Session #7

Soil Health Assessment

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Soil Health: the continued capacity of the soil to function …

These are both Buxton Silt Loam

Dorn Cox, 2012

Standard Soil Test says this soil is better!?
The productivity of conventional agricultural systems is maintained with increased technology, labor, fuel, nutrients, pesticides, water...
Reasons for Soil Health Assessment

- **Understand constraints or resource concerns** beyond nutrient limitations and excesses
- **Target management practices** to alleviate those constraints
- **Measure** soil improvement or degradation from management
- **Facilitate applied research** to identify success
- **Improve awareness** of Soil Health, its benefits & opportunities
- **Enable valuation** of farmland and producer management
- **Enable assessment** of farming system risk
NRCS Soil Health Resource Concerns

Resource Concern: An existing or expected degradation of the soil, water, air, plant, or animal resource base to the extent that the sustainability or intended use of the resource is impaired.

- Compaction
- Organic matter depletion
- Soil organism habitat loss or degradation
- Aggregate instability
Assessing Soil Health using Indicators

A soil health indicator is an assessment of a soil property that provides information about the status of specific important soil processes.

• In field assessment: qualitative or semi-quantitative, rapid, instant conversation

• Laboratory assessment: quantitative, recently more available, longer-term conversation with farmer, better for monitoring
Cropland In Field Soil Health Assessment

**Components:**
- *Field visit*
  - Farmer interview on management and observations
  - Use of web soil survey

**Tools of the Trade:**
- Conversation
- Soil Survey
- Shovel
- Knives
- Water
- Sink strainers
- Infiltration rings
- Notetaking
- Camera
- Color book
Web Soil Survey for inherent soil type

Provides inherent, non-management-influenced soil properties

Limitations to Soil Health Interpretations on WSS: represent soil’s vulnerability based on inherent properties, but management is primary driver of whether resource concern is present. Site-specific information on cropping systems essential to properly interpret soil health (e.g., crop rotations, cover crops, irrigation, soil stratification, fertility, tillage, grazing, etc.)

https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
Management History – Interview Cont’d

8. What integrated pest management strategies are used (e.g., crop scouting, selective spraying, treated seeds)?

9. What nutrient management strategies are used (e.g., banding, split application, use of the 4Rs, manure/other/organic/compost)?

10. Is the field irrigated? If yes, what type of irrigation system and how many acre-inches are applied for each crop in the rotation described above?

11. Does water pond or run off during or immediately after typical rainfall or irrigation events? Where in the field?

12. Are there problems with crop emergence or early crop growth? Where in the field?

13. Is water management a concern (i.e., field too wet or too dry at planting)?

Other observations not captured in the assessment including plant condition and recent weather and landscape characteristics that may affect assessment results:
**Soil Health Stewards:**

**Promoting Soil Health on Protected Agricultural Lands**

**September 8, 9, & 10, 2021**

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**Cropland In-Field Soil Health Assessment**

11 Indicators to determine if there

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**Cropland In-Field Soil Health Assessment Worksheet**

<table>
<thead>
<tr>
<th>Soil Health Resource Concerns</th>
<th>Meets Assessment Criteria (Yes/No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator Timing and Use</td>
<td></td>
</tr>
<tr>
<td>Anytime [ ] After Rain or Irrigation [ ] With Adequate Moisture [ ] Before a Tillage Event [ ] Primarily No-till Systems [ ] Before Growing Season [ ] During Growing Season [ ] Interview [ ]</td>
<td></td>
</tr>
<tr>
<td>Soil Cover [ SOM, HAB ]</td>
<td>Q Y N</td>
</tr>
<tr>
<td>Surface cover from plants, residue or mulch; cover greater than 75%</td>
<td></td>
</tr>
<tr>
<td>Residue Breakdown [ SOM, HAB ]</td>
<td>Q Y N</td>
</tr>
<tr>
<td>Natural decomposition of crop residues is as expected with crop and conditions</td>
<td></td>
</tr>
<tr>
<td>Surface Crusts [ SOM, HAB ]</td>
<td>Q Y N</td>
</tr>
<tr>
<td>Crusting on no more than 5% of the field</td>
<td></td>
</tr>
<tr>
<td>Ponding [ SOM, HAB ]</td>
<td>Q Y N</td>
</tr>
<tr>
<td>No ponding within 24 following typical rainfall or surface irrigation event</td>
<td></td>
</tr>
<tr>
<td>Penetration Resistance [ CPT ]</td>
<td>Q Y N</td>
</tr>
<tr>
<td>Penetrometer rating &lt;150 psi within top 6” depth and &lt;300 psi in the 6-18” depth; OR Slight or no resistance with wire flag inserted to 12”</td>
<td></td>
</tr>
<tr>
<td>Water Stable Aggregates [ HAB, AGG ]</td>
<td>Q Y N</td>
</tr>
<tr>
<td>Cylinder; At least 80% remains intact after 5 minutes with little cloudy water; OR Strainer; soil remains intact with aggregates apparent; OR Soil Quality Test Kit (SQTK); meets stability class 6</td>
<td></td>
</tr>
<tr>
<td>Soil Structure [ SOM, AGG, HAB ]</td>
<td>Q Y N</td>
</tr>
<tr>
<td>Granular soil structure in A horizon and no plate structure in A or B horizons</td>
<td></td>
</tr>
<tr>
<td>Soil Color [ SOM ]</td>
<td>Q Y N</td>
</tr>
<tr>
<td>No color difference between field and fence row sample; OR, Value is on the darker range using color chart and soil survey pedon description</td>
<td></td>
</tr>
<tr>
<td>Plant Roots [ SOM, HAB ]</td>
<td>Q Y N</td>
</tr>
<tr>
<td>Roots covered in a soil film (rhizospheres) or are part of soil aggregates; OR Living roots, if present, are healthy, fully branched and extend into subsoil</td>
<td></td>
</tr>
<tr>
<td>Biological Diversity [ SOM ]</td>
<td>Q Y N</td>
</tr>
<tr>
<td>Clearly evident; more than 3 different types of organisms observed without magnification</td>
<td></td>
</tr>
<tr>
<td>Biopores [ SOM, AGG, HAB ]</td>
<td>Q Y N</td>
</tr>
<tr>
<td>Presence of root or earthworm channels that extend vertically through the soil with some connection to the surface</td>
<td></td>
</tr>
</tbody>
</table>

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**Indicator: Adequate Soil Cover**

<table>
<thead>
<tr>
<th>Description</th>
<th>Soil cover is the percent of the soil surface that is covered by plant residue, organic mulch and/or live plants.</th>
</tr>
</thead>
</table>
| **Resource Concerns Addressed** | • Aggregate instability  
• Soil organism habitat loss or degradation  
• Soil organic matter depletion  
• Surface compaction |
| **In-field measurement** | 1. Farmer interview  
2. Photo estimation method or state approved method, OR  
| **Rating Criteria** | **Meets Criteria** | **Does Not Meet Criteria** |
| Cover > 75% after planting | Cover < 75% after planting |
Soil Health Stewards: Promoting Soil Health on Protected Agricultural Lands

September 8, 9, & 10, 2021
## Indicator: Surface Crusts

<table>
<thead>
<tr>
<th>Description</th>
<th>Crusts form after rain or irrigation on soils with weak aggregate stability.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Resource Concerns Addressed</strong></td>
<td><strong>Resource Concerns Addressed</strong></td>
</tr>
<tr>
<td>• Aggregate instability</td>
<td>• Soil organic matter depletion</td>
</tr>
<tr>
<td>• Soil organism habitat loss or degradation</td>
<td>• Surface compaction</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In-field measurement</th>
<th>Evaluated by visual observation after rainfall/irrigation and drying:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Note whether crusts are throughout the field or only in patches.</td>
<td></td>
</tr>
<tr>
<td>• Near surface will be dense, show layered sediment deposits</td>
<td></td>
</tr>
<tr>
<td>• Poor crop emergence uneven stand</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rating Criteria</th>
<th>Meets Criteria</th>
<th>Does Not Meet Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evidence of surface crust (\leq 5%) of field</td>
<td>Evidence of surface crust (&gt; 5%) of field</td>
<td></td>
</tr>
</tbody>
</table>
Surface Crusts
## Indicator: Ponding

<table>
<thead>
<tr>
<th>Description</th>
<th>Areas of the field that collect and hold runoff water from other parts of the field.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource Concerns Addressed</td>
<td>• Aggregate instability • Surface compaction</td>
</tr>
</tbody>
</table>
| In-field measurement | Farmer interview or visual observation after rainfall/irrigation:  
• Note evidence of crop residue deposits  
• Evidence of ponding from observation or on recent aerial photos  
• Poor crop conditions (yellowing) |
| Rating Criteria |  
| Meets Criteria | Does Not Meet Criteria  
| Evidence of ponding 24 hours or less after a typical rain event | Evidence of ponding more than 24 hours after a rain event |
# Indicator: Penetration Resistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Resource Concerns Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management induced reduction of large pores and degraded structure (i.e., platy) that results in decreased rooting depth, plant growth and soil biological habitat and activity.</td>
<td>• Aggregate instability</td>
</tr>
<tr>
<td></td>
<td>• Soil organic matter depletion</td>
</tr>
<tr>
<td></td>
<td>• Soil organism habitat loss or degradation</td>
</tr>
<tr>
<td></td>
<td>• Surface compaction</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In-field measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduct with soil moisture near field capacity:</td>
</tr>
<tr>
<td>• Evaluate multiple representative locations in the field</td>
</tr>
<tr>
<td>• Record depths of restrictive layer(s) &amp; PSI readings (penetrometer)</td>
</tr>
<tr>
<td>• Evaluate root development and distribution</td>
</tr>
<tr>
<td>• Look for platy structure</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rating Criteria</th>
<th>Meets Criteria</th>
<th>Does Not Meet Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granular structure, appropriate PSI reading, vertical channels or roots</td>
<td>Evidence of platy structure, unacceptable PSI, root restriction, surface ponding, horizontal or abnormal root architecture.</td>
<td></td>
</tr>
</tbody>
</table>
Penetration Resistance

UW- Extension
https://www.youtube.com/watch?v=Zq_785JqRq8
Roots and Platy Structure to show Compaction?

Healthy Roots
- Root growth not restricted
- Many fine roots

Unhealthy Roots
- Restricted root growth
- Few fine roots
- Short thick roots
- Discolored & Lesions (root pathogens present)
### Indicator: Aggregate Stability

<table>
<thead>
<tr>
<th>Description</th>
<th>Soil aggregate stability is related to soil porosity and how well a soil can resist raindrop impact and erosion.</th>
</tr>
</thead>
</table>
| Resource Concerns Addressed | • Aggregate instability  
• Soil organism habitat loss or degradation  
• Soil organic matter depletion  
• Surface compaction |

### In-field measurement

Choose one of the following three methods:

• Slake test (ensure samples are completely dry)
• Strainer test
• Jornada soil aggregate stability test (stability kit)

<table>
<thead>
<tr>
<th>Rating Criteria</th>
<th>Meets Criteria</th>
<th>Does Not Meet Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate remains intact</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• ≥80% for slake test  
• “stands up” for strainer test, runoff water is translucent  
• Jornada criteria | Aggregate disintegrates  
• <80% remaining (slake)  
• Soil “slumps” into a puddle, runoff is not translucent  
• Jornada criteria |
Manage for Water Stable Aggregates

You want this... NOT this!

a) aggregated soil

b) soil seals and crusts after aggregates break down
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Slump Test
“We feel that we have some soil health problems”
Dave Degolyer, Western NY Crop Management Association
**Indicator: Plant Roots and Biopores (continuity)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Roots influence the soil immediately adjacent to them through exudates, growing and leaving soil organic matter as they die.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Resource Concerns Addressed</strong></td>
<td>• Aggregate instability • Soil organism habitat loss or degradation • Soil organic matter depletion</td>
</tr>
<tr>
<td><strong>In-field measurement</strong></td>
<td>Observe evidence of dark, root channels or biopores left by previous plants or earthworms.</td>
</tr>
<tr>
<td><strong>Rating Criteria</strong></td>
<td><strong>Meets Criteria</strong></td>
</tr>
<tr>
<td>Presence of dark, root channels or biopores left by previous plants or earthworms</td>
<td>Roots are stressed and do not follow previous root channels, no pores evident from earthworms</td>
</tr>
</tbody>
</table>
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Roots and Biopores

Rye Root, Soybean root and earthworm sharing the same biopore
There’s an app for that

LandPKS

LANDPKS IN THE FIELD

Mobile App

Discover the value and potential of your land. Use this information to plan and track management actions. Monitor soil health and vegetation indicators over time.

https://landpotential.org/knowledge/intro-to-the-landpksoilhealth-module/

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• Nutrient management foundational to ag success
• Identifies nutrient deficiency/excess
• Critical New Component: apply principle to assess constraints in essential biological and physical functioning
Lab Indicators for Soil Health Assessment

- USDA consensus on standard current best available laboratory methods (NRCS Technical Note 450-03)

- Criteria:
  - Standardized
  - Scientific/agronomic relevance
  - Represent diverse processes
  - Easy & inexpensive to measure
  - Sensitive to agricultural management but robust
  - Interpretations accessible to public

- Regional calibration iterative, now available for most indicators through NRCS Soil Testing Conservation Activity 216

Standard Nutrient Test
Macro, Micro, SOM, CEC

Upgraded: Biological, C&N, Physical

NRCS Technical Note 450-03
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Lab Indicators For Soil Health

1. **Soil Structural Stability & Water Partitioning**
   - Aggregate stability
   - Infiltration, available water capacity

2. **Soil Organic Matter Cycling**
   - Soil organic C
   - C cycling, sequestration

3. **Carbon Food Source**
   - Permanganate oxidizable C (Active C)
   - Organism food source

4. **Microbial Activity**
   - Short-term C mineralization (respiration)
   - Organism activity

5. **Bioavailable N**
   - Acid Citrate Extractable protein
   - Organically bound environmentally stable soil N pool
Indicator Interpretation via soil-type-based scoring functions being iteratively developed.
### What to do based on Soil Health Assessments

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Short Term Management Suggestions</th>
<th>Long Term Management Suggestions</th>
</tr>
</thead>
</table>
| 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 |
| Soil Protein 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 |
| 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 |
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Photos: Bianca Moebius-Clune and Dorn Cox, 2012

Implementation of a Soil Health Management Plan resolves pond eutrophication at Tuckaway Farm, NH. What's Cropping Up?
https://blogs.cornell.edu/whatscroppingup/category/soil-health/

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Soil health training

Soil Health Assessment

Soil Health Management Planning

Soil Health Management Systems Implementation

Observation, Adaptation
Polls (S#7), Q&A and Discussion

Taking it back to your Day to Day:

1. What did you learn about assessing soil health that is particularly relevant to you?
2. How will you use what you learned in your action plan?
3. What key messages may particularly inspire ‘a-ha!’ moments with those you work with?
What’s next?

- 10:30 to 10:45 – Break
- 10:45 – Go back to the platform, click on links to sessions, and find the link for Session #8—Advancing SH through Conservation Easements and referenced Plans.