml water
- Jar sealed for 4 days
- Conductivity of KOH measured determining total captured CO2
- CO2 (0.25 M K2 CO2)

Active Carbon

- Indicator of SOM that can serve as readily available food and energy source for soil microbial community



https://enst.umd.edu/people/faculty/ray-weil



Active Carbon

Basic Protocol:

- 2.5g, air-dried soil in centrifuge tube with 20ml 0.02 potassium permanganate (KMnO4)
- Shaken for 2 minutes, settled for 8 min.
- Solution lightens and color is measured with colorimeter
- Reported as ppm

Total Carbon, Total Nitrogen

- Total Carbon is a measure of both the organic and inorganic forms of carbon in soil. Including relatively available organic carbon and more stable organic carbon that is protected in the soil.

- Total Nitrogen exists in organic forms and inorganic (or mineral) forms such as plant available ammonium (NH_4^+) and nitrate (NO_3^-). The majority of Tot N is bound in soil organic matter.

Photos: Scaler website

Total Carbon, Total Nitrogen

Measurement of the carbon and nitrogen in soil samples is accomplished using a temperature regulated dry combustion furnace with automatic control of gas flow and pressures.

- The Tot C in a sample is obtained with the complete oxidation of carbon to CO2 using high temperature combustion (1100 °C) and CO2 measurement using Non Dispersive Infrared Detection.

- The Tot N in a sample is obtained following the Dumas Methodology.
- In this analysis, the sample is moved into the combustion furnace where all Nitrogen is converted to NxOy using oxygen.
- Then the effluent gas is moved to the reduction furnace where all nitrogen is reduced to N2.
- The N2 gas is measured by Thermal Conductivity Detection (TCD).

Physical Indicators:

- Aggregate Stability
- Texture
- Available Water Capacity
- Surface/Subsurface Hardness

Aggregate Stability

- A measure of the extent to which soil aggregates resist falling apart when hit by rain drops and wetted.

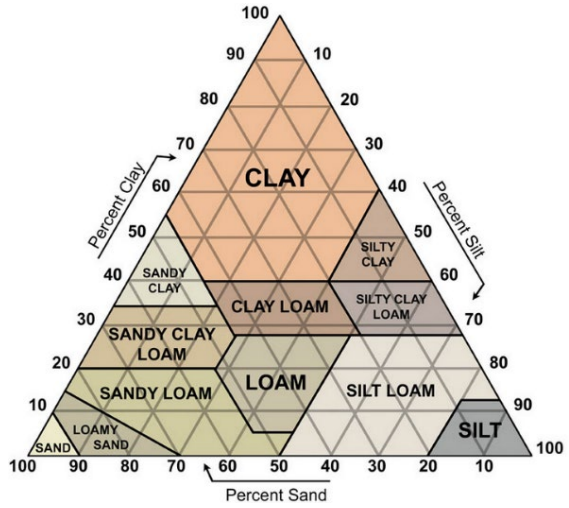
Aggregate Stability

Basic Protocol:

- Air-dried soil is shaken to remove aggregates >0.25mm
- Known weight placed on 0.25mm sieve
- Sieves “rained on” for 5 minutes
- Failed aggregates caught by filter, weighed
- Stones remaining weighed
- % stable aggregates quantified
- WSA=Wstable/Wtotal

Soil Texture

- Percentage of sand, silt and clay. Inherent soil property that affects many soil processes



Soil Texture

Basic Protocol:

- 14g air-dried soil shaken in soap solution for 2 hours to separate sand, silt and clay
- Sand removed by 0.053mm sieve
- Silt and clay removed via water into beaker
- Silt settles to bottom of beaker in 2 hours
- Decant clay, dry at 105C weigh sand and silt

Available Water Capacity

- Indicator of the range of plant available water the soil can store.
- The upper end of the range is referred to as ‘field capacity. The lower end of the range is called the ‘permanent wilting point’

Textural Class	Available Water Capacity (Inches/Foot of Depth)
Coarse sand	0.25–0.75
Fine sand	0.75–1.00
Loamy sand	1.10–1.20
Sandy loam	1.25–1.40
Fine sandy loam	1.50–2.00

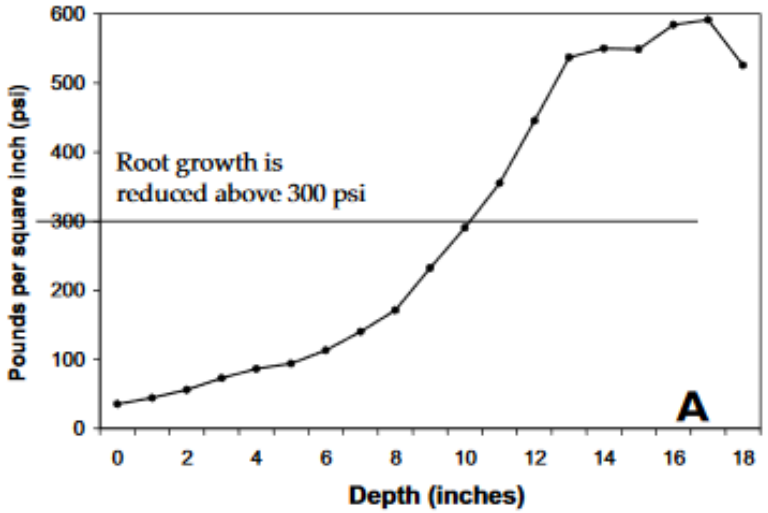
Available Water Capacity

Basic Protocol:

- Soil is placed on ceramic plates with known porosity
- Plates are placed in 2 high pressure chambers to extract water to field capacity (10 kPa) and permanent wilting point (1500 kPa)
- After sample equilibrates, samples dried in 105C oven and weighed

Surface and Subsurface Hardness

- Indicators of the soil compaction status, measured as field penetration resistance in pounds per square inch (psi)



Chemical Indicators:

(typical soil test)

- pH
- Major Nutrients (NPK)
- Minor Nutrients

Comprehensive Assessment of Soil Health

From the Cornell Soil Health Laboratory, Department of Soil and Crop Sciences, School of Integrative Plant Science, Cornell University, Ithaca, NY 14853. http://soilhealth.cals.cornell.edu

Grower:
Bob Schindelbeck

Sample ID: pp917
Field ID: Caldwell Field- Intensive cultivation
Date Sampled: 02/13/2017
Given Soil Type: Collamer silt loam
Crops Grown: WHT/WHT/WHT

Measured Soil Textural Class: **silt loam**

Sand: **10%** - Silt: **73%** - Clay: **16%**

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.16	52	
physical	Surface Hardness	260	12	Rooting, Water Transmission
physical	Subsurface Hardness	340	35	
physical	Aggregate Stability	13.4	16	Aeration, Infiltration, Rooting, Crusting, Sealing, Erosion, Runoff
biological	Organic Matter	2.1	16	Nutrient and Energy Storage, Ion Exchange, C Sequestration, Water Retention
biological	ACE Soil Protein Index	4.4	26	
biological	Soil Respiration	0.7	68	
biological	Active Carbon	312	15	Energy Source for Soil Biota
chemical	Soil pH	6.1	80	
chemical	Extractable Phosphorus	13.1	100	
chemical	Extractable Potassium	78.0	100	
chemical	Minor Elements Mg: 109.2 / Fe: 2.6 / Mn: 30.3 / Zn: 0.4		100	

Overall Quality Score: **52** / Medium

Comprehensive Assessment of Soil Health

From the Cornell Soil Health Laboratory, Department of Soil and Crop Sciences, School of Integrative Plant Science, Cornell University, Ithaca, NY 14853. http://soilhealth.cals.cornell.edu

Grower:
Bob Schindelbeck

Sample ID: pp918
Field ID: Caldwell Field- Sod rotation
Date Sampled: 02/13/2017
Given Soil Type: Collamer silt loam
Crops Grown: SOD/SOD/SOD

Measured Soil Textural Class: **silt loam**

Sand: **7%** - Silt: **77%** - Clay: **14%**

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.27	95	
physical	Surface Hardness	95	79	
physical	Subsurface Hardness	151	91	
physical	Aggregate Stability	52.7	88	
biological	Organic Matter	3.6	75	
biological	ACE Soil Protein Index	8.8	75	
biological	Soil Respiration	1.9	99	
biological	Active Carbon	536	57	
chemical	Soil pH	5.8	47	
chemical	Extractable Phosphorus	11.4	100	
chemical	Extractable Potassium	118.6	100	
chemical	Minor Elements Mg: 137.0 / Fe: 4.3 / Mn: 15.2 / Zn: 2.7		100	

Overall Quality Score: **84** / Optimal

Short and Long-Term Management

Management Suggestions for Physical and Biological Constraints

Constraint	Short Term Management Suggestions	Long Term Management Suggestions
Predicted Available Water Capacity Low	• Add stable organic materials, mulch • Add compost or biochar • Incorporate high biomass cover crop	• Reduce tillage • Rotate with sod crops • Incorporate high biomass cover crop
Surface Hardness High	• Perform some mechanical soil loosening (strip till, aerators, broadfork, spader) • Use shallow-rooted cover crops • Use a living mulch or interseed cover crop	• Shallow-rooted cover/rotation crops • Avoid traffic on wet soils, monitor • Avoid excessive traffic/tillage/loads • Use controlled traffic patterns/lanes
Subsurface Hardness High	• Use targeted deep tillage (subsoiler, yeomans plow, chisel plow, spader.) • Plant deep rooted cover crops/radish	• Avoid plows/disks that create pans • Avoid heavy loads • Reduce traffic when subsoil is wet
Aggregate Stability Low	• Incorporate fresh organic materials • Use shallow-rooted cover/rotation crops • Add manure, green manure, mulch	• Reduce tillage • Use a surface mulch • Rotate with sod crops and mycorrhizal hosts
Organic Matter Low	• Add stable organic materials, mulch • Add compost and biochar • Incorporate high biomass cover crop	• Reduce tillage/mechanical cultivation • Rotate with sod crop • Incorporate high biomass cover crop
ACE Soil Protein Index Low	• Add N-rich organic matter (low C:N source like manure, high N well-finished compost) • Incorporate young, green, cover crop biomass • Plant legumes and grass-legume mixtures • Inoculate legume seed with Rhizobia & check for nodulation	• Reduce tillage • Rotate with forage legume sod crop • Cover crop and add fresh manure • Keep pH at 6.2-6.5 (helps N fixation) • Monitor C:N ratio of inputs
Soil Respiration Low	• Maintain plant cover throughout season • Add fresh organic materials • Add manure, green manure • Consider reducing biocide usage	• Reduce tillage/mechanical cultivation • Increase rotational diversity • Maintain plant cover throughout season • Cover crop with symbiotic host plants
Active Carbon Low	• Add fresh organic materials • Use shallow-rooted cover/rotation crops • Add manure, green manure, mulch	• Reduce tillage/mechanical cultivation • Rotate with sod crop • Cover crop whenever possible

ACE Soil Protein Index: Low

Short term:

- Add N-rich organic matter (low C:N source like manure, high N well-finished compost)
- Incorporate young, green, cover crop biomass
- Plant legumes and grass-legume mixtures
- Inoculate legume seed with Rhizobia & check for nodulation

Long Term:

- Reduce tillage
- Rotate with forage legume sod crop
- Cover crop and add fresh manure
- Keep pH at 6.2-6.5 (helps N fixation)
- Monitor C:N ratio of inputs

Thank You!

Questions?

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