# Recognizing Soil Health

## Focus on Regenerating Soil Structure and the Soil Ecosystem

By Aaron Hird, NE NRCS Soil Health Specialist

## Extreme Weather

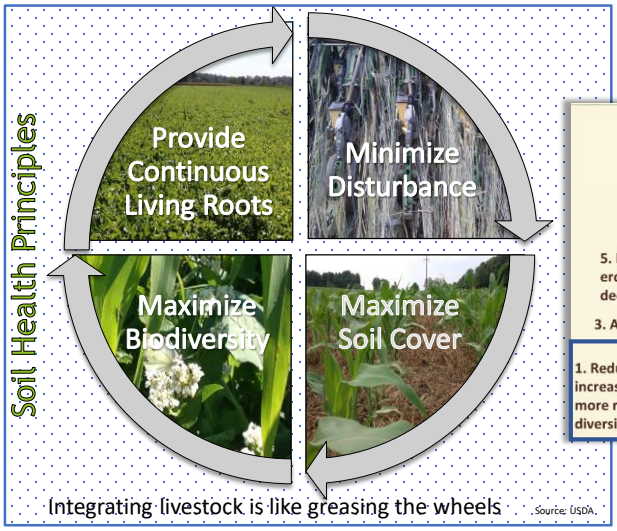


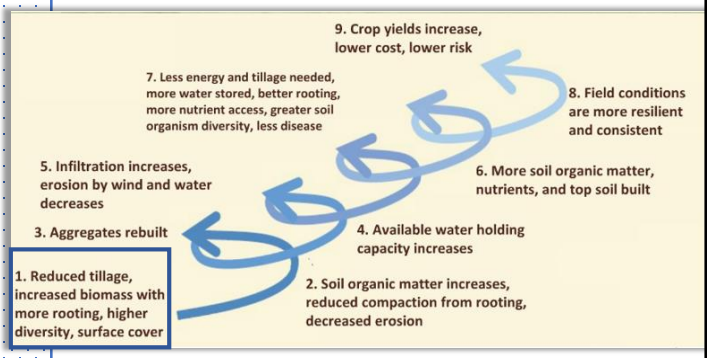
Resilient Soil


# Soil Health Defined:

- The continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals, and humans.

# Regenerating Soil Health is achieved by taking Step 1 - Implement the Soil Health Principles.



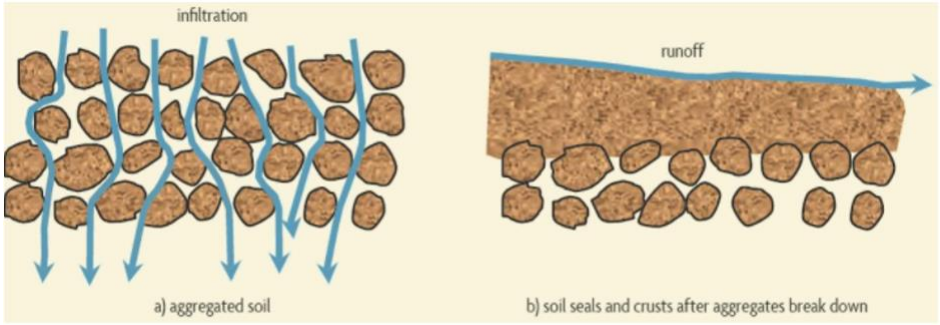

## NE NRCS Soil Health Assessment is based on Dynamic Soil Properties

- As the Dynamic Soil Properties change the Soil Functions change

| Dynamic Soil Properties | Soil Functions |
|---|---|
| Biological Activity | Nutrient cycling |
| Bulk Density | Water (infiltration & storage) |
| Soil Color | Filtering, buffering, stability & storage (SOM) |
| Aggregate Stability | Physical Stability and Support |
| Structure | Habitat for Biological Activity |

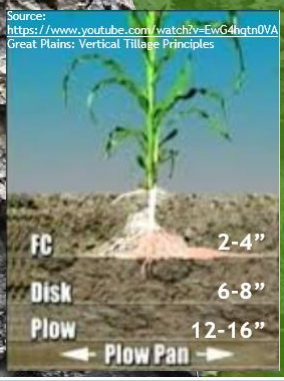
# Manage for Habitat; organisms will form Wet Stable Aggregates, increasing water infiltration, drainage, aeration and building Soil Organic Matter.

Soil Function is influenced primarily by biology which is impacted by management. (**90% of Soil Function is mediated by soil microbes**)




Magdoff, Fred, 1942- **Building soils for better crops : sustainable soil management** / by Fred Magdoff and Harold van Es. -- 3rd ed. p. cm. -- (Handbook series ; bk. 10) Includes bibliographical references and index. ISBN 978-1-888626-13-1

## A Common problem in Nebraska: Tillage Induced, Root Restrictive, Compaction Layers

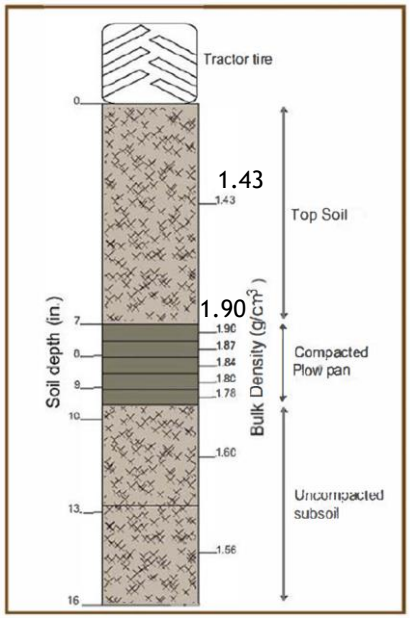





**Cover Crops can have a High Rooting Pressure Tolerance and Can Push through High Bulk Density Layers!**

# Root Restrictive Bulk Density

| Soil Texture | Ideal Density (g/cm3) | Density Affects Roots | Density Restricts Roots |
|---|---|---|---|
| Sands, loamy sands | < 1.60 | 1.69 | >1.80 |
| Sands, loamy sands | < 1.60 | 1.69 | >1.80 |
| Sandy loams, loams | < 1.40 | 1.63 | >1.80 |
| Sandy clay loams, clay loams | < 1.40 | 1.6 | >1.75 |
| Silts, silt loams | < 1.40 | 1.6 | >1.75 |
| Silt loams, silty clay loams | <1.40 | 1.55 | >1.65 |
| Sandy clays, silty clays, clay loams | < 1.10 | 1.49 | >1.58 |
| Clays (>45% clay) | < 1.10 | 1.39 | >1.47 |




Note: The engineering standard soil bulk density is 1.33
- Top Soil = 1.43, Plow Pan starts at 1.90
- No Tillage systems **Retain or Sustain** soil structure.
- Biological Activity **Regenerates** soil structure.

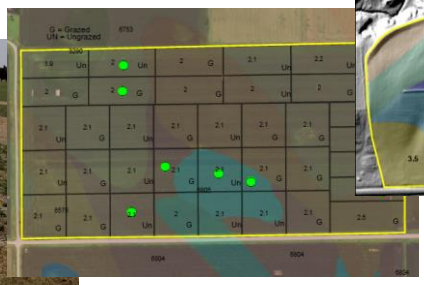
Source: Soil Quality Information Sheet, Soil Quality Resource Concerns: Compaction

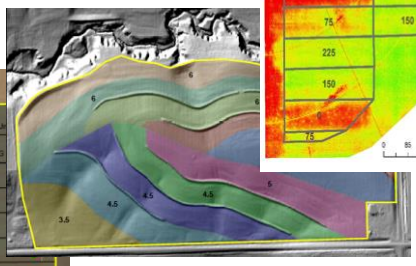
## Nebraska NRCS Soil Health Initiative

- Partnerships remain our central focus.
- Continue to geographically distribute key outreach and educational resources.
- Example: Fund and monitor a network of **Demonstration Projects on Farms and Ranches** across the state.
- The Goals of the EQIP Soil Health Management Demonstration Projects
  - Provide a local source of information to answer common questions
  - Validate Soil Health Management Systems locally via case studies w/ continued soil health assessment.
  - Focus on the Communication about Soil Health through outreach, education, training and partnership development

# Demonstration Fields = On Farm Research

- A Long Term, field scale, comparison of two Cover Crop Adaptive Management Activities
- A system comparison within an expanded crop rotation
- Randomized and Replicated Plots
- Soil Health Assessments, Soil Lab Analysis and Economic Evaluations
- Opportunity to include partners, including UNL Extension & NE On Farm Research Network and UNL's Agronomy and Horticulture Researchers.






Interested? Contact your local NRCS office by February 18th!

# 2016-21 Soil Health Demonstration– Nemaha Co

**Incorporation of Winter Terminated and Winter Hardy Cover Crop in a Corn-Soybean-Wheat Rotation**

***NRCS Soil Health Management Demonstration Field 5-year summary report***

- **Multi-Year Soil Health Assessment (2016 to 2021)**

Baseline and soil health measures were collected in 2016, 2018, 2019, 2020, and 2021.

**Table 5.** Soil physical, chemical, and biological properties for winter hardy and winter terminated treatments.

| Treatment | Infiltration (in/hr) | Soil moisture (%) | Bulk density (g/cm³) | Soil temp. (F) | Soil respiration[1] | Total soil health score[2] |
|---|---|---|---|---|---|---|
| **2016** *(1 composite sample collected for all replications of a treatment; samples collected on Oct. 19, 2016) '17 Corn* | | | | | | |
| Winter hardy | 1.30 | - | 1.22 | 59 | -[3] | 19.5 |
| Winter terminated | 1.12 | - | 1.32 | 59 | - | 20.8 |
| **2018** *(2 composite samples collected for all replications of a treatment, samples collected on Oct. 31, 2018)Soybean* | | | | | | |
| Winter hardy | 0.932 | 27.5 A | 1.22 A | 50.1 A | - | 18.5 |
| Winter terminated | 0.743 | 24.7 A | 1.26 A | 50.6 A | - | 18.5 |
| P-Value | - | 0.406 | 0.341 | 0.500 | | - |
| **2019** *(1 sample per treatment replication, n=4 per treatment; samples collected on Oct. 24, 2019) Wheat* | | | | | | |
| Winter hardy | 0.631 A | 29.5 A | 1.28 A | 48.4 A | 4.12 A | 20.2 A |
| Winter terminated | 2.259 A | 28.1 A | 1.20 A | 49.7 A | 4.38 A | 21.4 A |
| P-Value | 0.338 | 0.594 | 0.433 | 0.350 | 0.604 | 0.186 |
| **2020** *(1 sample per treatment replication, n=4 per treatment; samples collected on Oct. 15, 2020) Corn* | | | | | | |
| Winter hardy | 2.52 A | 15.6 A | 1.24 A | 57.4 A | 3.25 A | 22.4 A |
| Winter terminated | 4.85 A | 15.7 A | 1.25 A | 57.9 A | 3.00 A | 22.5 A |
| P-Value | 0.337 | 0.772 | 0.862 | 0.767 | 0.182 | 0.391 |
| **2021 (***1 sample per treatment replication, n=4 per treatment; samples collected on Nov. 23, 2021) Soybean* | | | | | | |
| Winter hardy | 3.433 A | 24.5 A | 1.22 A | 40.0 A | 3.00 A | 21.2 A |
| Winter terminated | 0.567 A | 21.7 A | 1.26 A | 40.2 A | 2.75 A | 21.4 A |
| P-Value | 0.226 | 0.392 | 0.695 | 0.886 | 0.495 | 0.761 |

[1]Soil respiration (Modified Solvita burst).
[2]Score based on field assessment. The overall indicator score is based on the sum of 8 indicators (1=degraded, 2=in transition, 3=healthy): soil structure, structure type, surface condition, soil management, soil pores, earthworms, biological activity, and smell.

# The Compounding Effects of Applying the 4 Soil Health Principles

Krupek, F. S., Redfearn, D., Eskridge, K. M., & Basche, A. (2022). Ecological intensification with soil health practices demonstrates positive impacts on multiple soil properties: A large-scale farmer-led experiment. Geoderma, 409, [115594]. https://doi.org/10.1016/j.geoderma.2021.115594

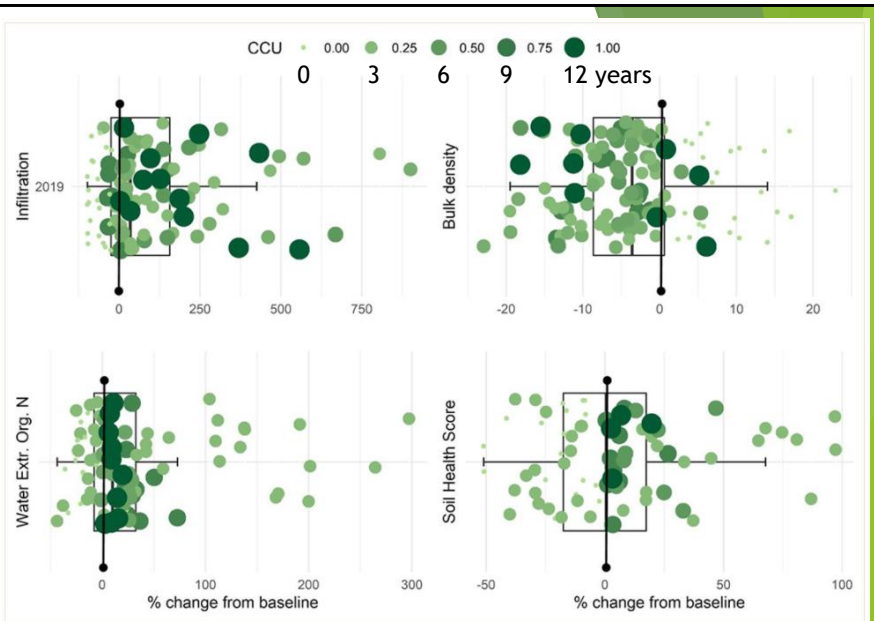



Figure 3. Relationship between relative length of cover crop use (CCU index representing from zero, CCU=0, up to 12 years, CCU=1) and the percentage change in soil property measurements from the baseline samples (from Fall 2016 or 2017, depending at the initiation of the on-farm experiment). The soil health score was calculated according to HSHT measurements according to the formula: Soil health score = $CO_2$/10 + WEOC/100 + WEON/10, where $CO_2$ is the soil-test biological activity and WEOC and WEON are water-extractable organic carbon and nitrogen, respectively.

# The Compounding Effects of Applying the 4 Soil Health Principles

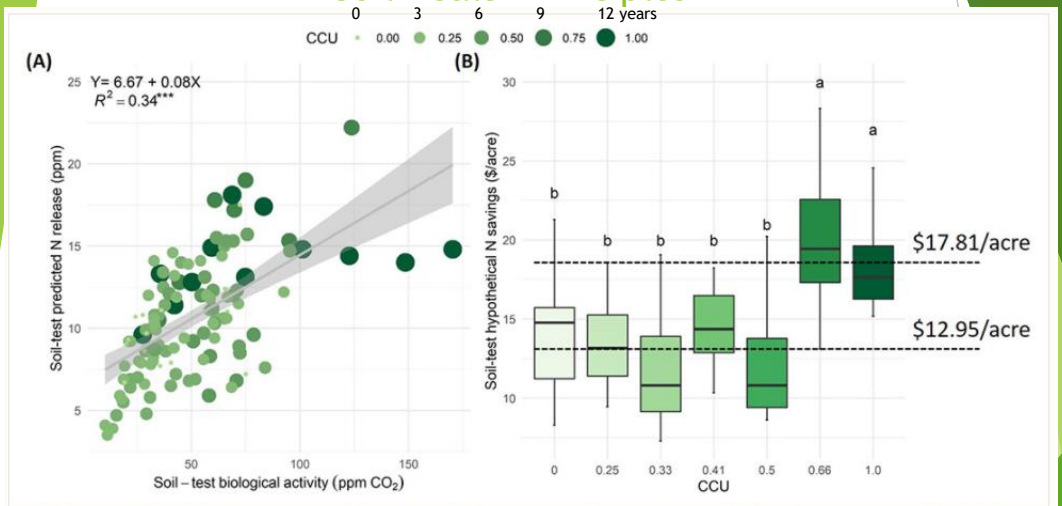
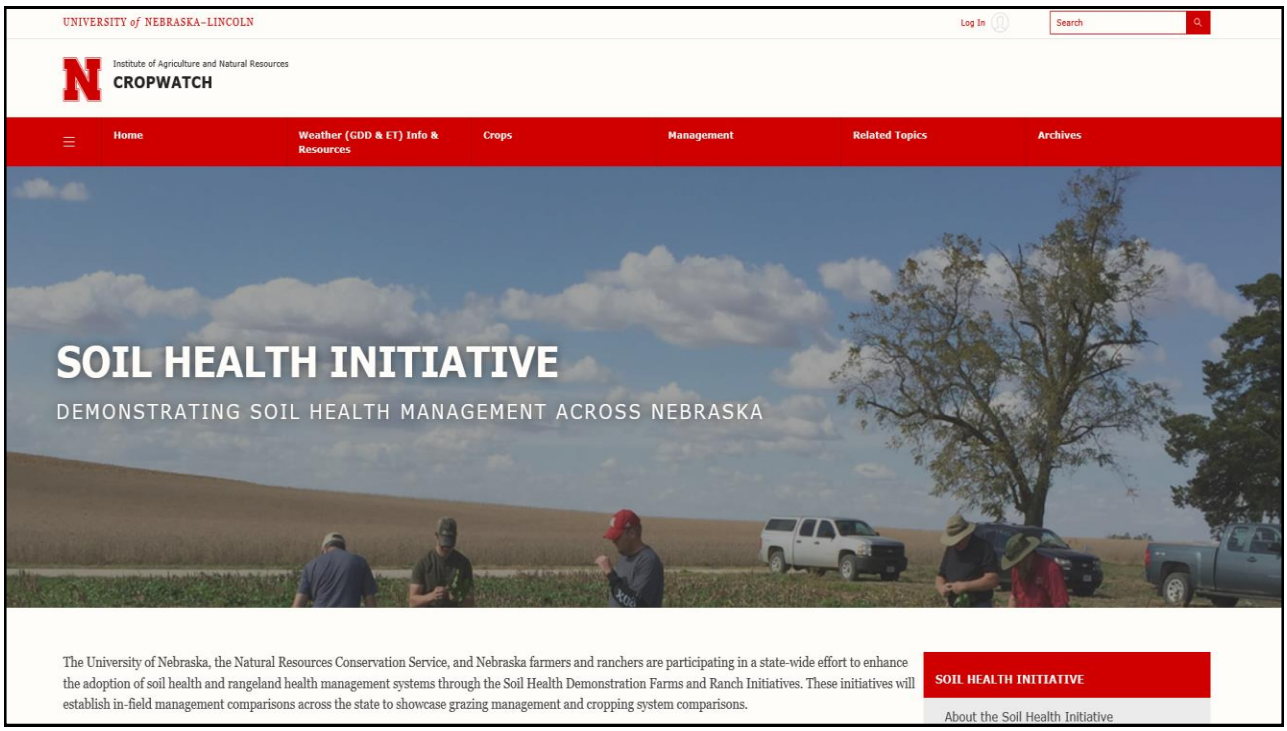
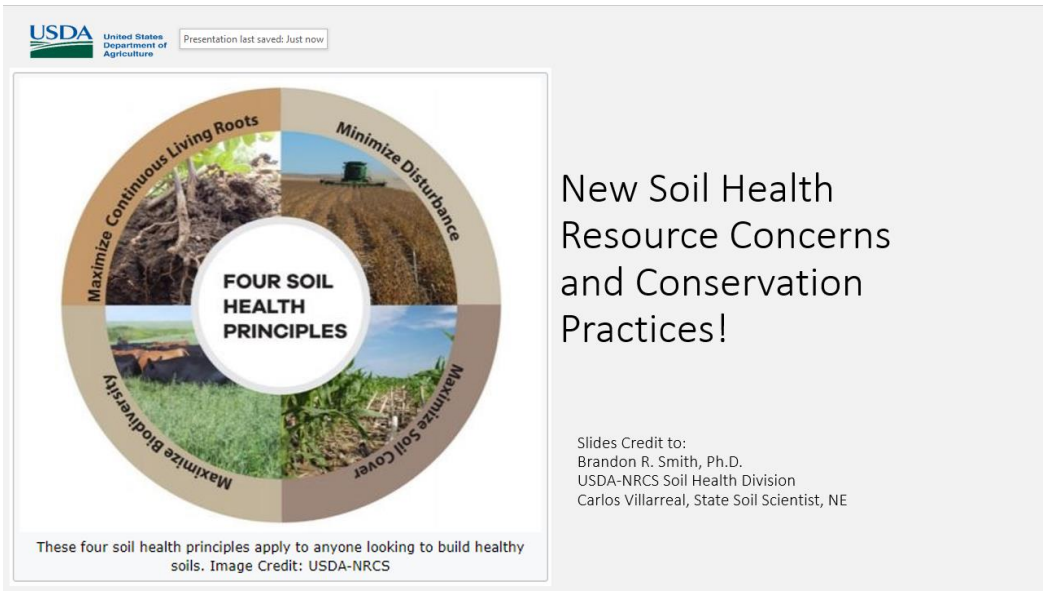



Figure 2. Relationship between soil-test biological activity and predicted nitrogen release (A) and cover crop use (CCU) and nitrogen-savings (B). Hypothetical nitrogen-savings represent the potential amount ($/acre) saved on nitrogen application based on the difference in the nitrogen results between HSHT (using organic nitrogen pools) and traditional soil tests (using nitrate). Based on field history of the 10 on-farm trials, the length of time of cover crop use varied from zero to up to 12 years. Intensification in cover crop use (CCU) was quantified using an index varying from 0 to 1, with higher CCU values indicating greater a number of years cover crops were applied.

Krupek, F. S., Redfearn, D., Eskridge, K. M., & Basche, A. (2022). Ecological intensification with soil health practices demonstrates positive impacts on multiple soil properties: A large-scale farmer-led experiment. Geoderma, 409,

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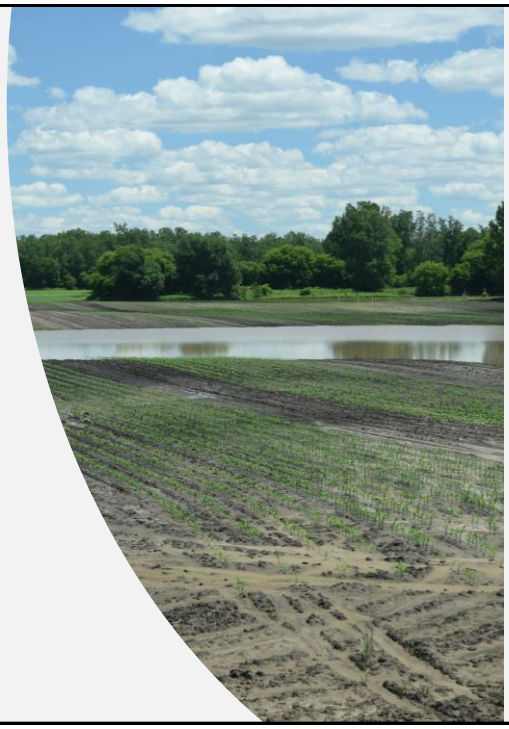
# New NRCS Soil Health Resource Concerns

- Compaction
- Organic matter depletion
- Concentration of salts or other chemicals
- Soil organism habitat loss or degradation
- Aggregate instability



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## Cropland In-Field Soil Health Assessment Worksheet

**Soil Health Resource Concerns**

CPT: Compaction

SOM = Soil organic matter depletion

AGG = Aggregate instability

HAB = Soil organism habitat degradation

| |
|---|
| Location |
| Field/CMU |
| Tract# |
| Client/Customer |
| Planner |

**Indicator**

Timing: Anytime, After rain or irrigation, With adequate moisture, Primarily for Before a tillage event, Interview, Before growing season, During growing seasc

**Soil cover**
Meets: Surface cover from plants, residue or mulch; cover greater than 75%.

**Residue breakdown**
Meets: Natural decomposition of crop residues is as expected with crop and conditions.

**Surface crusts**
Meets: Crusting on no more than 5% of the field.

**Ponding**
Meets: No ponding within 24h following typical rainfall or surface irrigation event.

**Penetration resistance**
Meets:
- Penetrometer rating less than 150 psi within top 6" depth and < 300 in 6-18" depth;
- OR Slight or no resistance with wire flag inserted to 12".

**Water stable aggregates**
Meets:
- 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

Technical Note No. 450-06 Jan 2021

**Soil structure**

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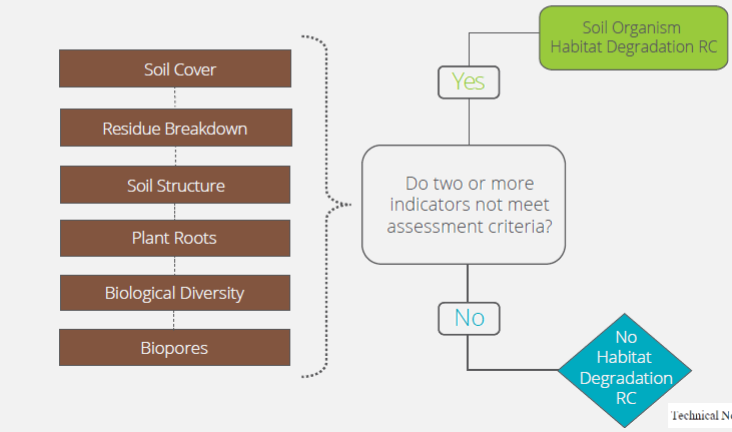
## Soil Organism Habitat Degradation Resource Indicator Decision Tree

Circle the indicators that do not meet assessment criteria during the evaluation and follow decision tree below to determine if the given resource concern (RC) is present. Document on worksheet.




Technical Note No. 450-06 Jan 2021

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# New Conservation Practices

- Soil Health Testing Activity (216)
  - Soil Health Assessments
- Soil Carbon Amendment (808)
  - Compost (Composted Manure)
  - Carbon Amendments (Coal Ash)
  - Biochar
  - Wood Chips

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# CP 216 - Soil Sampling Practice

- **Facilitating Cons. Practice**
- **Quantitative analysis of soil physical, chemical, and biological properties**
- **Assist in designing a Soil Health Management System based on the results of the soil tests**
- **5-yr recommendation; 3-yr return interval preference**
- **Conservation Practices made available in EQIP**

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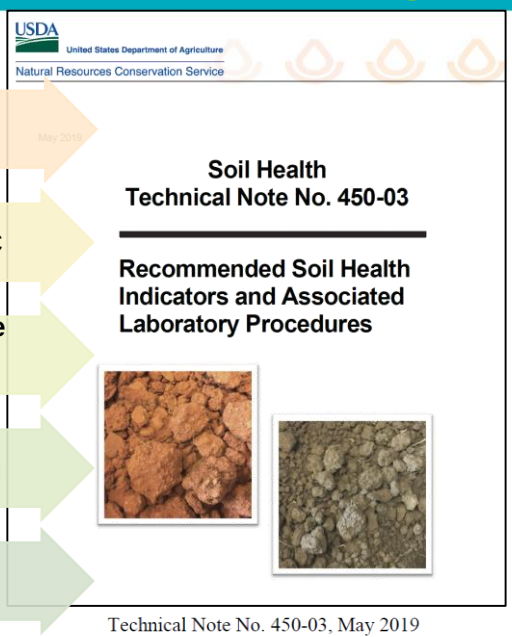
# 216 - Soil Health Testing Activity

Using the same validated methods

| | |
|---|---|
| Soil Structural Stability & Water Partitioning | • **Aggregate stability** |
| Soil Organic Matter Cycling | • **Soil organic C** |
| Active Carbon | • **Permanganate Oxidizable C (Active C)** |
| Microbial Activity | • **Short-term C mineralization (respiration)** |
| Bioavailable Nitrogen | • **Acid Citrate Extractable Protein** |




Technical Note No. 450-03, May 2019

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# The Importance of the combination of Tests

- Aggregate Stability
- Soil Organic Carbon
- Active Carbon POX-C
- Short Term Carbon Mineralization
- Bioavailable Nitrogen

Soil Health Technical Note 450-03: Recommended Soil Health Indicators and Associated Laboratory Procedures (For quantitative assessment of soil health):
https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/soils/health/?cid=nrcseprd1315420

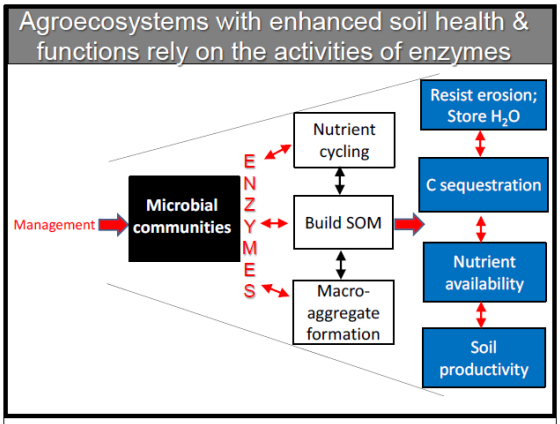


**Figure 1**. Microbial indicators of soil health are important drivers in a healthy soil leading to improved functions such as soil stability and resistance to erosion. Diagram courtesy of Veronica Acosta-Martínez.

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# CP 216 - Soil Sampling Practice

**<u>Typical scenario:</u> We Just Dive In! Right?**
**HOLD ON – Let's Make a Plan**

Example: If ***Compaction*** and ***Aggregate Instability*** are identified as the resource concerns.

**Identify the preferred sampling locations and timing.**

Management options to address include ***Cover Cropping, Conservation Crop Rotation, and No-Till Management.***

**There are still decision to be made!**

- **Cover crop mix/seeding rate/timing**
- **Residue type/amount**
- **Crop Rotation**
- **Nutrient Management**
- **Soil Carbon Amendments?**

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# A Planning and Monitoring Matrix

## A New National Technical Note: Addressing Resource Concerns with Conservation Practices within an Integrated Soil Health Management System

| Indicator | Suggested Management Practices | | NRCS Practice |
|---|---|---|---|
| | Short Term | Long Term | (code) |
| Low Aggregate stability | • Incorporate fresh organic materials<br>• Use shallow-rooted cover/rotation crops<br>• Add manure, green manure, mulch | • Reduce tillage<br>• Use a surface mulch<br>• Rotate with sod crops | **(328)** Conservation Crop Rotation;<br>**(329)** Residue Mgmt No-Till/Strip-Till;<br>**(340)** Cover Crop; **(484)** Mulching;<br>**(512)** Forage & Biomass Planting;<br>**(528)** Prescribed Grazing |
| Low Active Carbon | • Add fresh organic materials<br>• Use shallow-rooted cover/rotation crops<br>Add manure, green manure, mulch | • Reduce tillage/mechanical cultivation<br>• Rotate with sod crop<br>• Cover crop whenever possible | **(328)** Conservation Crop Rotation;<br>**(329)** Residue Mgmt, No-Till;<br>**(340)** Cover Crop; **(484)** Mulching;<br>**(345)** Residue Mgmt, Mulch Till;<br>**(528)** Presc.Grazing;<br>**(511)** Forage Harvest Management;<br>**(512)** Forage & Biomass Planting |

Soil Health Management Systems Technical Note 450-04: The Basics of Addressing Resource Concerns with Conservation Practices within Integrated Soil Health Management Systems on Cropland:
https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/soils/health/?cid=nrcseprd1315420

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# Soil Carbon Amendment (808)

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808-CPS-1

**Natural Resources Conservation Service**

**INTERIM CONSERVATION PRACTICE STANDARD**

**SOIL CARBON AMENDMENT**

**Code 808**

**(Ac)**

**Future Code-336**

**DEFINITION**

Using carbon-based amendments (e.g. compost and biochar) to increase soil carbon and improve the physical, chemical, and biological properties of the soil.

**PURPOSES**

- Maintain, increase, or improve soil organic matter quantity and quality
- Maintain or improve soil aggregate stability
- Maintain or improve habitat for soil organisms
- Improve the efficient use of irrigation water
- Improve plant productivity and health

**CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to cropland, urban land, pasture, and rangeland.

**CRITERIA**

**General Criteria Applicable to All Purposes**

This practice includes the application of carbon-based amendments to improve the condition of the soil.

**Amendment Analysis:** It is the responsibility of the amendment provider to provide analysis of material. In cases where the amendment is produced on-farm or on-site, the producer must have the material tested.

DRAFT

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# Soil Carbon Amendment

**Compost**: Use compost that is either analyzed for the following parameters according to the Test Methods for the Examination of Composting and Compost (TMECC) or other Land Grant University (LGU) recognized methods:

- Maturity index rating of "mature" or "very mature"
- Carbon to nitrogen (C:N) ratio between 15:1 and 30:1 at maturity
- 40-60% moisture (60-40% solids) at maturity

Measure and document the amount of phosphorus, potassium, pH, soluble salts (electroconductivity), organic matter, and bulk density.

**Other Carbon Amendments:** Use regionally appropriate carbon-based materials, such as wood chips, pulverized paper, bagasse, coal ash, wood ash, or distillation residue to meet the conservation objective. Consult appropriate land-use specialists for assistance to plan for a specific conservation objective using alternative carbon amendments.

**Biochar:** Use biochar that is produced by heating biomass to a temperature in excess of 350°C under conditions of controlled and limited oxidant concentrations to prevent combustion (pyrolysis or gasification).

Measure and document the amount carbon, nitrogen, phosphorus, potassium, and pH.

**Woody Materials:** Use regionally appropriate woody materials, such as wood chips, sawdust, pulverized paper, bagasse, distillation residue to meet the conservation objective.

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# Biochar

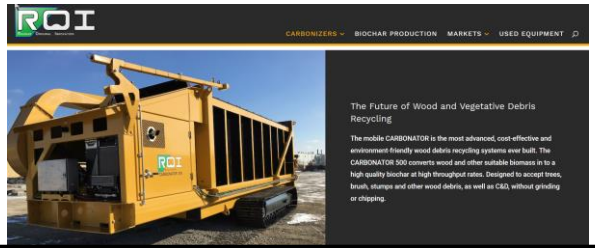
## Stable form of carbon

in organic-mineral complexes that are very slowly decomposed and thus can be retained in the soil for decades to centuries or more. Following fires, small amounts of so-called 'black carbon' are produced, which constitute a nearly inert carbon fraction with turnover times that may span millennia. Biochar C[4] may be produced through pyrolysis and amended to soils with a long turnover time. Lehmann et al.

## High C char can lock up P in soils (and immobilize N though)

## Good for soil organism habitat, space/shelter, drawing diversity

## Good companion with Woody Residue & Brush Management, Forest Stand Improvement




Not an endorsement, only an example

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## 3 to 5 years down the road…

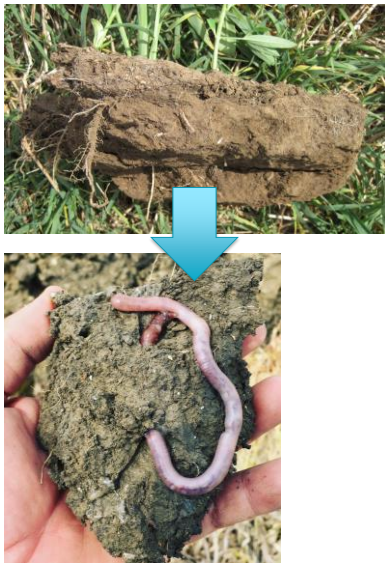
**Repeat Soil Sampling with 216 Soil Health Testing Activity**

**Evaluate Environmental Benefits and Outcomes**

**Adjust the Plan**

**Support Continuing Education**

**Measure Success and Recognize the Benefits!**



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## For more information

- **Contact your local USDA-NRCS Service Center to discuss these new opportunities.**
- **Field Office Technical Guide (eFOTG) - to learn about expected physical effects of conservation management systems**
- **Web Soil Survey - for general land use planning and decision making**

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# How can you improve Your Soil's Health?

# Dig In and Learn A Lot!

Contact Info:

- Aaron Hird, State Soil Health Specialist, Nebraska - USDA/NRCS
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- **Aaron.Hird@usda.gov**
- www.nrcs.usda.gov/clientgateway
- Nebraska NRCS http://**www.nrcs.usda.gov**/wps/portal/nrcs/site/ne/home/