
Understanding laboratory soil health tests: where are we now and where are we going?
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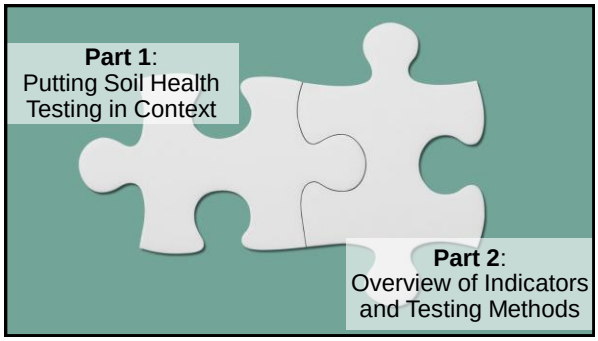
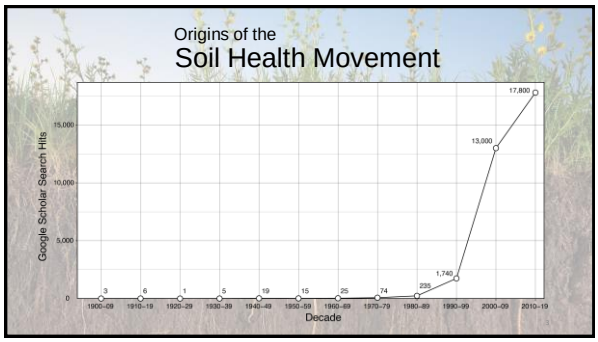
PURDUE UNIVERSITY


Part 1:
Putting Soil Health Testing in Context
Part 2:
Overview of Indicators and Testing Methods


Origins of the
Soil Health Movement
Google Scholar Search Hits
15,000
10,000
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1,740
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1900–09
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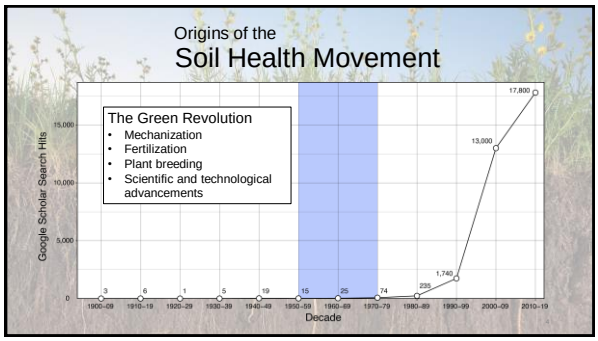
1960–69
1970–79
1980–89
1990–99
2000–09
2010–19
Decade


Origins of the
Soil Health Movement
The Green Revolution
• Mechanization
• Fertilization
• Plant breeding
• Scientific and technological advancements
Google Scholar Search Hits
Decade
3
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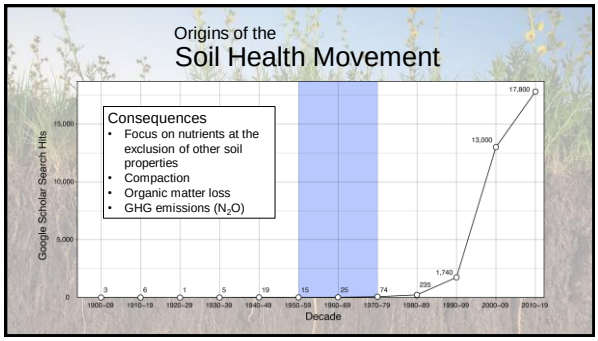
Origins of the
Soil Health Movement
Consequences
• Focus on nutrients at the exclusion of other soil properties
• Compaction
• Organic matter loss
• GHG emissions (N_2O)
Google Scholar Search Hits
Decade
3
6
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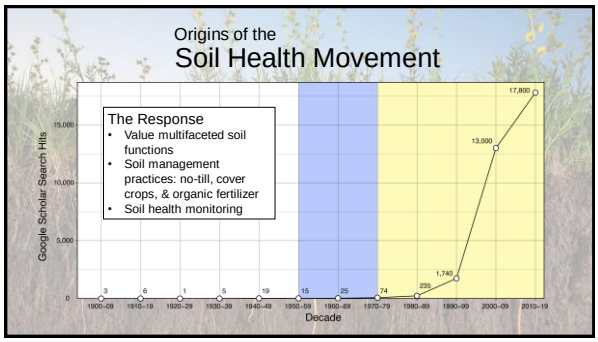
5
19
15
25
74
235
1,740
13,000
17,800


Origins of the
Soil Health Movement
The Response
• Value multifaceted soil functions
• Soil management practices: no-till, cover crops, & organic fertilizer
• Soil health monitoring
Google Scholar Search Hits
Decade
3
6
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Google: "Soil Health Policy Resources Catalog"

STATE OF NEW YORK

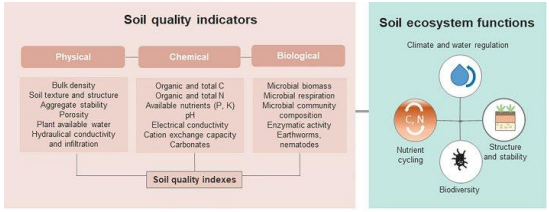
NY Bill A05386 (February 10th, 2021)

"Soil health" means soils that have the continuing capacity to function as a vital, living ecosystem that sustains plants, animals, and humans.

The benefits of healthy soil include:

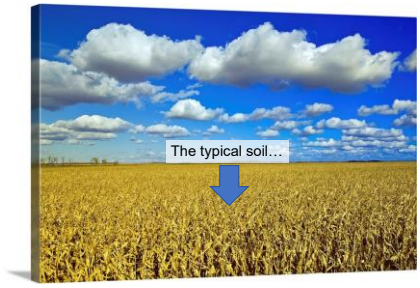
1. supporting the **production** of food, feed, fiber, and fuel
2. **facilitating infiltration, storage and filtration of water** and protecting water quality
3. enhanced nutrient-holding capacity and **nutrient cycling**
4. providing habitat for **diverse soil organisms**
5. enhanced **resilience** to drought, extreme precipitation events, temperature extremes, pests, diseases and other stresses
6. **breaking down harmful chemicals**
7. reducing agricultural impacts on, and mitigating the impact on agriculture of, global climate change
8. **sequestering carbon** and net long-term greenhouse gas benefits.

Soil Health Indicators

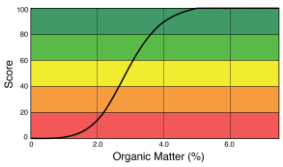


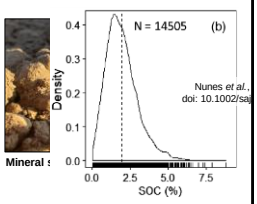
Soil Health Indicators (*n*) – are soil properties that correspond with soil health functions *and* are sensitive to environmental changes.

The Foundation of Current Soil Health Frameworks



Assumptions are part of **Soil Health Indicators**





- Current Soil Health assessment rating systems are for mineral soils

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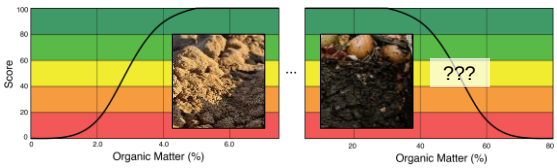
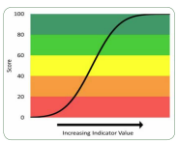


- In others contexts, one might have too much of a good thing

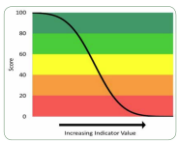
Current Assumptions in Soil Health Indicators

More is better



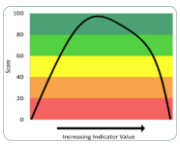
- Soil organic matter
- Aggregate stability
- Available Water Capacity
- Potential mineralizable N

Less is better



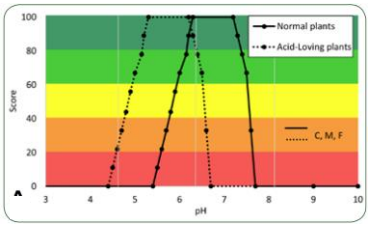
- Soil hardness
- Bulk density
- Pathogen burden

Balance is better



- Soil pH
- Phosphorus

Diverging assumptions about soil pH



Moebius-Clune *et al.*, 2016;
http://www.css.cornell.edu/extension/soil-health/manual.pdf

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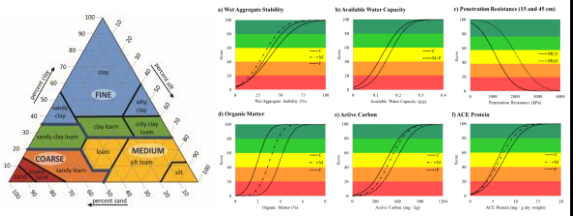
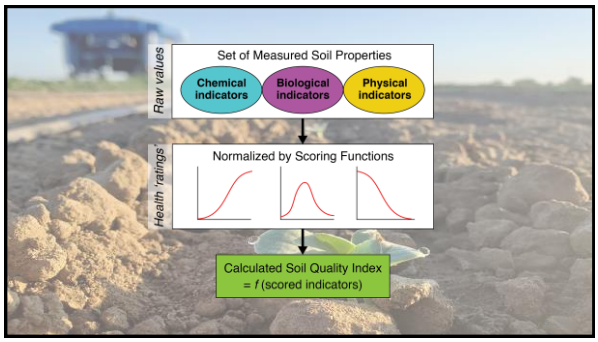
Influences of Soil Texture



- Scoring functions provide adjustments based on other soil factors

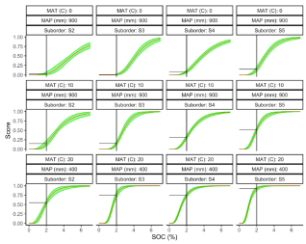


Example Results from Cornell Soil Health Lab

Measured Soil Textural Class: **silt loam**
Sand: **2%** - Silt: **83%** - Clay: **15%**

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.14	37	
physical	Surface Hardness	260	12	Rooting, Water Transmission
physical	Subsurface Hardness	340	35	
physical	Aggregate Stability	15.7	19	Aeration, Infiltration, Rooting, Crusting, Sealing, Erosion, Runoff
biological	Organic Matter	2.5	28	
biological	ACE Soil Protein Index	5.1	25	
biological	Soil Respiration	0.5	40	
biological	Active Carbon	288	12	Energy Source for Soil Biota
chemical	Soil pH	6.5	100	
chemical	Extractable Phosphorus	20.0	100	
chemical	Extractable Potassium	150.6	100	
chemical	Minor Elements Mg: 131.0 / Fe: 1.2 / Mn: 12.8 / Zn: 0.3		100	

On-going Improvement: Larger Databases and Better Modeling



Soil Health Assessment Protocol and Evaluation (SHAPE)

Nunes *et al.*, 2020;
doi: 10.1002/saj2.20244)

Summary for Part 1

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6. Get together – share and compare data

Questions

Part 2:
An Overview of Soil Health Indicators and Testing Methods

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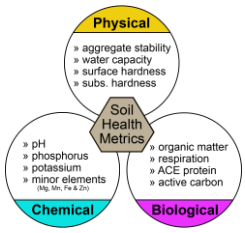
Soil Nutrient Assessment

» soil pH and buffering capacity
» P, K, Mg, Ca
» % base saturation and CEC
» organic matter content
» other elemenal analyses

Chemical

- Will include specific advice for nutrient management.

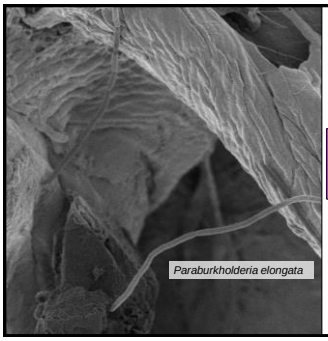
Soil Health Assessment



- Offers guidelines and actionable information

Sets of Soil Health Indicators Differ by Test Providers

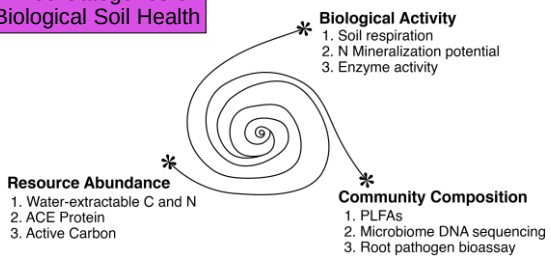
1. **Nutrient Analysis Labs**
   - Ward Lab ($52)
   - Regen Ag Lab ($50+)
   - Midwest Laboratories
2. **University of Missouri Soil Health Assessment Center** ($40+)
3. **Cornell Soil Health Lab** ($90)



Biological Indicators of Soil Health

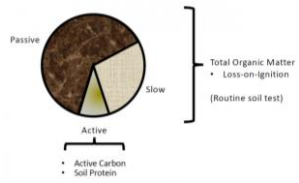
Wilhelm *et al.*, 2020

Three Categories of Biological Soil Health

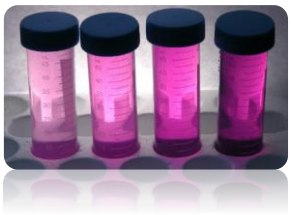


Resource Abundance

1. Water-extractable C and N
   - Estimate of bioavailable growth substrates
2. Autoclaved-citrate extractable (ACE) Protein
   - Quality of soil organic matter
3. Active carbon
   - Quality of soil organic matter



Active Carbon (Permanganate Oxidizable Carbon)



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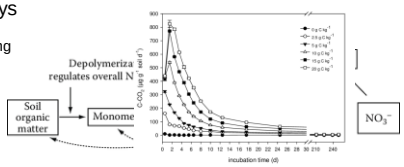
Biological Activity

1. Soil Respiration
   - Bulk microbial activity (function of total C and biomass)
2. N Mineralization Potential
   - Capacity to convert N from organic to inorganic forms
3. Enzyme assays
   - Phosphatase
   - Chitin-degrading
   - Cellulose etc.



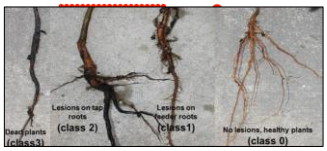
Sidebar: 'Haney Test'

24 hrs soil respiration + water extractable C and N

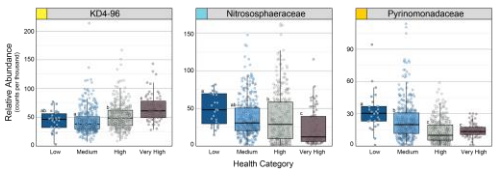
24 hrs soil respiration via the 'Solvita' test

Community Composition

1. Phospholipid Fatty Acids
   - Estimate of absolute abundance of fungi and bacteria
   - Distinguish among broad ecological groups (ex. arbuscular mycorrhizae)
2. DNA Sequencing
   - Determine relative abundance and diversity of soil bacteria and fungi
3. Root pathogen assay
   - Test soil pathogen burden
   - (Fusarium)

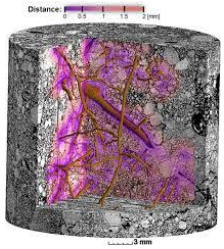


Sidebar: Microbiome Indicators of Soil Health



- "*Nitrososphaera* …are correlated to agricultural practices in long-term field experiments"
- *"Pyrinomonadaceae…* which appear to be characteristic for dry, organic matter depleted soil habitats"

Wilhelm *et al.*, 2022



Physical Indicators of Soil Health

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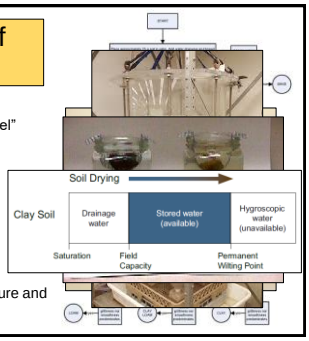
Physical Indicators of Soil Health

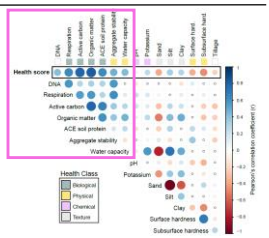
1. Soil texture
   - Google “Guide to Texture by Feel”
   - LandPKS app
2. Slake Test
   - Google App ‘SLAKES’
3. Aggregate stability
   - Rainfall simulator (Cornell Test)
   - ‘Dunking machine’
4. Available Water Capacity
   - Can be estimated from soil texture and soil carbon measurements



Recommendations

1. ‘The magnitude and direction of indicators were consistent within a site’
2. Best to use two indicators to provide confidence
3. For biological indicators:
   - 24 hr respiration & total SOC

Liptzin *et al.*, 2022;
doi: 10.1016/j.soilbio.2022.108708



Part 2: Summary

1. Several options for commercial soil health testing – each have a different suite of tests.

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2. Inquire about your soil type and land-use with the company before submitting

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Additional resources:

- *"Comprehensive Assessment of Soil Health Manual"* (Moebius-Clune)
- *"Soil Health Analysis, Set"* (Douglas Karlen and Diane Stott)

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Sampling Considerations

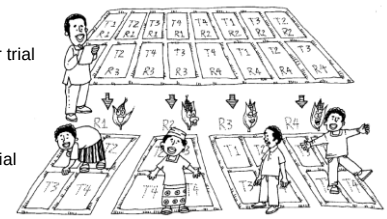
What are your goals?
- Monitoring change over time?
- Explaining differences among plots?
- Comparing effects of management?

Can you sample a reference site?
- More informative to benchmark against a reference sample
- When changing land use: set aside a 'reference' parcel of land

Soil Health Testing is Better at Scale

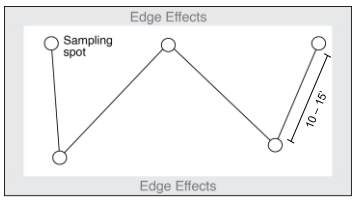
Mother trial

Baby trial



Kanyama-Phiri et al., 2000; "Towards integrated soil fertility management in Malawi"

Sampling logistics



- If possible, sample five locations using a random 'W' walk
- Composite soils into a single sample
- Avoid plot boundaries

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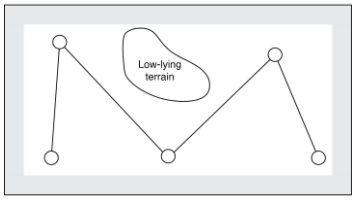
Sampling logistics



- Avoid obvious areas that are clear outliers when collecting samples for compositing

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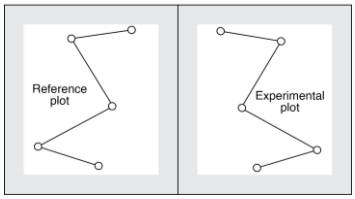
Sampling logistics



- Be intentional when sampling and look to better understand differences in fields / growing areas.

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Sampling Equipment
1. Straight shovel
2. Bucket
3. GPS
4. Cooler
5. Ziplock bag

Testing helps one know the soils inner strengths and weaknesses

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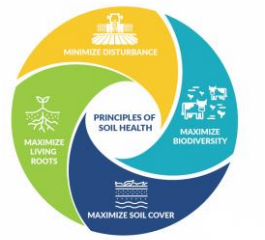

Testing is not necessary to improve soil health

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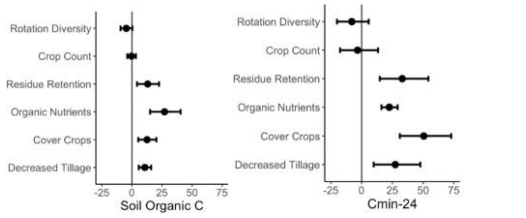
Liptzin *et al.*, 2022; doi: 10.1016/j.soilbio.2022.108708



Testing is not necessary to improve soil health

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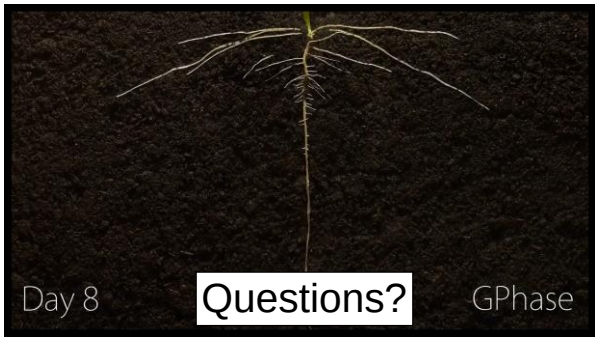
SOIL HEALTH PARTNERSHIP
SARE
Sustainable Agriculture Research & Education
NRCS Soil Health Division
FOUR SOIL HEALTH PRINCIPLES
PURDUE EXTENSION
Cornell Soil Health Laboratory
Leadership in Soil Health
• Farmer-led adoption
• Government programs
• University extension research
• NGOs
• Soil health testing labs
• Policy and legislation


Day 8
Questions?
GPhase