Managing for Soil Health and Fertility

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DEPARTMENT OF PLANT SCIENCE & LANDSCAPE ARCHITECTURE

In today's talk…

- Why do we care about soils?
- What is soil health?
- What can we do to manage soil fertility and soil health?
  - Changes in thinking
  - Changes in management

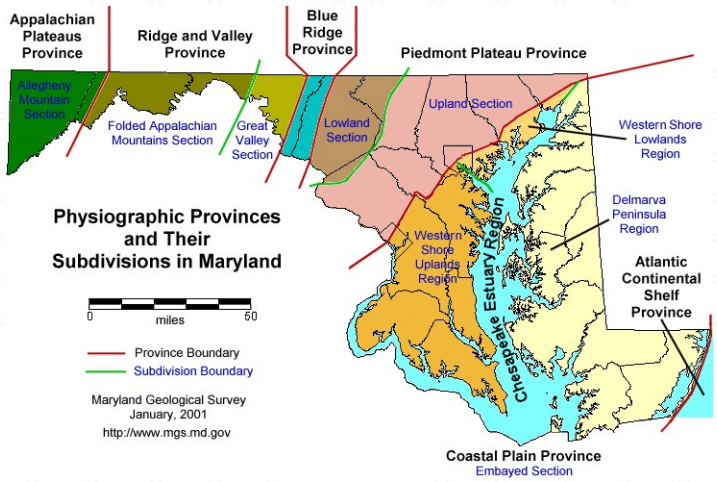
Why do we care about soils?
What can we learn from our soil?

Medium for Plant Growth

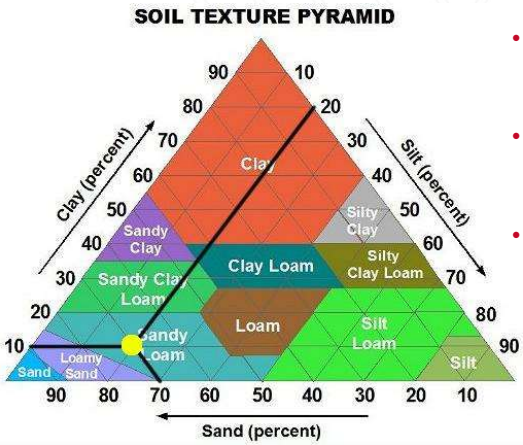
- Anchorage
  - Foundation for plant growth and development
- Water
  - For transpiration, and growth
- Oxygen
  - Plants, like most living organisms, need oxygen
- Nutrients
  - There are 17 essential elements required for plant growth; 14 of these are supplied by the soil.

Prairie grass roots, Land Institute, Salina Kansas. http://ngm.typepad.com/our_shot/january-3-2008.html

Maryland's Physiographic Provinces



Soil Texture



USDA Textural Triangle

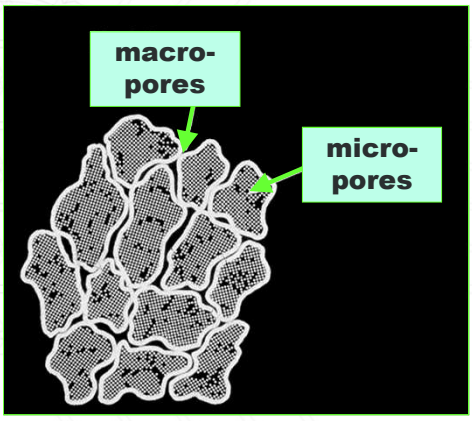
- Most fundamental soil physical property
- Relative proportion of sand, silt, and clay
- Coarse fragments (particles > 2.00 mm) are not considered in texture

Soil Structure

- Soil aggregation is the cementing of several soil particles into a secondary unit or aggregate
- Soil particles are grouped together during the aggregation process to form structural units (or peds)
- The structure of the soil affects pore space size and distribution and rates of air and water movement
- Well-developed structure allows favorable movement of air and water and root development

Soil porosity: Macropores and Micropores

- The size of the individual pore spaces will have the most effect on air and water movement in soil
- Pores smaller than about 0.05 mm (or finer than sand) in diameter are typically called micropores
- Pores larger than 0.05 mm are called macropores



Soil porosity: Macropores and Micropores

- Macropores allow the ready movement of air, roots, and percolating water
  - Movement of air and water through a coarse-textured sandy soil is often rapid
- Micropores in moist soils are typically filled with water
- Does not permit much air movement into or out of the soil
  - Movement of air and water through a fine textured clay soil may be slow (see picture at right)

Jim Baker, Virginia Tech

Soil Organic Matter

- Plant and animal residues in various stages of decay
- Sources: dead roots, root exudates, litter and leaf drop, and the bodies of soil animals such as insects and worms

Soil Organic Matter

- Primary energy and nutrient source for insects, bacteria, fungi, and other soil organisms
- After decomposition, nutrients released from the residues available for use by growing plants

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FEARLESS IDEAS

Organic Matter

Sources

- Compost provides slow release nutrients through decomposition
- Use only composted manures – incorporate into the soil
- Commercial organic fertilizers
- Non-leguminous covers conserve N from year to year
- Vetch, clover, and other legumes as a winter cover provide excellent source of N

Benefits

- Stable release of nutrients throughout growing season
- Increase soil micro and macro fauna
- Increase aeration and drainage
- Conserves soil moisture providing more consistent performance across weather conditions

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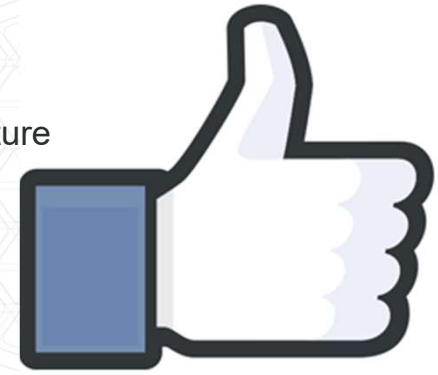
FEARLESS IDEAS

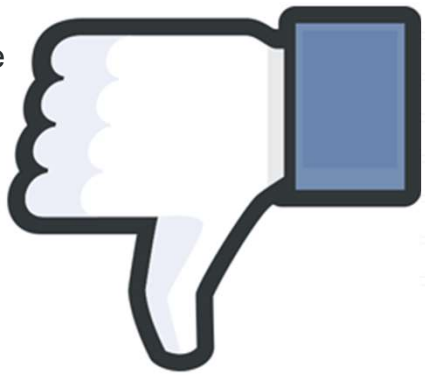
Soil Organic Matter - Likes

- Favors buildup
  - Lower temperature
  - Increased soil moisture
  - Grasslands
  - Finer texture soils
  - Less aeration
  - Poor drainage



Soil Organic Matter - Dislikes

- Favors breakdown
  - Increased temperature
  - Dry soils
  - Forest or row crops
  - Coarse texture soils
  - More aeration
  - Improved drainage



Management Practices – Increase or Decrease OM?

- Conversion to cropland?

- Fewer trips across soil with equipment?

- Addition of nutrients?

- Plant residues left on soil?

Management Practices – Increase or Decrease OM?

- Perennial vegetation?

- Overgrazing of livestock?

- Bare soil exposed?

What is Soil Fertility?

- Wikipedia: **Soil fertility is the characteristic of soil that supports abundant plant life. In particular, the term is used to describe agricultural and garden soil**

What are the components of a fertile soil?

Soil nutrients
Soil organic matter
Soil pH
Soil structure
Soil fauna

- Amendments
  - Inorganic fertilizer
  - Organic fertilizer
  - Organic matter
  - Lime
  - Others?
- Ground cover or crop choice
- Tillage and soil compaction

Soil Mineral Nutrients

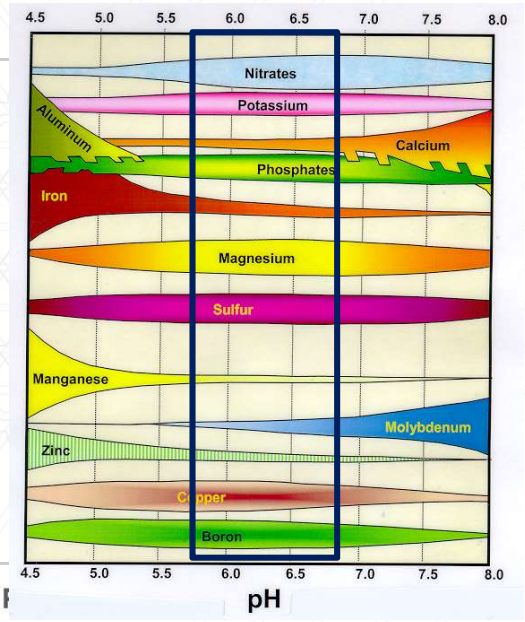
- There are two main groups: macronutrients (primary and secondary) and micronutrients.
- What are the primary nutrients?
  - Nitrogen (N), phosphorus (P), and potassium (K)
- What are the secondary nutrients?
  - Calcium (Ca), magnesium (Mg), and sulfur (S)
- Micronutrients?
  - Boron (B), copper (Cu), iron (Fe), chloride (Cl), manganese (Mn), molybdenum (Mo), and zinc (Zn)

Secondary and Micronutrients

- APPLY WITH CAUTION
- If you are managing organic matter it is unlikely you will need them
- Potential for plant (or maybe even animal) toxicity

Soil pH and Nutrient Availability

- Master variable
- Controls nutrient solubility
- pH < 5: soluble Al, Fe, and Mn may be toxic
- Most micronutrients are more available in acid soils
- Alkaline soils can "tie up" micronutrients



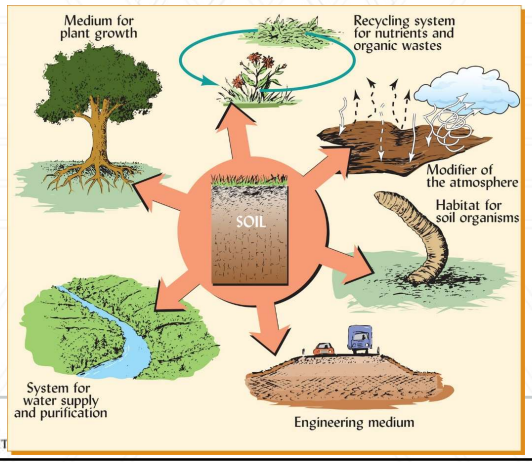
What is soil health?

Soil Health

- Self-regulation, stability, resilience, and lack of stress symptoms in a soil as an ecosystem
- Biological integrity of the soil community

Soil Quality

- Properties that make a soil fit to perform specific functions



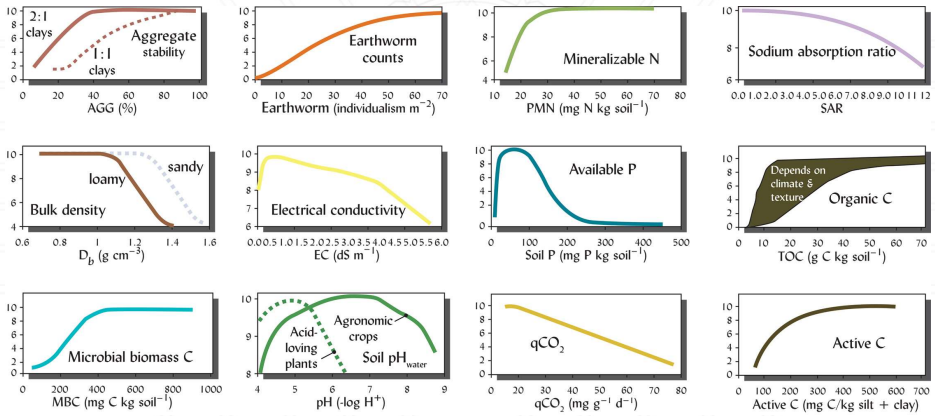
Soil Resistance and Resilience

- Resistance – soil's ability to resist degradation when faced with disturbance
- Resilience – capacity of soil to rebound from change
  - Important component of soil health
- Factors affecting both can be inherent or management-driven

Measuring Soil Quality

- Hard to measure exact rates of processes within soils
- Can measure properties as a proxy to indicate rates
- Can be a dozen or more properties that are measured to assess soil quality

Measuring Soil Quality



Measuring Soil Quality

- Soil quality and soil health indicators are sensitive to management
  - *We can control this
- Also sensitive to soil properties
  - Soil texture and structure, at various time scales
  - Days to years to eons
  - *We cannot control this

Plant Productivity Related to Soil Microorganisms

- OM formation and nutrient cycling
- Breakdown of toxic compounds
- Inorganic transformations
  - Keep Fe and Mn insoluble to prevent toxicity
- Nitrogen fixation
- Rhizobacteria
  - Promote plant growth
  - Hormonal simulation
- Protect roots from pathogens

Soil Management and Diversity and Abundance of Soil Organisms

↓ Biodiversity	↑ Biodiversity
Fumigants	Proper fertilizer use
Nematicides	Lime on acid soils
Some insecticides and herbicides	Proper irrigation
Compaction	Improved drainage and aeration
Soil erosion	**Animal manures and composts**
Industrial wastes and heavy metals	Domestic (clean) sewage sludge
Intensive tillage	**Reduced or zero tillage**
Monocropping	Complex crop rotations
Row crops	**Grass-legume pastures**
Bare fallows	Cover crops or mulch fallows
Residue burning or removal	Residue return to soil surface
Plastic mulches	Organic mulches

What can you do to manage soil fertility and soil health?

Soil Testing

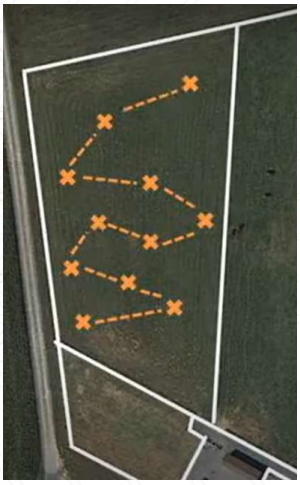
- Why should you soil test?
  - Guidance on proper amount of lime and fertilizer
  - Diagnose nutrient deficiencies or toxicities
  - Limits pollution
  - Saves money
  - Optimizes plant and soil health
- Many studies have shown that most home soil testing kits are unreliable – Use a reputable lab

Soil Sampling Equipment

- A sampling tool
  - Do not use a brass, bronze, or galvanized tool
  - A soil probe is the best
- A clean plastic bucket
- Soil sample bag or box from the lab you plan on using

Soil Sample Collection

- Walk through the field in an “M” or “W” shape, stopping occasionally to pull a sample
- Sample to about 8”, mix all samples in a bucket
- Avoid fencelines or areas under a feeder
- Focus on the middle of the field and sample across the entire length



Soil Sample Collection

- Mix well in clean plastic bucket
- Mix it some more
- Take a subsample (about 1 pint)
- Air dry soil; NEVER heat in oven
- **Provide all requested information to laboratory**

Now What?

- Package in soil testing lab packaging following their instructions
- Be sure to fill out information form as accurately as possible
- Listing of soil testing labs: https://extension.umd.edu/resource/soil-testing-and-soil-testing-labs

Interpreting Results

- Soil testing labs will often report fertilizer recommendations based on the information provided
- There is no accurate measurement of soil nitrogen – recommendations based on crop being grown
- There are many source online that provide fertility recommendations for various crops – be sure you know what test was used and what the units are

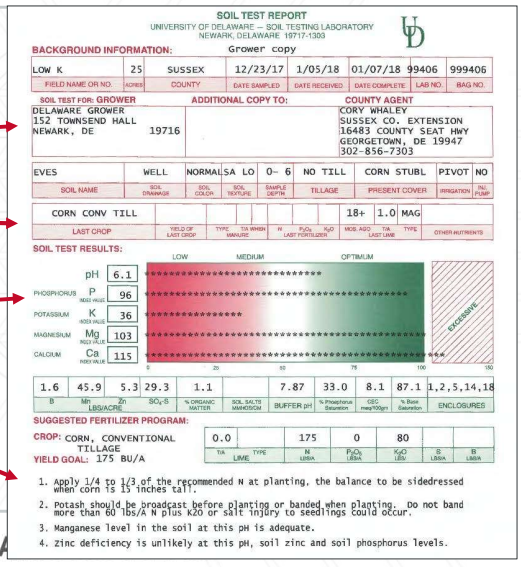
Soil Test Result & Recommendations

Client and Field Information

Crop

Results of soil test

Recommendations



SOIL TEST REPORT
UNIVERSITY OF DELAWARE – SOIL TESTING LABORATORY
NEWARK, DELAWARE 19717-1303
Grower copy

BACKGROUND INFORMATION:

FIELD NAME OR NO.	ACRES	COUNTY	DATE SAMPLED	DATE RECEIVED	DATE COMPLETE	LAB NO.	BAG NO.
LOW K	25	SUSSEX	12/23/17	1/05/18	01/07/18	99406	999406

SOIL TEST FOR: GROWER
DELAWARE GROWER
152 TOWNSEND HALL
NEWARK, DE 19716

ADDITIONAL COPY TO:

COUNTY AGENT
CORY WHALEY
SUSSEX CO. EXTENSION
16483 COUNTY SEAT HWY
GEORGETOWN, DE 19947
302-856-7303

SOIL NAME	SOIL DRAINAGE	SOIL COLOR	SOIL TEXTURE	SAMPLE DEPTH	TILLAGE	PRESENT COVER	IRRIGATION	PH/PUMP
EVES	WELL	NORMAL	SA LO	0- 6	NO TILL	CORN STUBL	PIVOT	NO

LAST CROP	YIELD OF LAST CROP	TYPE	T/A WHEN MANURE	N	P_2O_5	K_2O	MOS. AGO	T/A LAST LIME	TYPE	OTHER NUTRIENTS
CORN CONV TILL							18+	1.0	MAG	

SOIL TEST RESULTS:

	INDEX VALUE	LOW	MEDIUM	OPTIMUM	EXCESSIVE
pH	6.1				
PHOSPHORUS P	96				
POTASSIUM K	36				
MAGNESIUM Mg	103				
CALCIUM Ca	115				

0 20 50 75 100 150

B	Mn	Zn	SO_4-S	% ORGANIC MATTER	SOIL SALTS MMHOS/CM	BUFFER pH	% Phosphorus Saturation	CEC meq/100gm	% Base Saturation	ENCLOSURES
1.6	45.9	5.3	29.3	1.1		7.87	33.0	8.1	87.1	1,2,5,14,18

LBS/ACRE

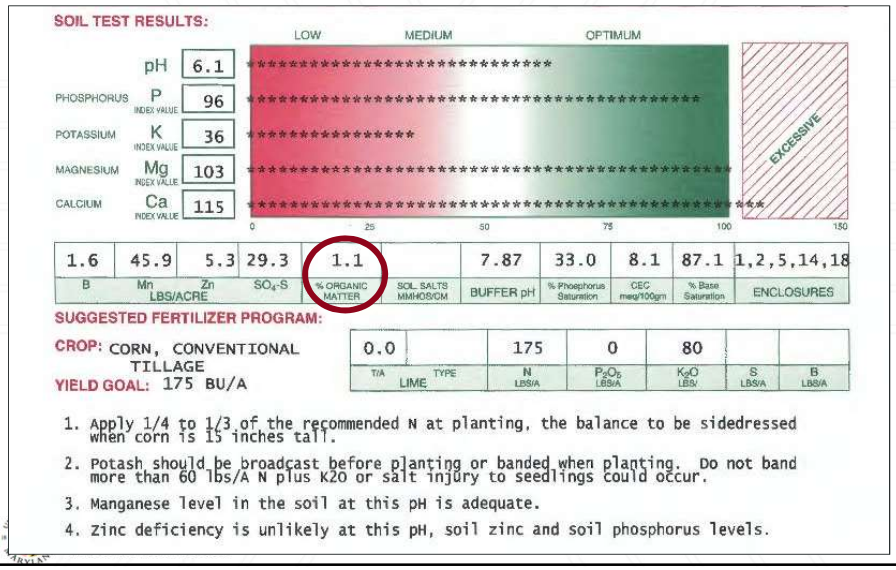
SUGGESTED FERTILIZER PROGRAM:

CROP: CORN, CONVENTIONAL TILLAGE
YIELD GOAL: 175 BU/A

T/A LIME	TYPE	N LBS/A	P_2O_5 LBS/A	K_2O LBS/A	S LBS/A	B LBS/A
0.0		175	0	80		

1. Apply 1/4 to 1/3 of the recommended N at planting, the balance to be sidedressed when corn is 15 inches tall.
2. Potash should be broadcast before planting or banded when planting. Do not band more than 60 lbs/A N plus K2O or salt injury to seedlings could occur.
3. Manganese level in the soil at this pH is adequate.
4. Zinc deficiency is unlikely at this pH, soil zinc and soil phosphorus levels.

Soil Test Result & Recommendations



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Fertilizers

- Natural and synthetic types
- 'Analysis' is % by weight of major elements
- Represent N, P_2O_5, and K_2O
  - % N,P & K in container don't equal 100%
- Includes fillers and conditioners
- May include absorbents for slow release
- 'Complete' fertilizers have all 3 elements
  - e.g.10-10-10; 29-6-4, 2-50-2
- 'Incomplete' do not
  - 10-0-20; 12-0-0
- Balanced means that N-P-K are present in equal amounts
  - 10-10-10
- Can be powdered, granular, liquid, spikes

Application timing and method

- Broadcast versus banded
- Liquid versus dry
- Apply when the crop needs it most
  - Small amount of fall N on lawns – may not prove very beneficial
- Starter and in-season
- Know what and how much you are applying
  - Spreader calibration
  - Analyze manure
  - Read the label

Composting

- Creating partially stabilized organic decay products using aerobic decomposition
  - Slow-release fertilizer
- Differences – high temperatures in composting not typically found in soils
- Composting ≠ stockpiling
  - Composting in an ACTIVE VERB and requires action and management

Not Composting

Process of Composting

- First mesophilic stage
  - High availability of easily-digestible microbe food available
  - Rapid metabolism → increase in temperature of pile
- Thermophilic stage
  - Temperatures rise to 122°-167°F
  - Decompose cellulose and other resistant materials
  - Mixing is important to evenly distribute heat
  - Forming humus-like compounds

Process of Composting

- Second mesophilic stage
  - Curing stage
  - Temperature returns to ambient
  - Recolonization of the pile by beneficial microorganisms

Final Product of Composting

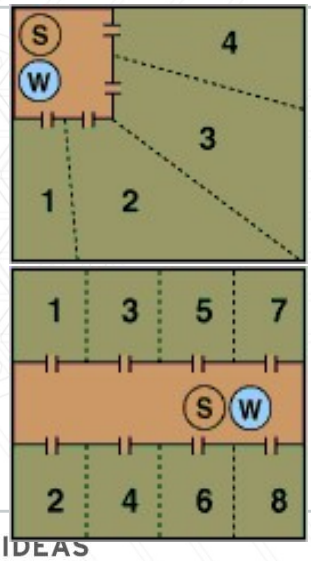
- Low C/N ratio
  - 10:1 – 20:1
- Increased CEC
- Mineral nutrients concentrated
- No harmful bacteria or microbes
- No weed seeds
- Heavy metals and inorganic contaminants remain

Benefits and Disadvantages of Composting

Benefits	Disadvantages
• Safe storage of organic materials	• Low nutrient content
• Easier to handle than raw material	• Slow availability of nutrients
• ↓ C/N ratio	• High P/N ratio
• High temps kill weed seed and pathogens	• Compared to plant needs
• Carbon neutral	• P can be a pollutant
	• Less beneficial to soil aggregation

Livestock Specific Management to Increase Soil Health and Quality

- Rotating animals through multiple small pastures
- Allowing pasture to rest and re-grow to maximize grass production



Livestock Specific Management to Increase Soil Health and Quality

- Reseeding or overseeding pastures
- Keeps bare soil covered, minimizes aeration and soil temperature
- Helps avoid weeds in pasture

https://albemarle.ext.vt.edu/programs/pasture-weeds.html

Livestock Specific Management to Increase Soil Health and Quality

- Make hay in resting pastures if grazing animals cannot keep up with growth

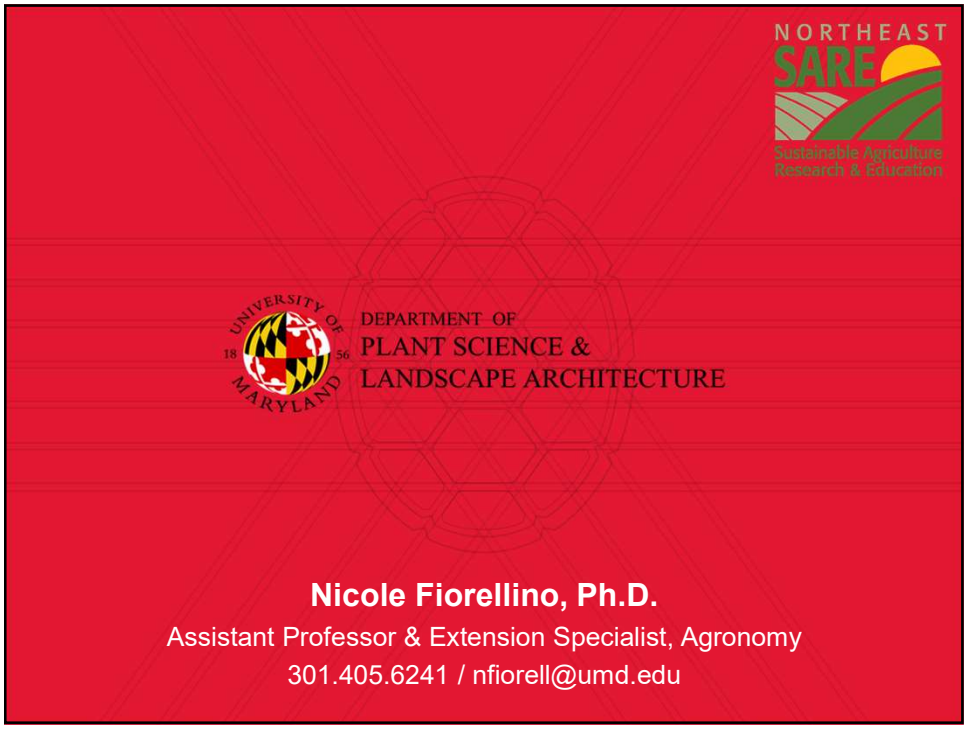
Livestock Specific Management to Increase Soil Health and Quality

- Dragging pastures to break up deposited manure
- This will evenly distribute nutrients across pasture
- Avoid “hot spots” of nutrients or pH

https://www.farmtechsupplies.com/2017/03/03/to-harrow-or-not-to-harrow/

Conclusions

- Learn about properties of the soil on your individual operation
  - Know what you can change via management and what you cannot
- Utilize routine soil testing to diagnose problems or maintain current fertility
- Make management adjustments with soil health and quality in mind



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Spectrum Analytic
1087 Jamison Road NW
Washingon Court House, OH 43160-8748
www.spectrumanalytic.com

Report To	Prepared For	
UNIVERSITY OF MARYLAND WMREC 18330 KEEDYSVILLE RD KEEDYSVILLE, MD 21756	AMANDA GREV 18330 KEEDYSVILLE RD KEEDYSVILLE, MD 21756	Sampled 03-12-2021 Tested 03-31-2021

Sample Number	Lab Number	pH		Organic Matter	Analysis Result* and Rating				CEC	Base Saturation			Mehlich-3 PPM and Rating						
		Soil pH	Buffer pH	%	Phosphorus P	Potassium K	Magnesium Mg	Calcium Ca		K %	Mg %	Ca %	Sulfur S	Boron B	Zinc Zn	Iron Fe	Copper Cu	Mang. Mn	Alum. Al
FIELD 1	G27821	6.6	7.1	3.5	26 L	166 G	136 M	1289 G	7.7	4.6	12.9	62.5							
FIELD 2	G27822	6.2	6.9	5.4	66 G	156 G	153 G	1044 G	6.6	5.1	17.1	59.6							
FIELD 3	G27823	6.2	6.9	4.1	14 L	137 G	152 G	727 G	5.3	5.5	20.9	51.1							
FIELD 4	G27824	6.3	7.0	3.1	35 M	184 G	139 G	1011 G	5.2	7.6	19.6	72.8							
FIELD 5	G27825	6.2	6.8	3.6	35 M	235 H	151 G	991 G	7.7	6.5	14.3	48.1							

Sample Number	Lab Number	P-FIV
FIELD 1	G27821	37
FIELD 2	G27822	79
FIELD 3	G27823	24
FIELD 4	G27824	46
FIELD 5	G27825	46

P, K, Mg and Ca are extracted by Mehlich-3 (ICP) and are reported in ppm

Sample Number	Lab Number	Year	Crop	Yield Goal	Acres	Nutrient recommendations expressed in broadcast rates of lbs/A except where noted.										
						CaCO3** Lime	N	P2O5	K2O	Mg	S	B	Cu	Fe Foliar	Mn Row	Zn
FIELD 1	G27821	21	Grass, Cool Season Pasture, Topdress	2 ton	5	0	31	67	74	16						
FIELD 2	G27822	21	Grass, Cool Season Pasture, Topdress	2 ton	3	1179	12	13	77	10						
FIELD 3	G27823	21	Grass, Cool Season Pasture, Topdress	2 ton	3	1179	25	86	85	10						
FIELD 4	G27824	21	Grass, Cool Season Pasture, Topdress	2 ton	5	608	35	58	52	27						
FIELD 5	G27825	21	Sudan Grass	5 ton	7	1597	89	73	48	26						

Lime expressed in 100% pure CaCO3. Adjust accordingly. D = Dolomitic Lime. C = Calcitic Lime.

Grass, Cool Season Pasture, Topdress: Omit N if legume >40% of stand. If cut as hay, increase fertilizer rate by 10 lb. N, 20 lb. P2O5, and 40 lb. K2O per acre to offset lack of manure recycling. P2O5 and K2O recommendations based on removal plus a 7 to 10 yr. soil buildup.

Sudan Grass: Monitor and adjust nutrient program based on annual tissue analysis

United States Department of Agriculture

NRCS Natural Resources Conservation Service

MARYLAND SOIL HEALTHCARD

What is Soil Health?

Soil Health is the continued capacity of a soil to function. Healthy soils support plants, animals, and humans by:

- Cycling nutrients and increasing their availability;
- Increasing water infiltration and availability;
- Maintaining a stable porous structure that withstands natural forces (e.g., water, wind).

Healthy, fully functioning soil creates a habitat that sustains diverse soil micro and macroorganisms.

Why is Soil Health Important?

Soils that lack organic matter, structure, and microorganisms are susceptible to erosion, hold less water, and need more chemical inputs to rebalance their productivity. Improving soil health increases soil aggregates and improves soil structure, resulting in greater water infiltration, decreased erosion, and reduced runoff and sedimentation.

Follow these 4 Key Principles to Improve Soil Health:

1. Minimize soil disturbance;
2. Maximize the diversity of plants in the rotation;
3. Keep living roots in the soil as much as possible;
4. Keep the soil covered with plants and plant residues at all times.

What Is the Soil Health Card?

The Soil Health Card evaluates a soil's health as a function of a select number of soil, water, plant, and other biological properties. The Card is a tool to help you monitor and make suggestions on how to improve soil health based on your own field experience and a working knowledge of soils. It is suggested to review the Web Soil Survey to gain an understanding of the soils mapped where you are measuring soil health. Regular use will allow you to record long-term changes in soil health, and to compare the effects of different soil management practices. It provides a mix of quantitative and qualitative assessment of soil health and evaluation ratings. The purpose is not to measure one soil type against another, but rather to use indicators that assess each soil's ability to function within its capabilities and site limitations. It can be used to compare one tillage practice or land use to another, of the same soil type. The Bucket Kit can be used as a follow up providing a more detailed analysis of the soil's health.

How Do You Use the Soil Health Card?

Step 1 The instructions to determine the "indicator descriptive ratings" is at the end of this document. One should also find out the soil series and map unit at the sample location.

Step 2 Use the table on page 2 for the best times to assess each indicator of soil quality and health.

Step 3 Divide the farm and fields into separate sections for evaluation in the same way you would divide them for soil-fertility sampling: separate by factors such as soil type, topography, and history of tillage, crop rotation, and manure application.

Step 4 Select a representative spot in your field and evaluate each soil health Indicator. Read the Descriptive Ratings in the table, and based on your test results or judgment, rate the indicator as Excellent, Good, Fair, or Poor by checking the box with the best description and entering the point value, in the score column, that you feel is appropriate.

Step 5 If you identify soil health indicators that are Poor or Fair, prescribe management strategies and conservation practices (see page 2) to improve soil health and quality over time.

Step 6 Follow changes in each of the soil health indicators over time, examine current field management practices, and consider ideas for management changes in problem areas.

Using Soil Health Management Strategies and Associated NRCS Conservation Practice Standards to Improve Observed Fair and Poor Soil Health Indicators

Surface Cover, Organic Matter, Soil Odor, and Earthworms Indicators

Management strategies such as:

- Using diverse high-residue crops -- see Conservation Crop Rotation (328);
- Using cover crops and cover crop mixes with grasses and legumes -- see Cover Crop (340);
- Using no-till or reduced tillage -- see Residue and Tillage Management (329) and (345);
- Reducing pesticide risk to beneficial soil organisms -- see Integrated Pest Management (595); and,
- Applying solid manure or compost at a proper agronomic rate -- see Nutrient Management (590).

These strategies will increase soil organic matter, soil biological activity, water holding capacity, and nutrient availability.

Infiltration, Compaction, and Soil Structure Indicators

Management strategies such as:

- Using diverse high-residue crops -- see Conservation Crop Rotation (328);
- Using cover crops, cover crop mixes, and deep-rooted cover crops -- see Cover Crop (340);
- Managing equipment traffic, especially on wet soils; and,
- Using no-till or reduced tillage -- see Residue and Tillage Management (329) and (345).

These strategies will improve soil structure and aggregation by increasing organic matter content and porosity, and will improve infiltration while minimizing compaction.

Best Times to Assess Indicators

Indicators	**Recommended Timing for Assessment**				
	Early Spring Before Planting	***Spring***	***Summer***	***Fall***	***After Rainfall***
Surface Cover	X	X	X	X	X
Infiltration	X	X	X	X	
Compaction	X	X		X	
Organic Matter	X	X	X	X	
Soil Structure	X	X	X	X	X
Earthworms	X	X		X	X
Soil Odor	X	X	X	X	X

MARYLAND SOIL HEALTH CARD

Farm/Tract/Field#s:	Assisted by:	Date and air temp:
Current Tillage System with number and kind of crops in rotation:	**Soil Series and Map unit sym:**	**Soil Surface Texture at site:**
Data from recent soil pH and/or organic matter analysis (if available):		

Indicators	Descriptive Ratings and Potential Scoring Points					
	Excellent 9-11 pts	***Good 6-8 pts***	***Fair 3-5 pts***	***Poor 0-2 pts***	**Score**	**Notes**
Surface Cover (Count living plants and dead residue)	>80% living plants and dead residue visible on soil surface. ☐	60-80% living plants and dead residue visible on soil surface. ☐	30-60% living plants and dead residue visible on soil surface. ☐	0-30% living plants and dead residue visible on soil surface. ☐		
Infiltration (Based on soil texture, refer to Infiltration Chart)	Infiltration rate at least two classes higher then listed range, indicates soil absorbs water easily. ☐	Infiltration rate one class higher then listed range, indicates soil absorbs water in a timely manner and is not susceptible to runoff or ponding. ☐	Infiltration rate within listed range, indicates soil absorbs water, but more slowly, and runoff and ponding may occur. ☐	Slower infiltration rate then listed range, indicates soil absorbs water very slowly, and runoff and ponding will occur. ☐		
Compaction/Root growth (Based on moist topsoil conditions)	Wire flag penetrates easily into 8 inches or more of soil with no resistence; unrestricted root growth. ☐	Wire flag penetrates into 6-8 inches of soil with a little resistence; requires a little wiggling of pin flag; little root growth restriction. ☐	Wire flag penetrates into 4-6 inches of soil with a lot of wiggling of pin flag and moderate force; root growth restricted. ☐	Wire flag penetrates into 2-4 inches of soil with force, roots maybe growing laterally. ☐		
Organic Matter (Compare to samples or Munsell book using Hues 7.5YR, 10YR or 2.5Y)	Soil is black in color; organic matter is visible in the topsoil layer. Value $\leq$ 2 and chroma $\leq$ 2. ☐	Soil is dark brown in color; organic matter is visible in the topsoil layer. Value = 3 and chroma = 3. ☐	Soil is somewhat dark in color; little organic matter is visible in the topsoil layer. Any value or chroma that doesn't meet Good or Poor numbers. ☐	Soil is light brown to dull colored; no organic matter is visible in the topsoil layer. Value > 4 and chroma > 4 ☐		
Soil Structure/ Aggregation	Soil is granular, soft and crumbly, held together with many fine roots. Looks like cottage chesse. ☐	Soil is granular, but not soft and crumbly, held together with some fine roots. ☐	Soil is blocky and firmer with few fine roots. ☐	Soil is single grain, massive or platy and hard to break apart. It has few or no fine roots. ☐		
Earthworms and Macroinvertebrates	Earthworms/grubs etc. >7 per spade, obvious middens and casts, and many pores. ☐	Earthworms/grubs etc. 4-6 per spade, obvious middens, casts, and pores. ☐	Earthworms/grubs etc. 1 to 3 per spade, few middens, casts, and pores. ☐	Earthworms/grubs etc. None present per spade, no middens, casts, or pores. ☐		
Soil Odor	Earthy/Sweet odor noticeable > 6 inches from nose. ☐	Earthy/Sweet odor, noticeable when close to nose. ☐	Little odor at all. ☐	No odor at all or sour, metallic, kitchen sink, rotten egg, stagnant. ☐		
					Total Score =	

Interpretation of Total Score Results

Excellent 60-77 pts	***Good 40-56 pts***	***Fair 20-39 pts***	***Poor 0-19 pts***

Instructions to determine the Indicator Descriptive Ratings

Equipment needed: measuring tape, small spray bottle of water, paper towels, 1-quart water, sharp shooter shovel, pin flag. Photos, charts, and guides of Attachments.

All determinations are performed either on the soil surface or within the topsoil layer, 6-12 inches thick. (You should dig a hole to determine the thickness of the topsoil layer).

Soil Texture (see Attachment A)

1. Take sample 2-4 inches into topsoil layer.
2. Follow directions on Guide for Estimating Soil Texture by Feel.

Surface Cover: (see Attachment B)

1. Visual judgement by using NRCS residue photos or with a measuring tape.
2. Make estimates based on decomposing residue and living plant material.

Infiltration (see Attachment C)

1. Dig a small 2-inch-deep hole so that it has a flat bottom with straight sides.
2. Lightly scratch the bottom and sides of the hole with the pin flag.
3. Pour in1 inches of water.
4. Time how long it takes water to completely infiltrate.
5. Repeat two to three times.
6. Compare to Infiltration Chart with soil textures.

Compaction:

1. Hold pin flag about 12-15" from lower end.
2. Push lower end into soil surface, wiggling if needed. Pin flag shouldn't bend.
3. Observe how deep the pin flag penetrates the soil.

Organic Matter (see Attachment C)

1. Select soil sample from topsoil layer.
2. Moisten soil if dry.
3. Match soil with organic matter color chart or use Munsell color chart if available.

Soil Structure/Aggregation: (see Attachment D) Can be done along with Earthworms.
Visual judgement using NRCS photos.

Earthworms:

1. Remove a large shovel of topsoil.
2. Separate the soil gently looking for earthworms and other macroinvertebrates.
3. Count number of them present.

Soil Odor:

1. Cup soil in both hands and smell.
2. Healthy soil should have a sweet earthly aroma.
3. If soil smells sour, metallic, stagnant, or like kitchen cleanser, this may be a good indicator that the soil is not functioning.

GUIDE FOR ESTIMATING SOIL TEXTURE BY FEEL

START

Place some soil, about the size of an egg, in your palm. Spray with water to moisten it and knead the soil to break down all lumps (aggregates). Remove any pebbles or wood fragments. Knead it until it feels like moist putty, not mud.

Add dry soil to soak up water

Does soil remain in a ball when thrown 1 ft. in air and caught?

Is soil too dry?

Is soil too wet?

SAND → **COARSE**

Place ball of soil between thumb and forefinger gently pushing the soil with the thumb, squeezing it upward into a ribbon. Form a ribbon of uniform thickness and width. Allow the ribbon to emerge and extend over the forefinger, breaking from its own weight.

Does soil make a weak ribbon >1/2" long?

LOAMY SAND → **COARSE**

Does soil make a ribbon <2" long after breaking?

Does soil make a medium ribbon 2-3" long after breaking?

Does soil make a strong ribbon >3" long after breaking?

Wet a small pinch of soil in palm and rub with forefinger.

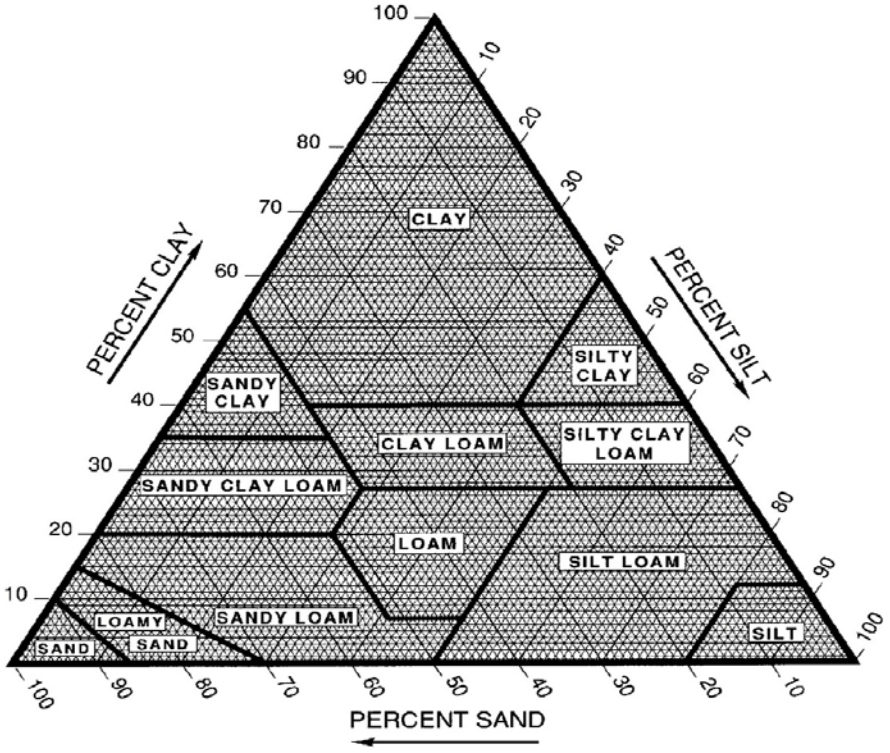
Does soil feel very gritty?	Does soil feel very smooth?	Neither grittiness nor smoothness predominates.
SANDY LOAM → **MODERATELY COARSE**	SILT LOAM → **MEDIUM**	LOAM → **MEDIUM**
SANDY CLAY LOAM → **MEDIUM**	SILTY CLAY LOAM → **MODERATELY FINE**	CLAY LOAM → **MODERATELY FINE**
SANDY CLAY → **FINE**	SILTY CLAY → **FINE**	CLAY → **FINE**

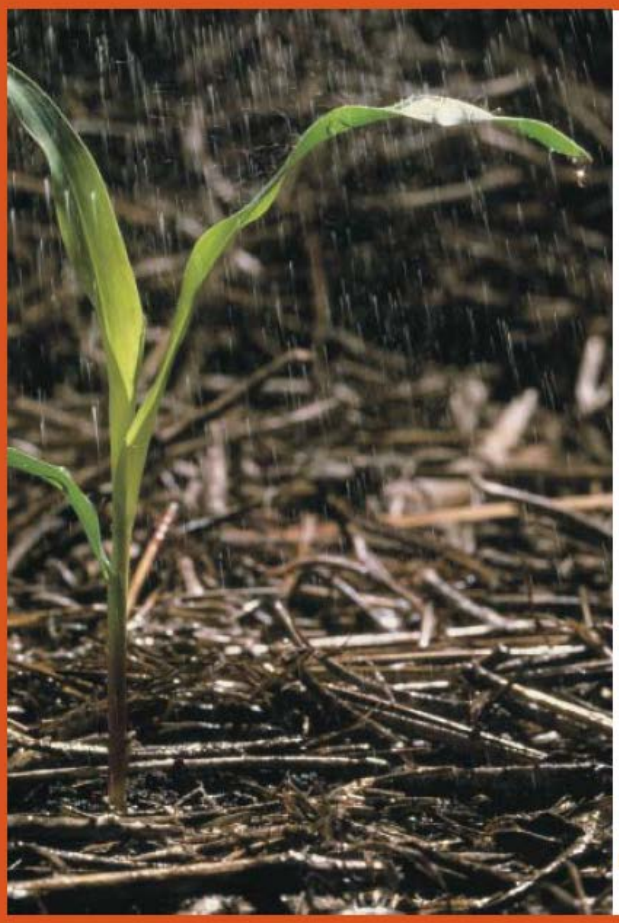
LOW ← % CLAY → HIGH

Generally, each inch of ribbon equals 10% CLAY

FIELD CRITERIA USED IN DETERMINING MAJOR TEXTURAL CLASSES

TEXTURE CLASS MAJOR (USDA)	FEEL MOIST	ABILITY TO FORM STABLE BALL	ABILITY TO RIBBON OUT	SOIL HANDS	STICKY	CONSISTENCY MOIST	CONSISTENCY DRY
COARSE (sand)	very gritty	no	no	no	no	loose	loose
COARSE (loamy sand)	very gritty	yes	yes, very weak <1/2" long	yes slight	no	loose	loose
MOD. COARSE (sandy loam)	gritty	yes, easily deformed	yes, dull surface poorly formed	yes	no	very friable	soft
MEDIUM (loam)	slightly gritty	yes	yes, dull surface poorly formed	yes	yes, slight to moderate	friable	soft
MEDIUM (silt loam)	velvety	yes	yes, dull surface poor to well formed	yes	yes, slight to moderate	friable	soft
MOD. FINE (silty clay loam)	velvety & sticky	yes very stable	yes, shiny surface well formed	yes	yes	friable to firm	slightly hard
MOD. FINE (clay loam)	slightly gritty & sticky	yes very stable	yes, shiny surface well formed	yes	yes	firm	slightly hard to hard
MEDIUM (sandy clay loam)	very gritty & sticky	yes very stable	yes, shiny surface well formed	yes	yes	friable to firm	slightly hard to hard
FINE (sandy clay)	very gritty ext. sticky	yes very stable	yes, shiny surface well formed	yes	yes very	firm	hard to very hard
FINE (silty clay)	ext. sticky & very smooth	yes, very resistent to molding	yes, shiny surface well formed	yes	yes very	firm to ext. frim	hard to very hard
FINE (clay)	ext. sticky & very smooth	yes, very resistent to molding	yes, shiny surface well formed	yes	yes very	firm to ext. frim	hard to very hard





Farming with Crop Residues

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

February 1992

How to use the photos

Use these photographs of residue amounts to get a good picture in your mind of what the various percentages of ground cover might look like as you look down at evenly distributed residues.


30%


60%

How to measure residues

- Use any line that is equally divided into 100 parts. Fifty foot cable transect lines are available for this purpose. Another tool is a 50-foot nylon rope with 100 knots, six inches apart. A 50-foot tape measure using the 6-inch and foot marks also works well.
- Stretch the line diagonally across the rows. Count the number of marks (tabs or knots) that have residue under them when sighting from directly above one end of the mark. It is important to use the same point on each mark for accuracy. Don't count residue smaller than 1/8 inch in diameter.
- Walk the entire length of the rope or wire.

The total number of marks with residue under them is the percent cover under them is the percent cover for the field. If your rope or tape has only 50 marks, multiply by 2; for 25 marks, multiply by 4.

- Repeat the procedure at least 3 times in different areas of the field and average the findings.

Helping People Help the Land.

INFILTRATION RATE BASED ON SOIL TEXTURE CLASS

(Attachment C)

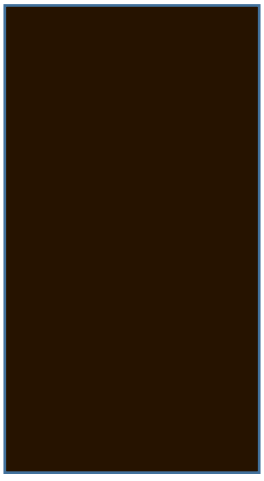
MAJOR SOIL TEXTURE CLASS	USDA SOIL TEXTURE CLASS	INFILTRATION RATE (1 in of water to infiltrate)
Coarse	sand or loamy sand	<10 min
Moderately Coarse	sandy loam	10-30 min
Medium	silt loam, loam, or sandy clay loam	30-120 min
Moderately Fine	silty clay loam, or clay loam	2-10 hrs
Fine	silty clay, clay, or sandy clay	>10 hrs

ORGANIC MATTER DETERMINATION BY COLOR

(Compare using the color chips below or use a Munsell color book.)

EXCELLENT

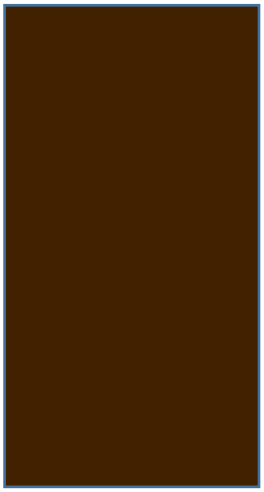
This color or darker



GOOD

This color

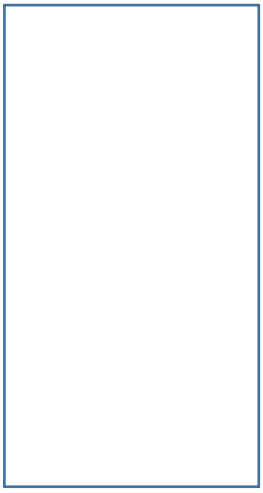
or close to it.



FAIR

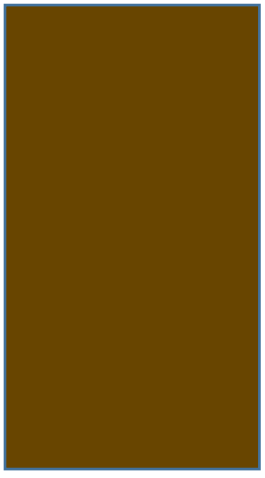
All colors in between

good and poor.



POOR

This color or lighter.



SOIL STRUCTURES USED IN SOIL HEALTH

Granular

Blocky

Single grain

Massive

Platy