How Can I Tell if My Soil is Healthy?

unlock the SECRETS IN THE SOIL

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Soil Health What is It?

- The continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals, and humans
  - Nutrient cycling
  - Water (infiltration & availability)
  - Filtering and Buffering
  - Physical Stability and Support
  - Habitat for Biodiversity

United States Department of Agriculture
NRCS Natural Resources Conservation Service OKLAHOMA

SOIL QUALITY CARD

Date_____ **Crop**_____ **Yield**_____

Field Location_____ **Owner/Producer** _____

Indicator → Preferred 1 2 3 4 5 6 7 8 9 10	Observations	Rating the Indicator LOW 1-4	MEDIUM 5-7	HIGH 8-10
Soil Tilth		Soil clods difficult to break, tillage creates large clods, crusting	Soil clods break with some difficulty, tillage creates small clods, some crusting	Soil crumbles well, tills easily, mellow
Organic Matter		No visible roots or residue, light colored surface	Some roots and residue, light brown surface	Lots of roots and residue in many stages of decomposition, dark colored surface
Compaction		Hard layers, tight soil, limited root pentration below 8 inches, roots turn at 90 degree angles	Firm soil, some restriction of roots, moderate shovel resistance	Loose soil, no root restrictions, mostly vertical root plant growth
Earthworms and other Life		None to a few worms, insects or other soil life	Some worms, insects or other soil life	Many worms, insects or other soil life
Water Infiltration		Water on surafce for a long period after rains or irrigation, high runoff	Water drains slowly after rain or irrigation, some ponding, moderate runoff	Water moves steadily through the soil, little or no runoff
Plant Health		Stunted growth, uneven stands, discoloration, low yields	Some uneven or stunted growth, slight discoloration, signs of stress	Healthy, vigorous and uniform stand
Erosion		Signs of severe windstress or gullies throughout field	Some deposition, few gullies, sign of sheet and rill erosion, some colored runoff	No visible soil movement, no gullies, clear or no runoff
Salinity		Visible salts/alkali, bare areas, EC greater than 8 dS/m	Stunted growth, saline spots, EC 2 to 8 dS/m	No visible salt, or plant damage, EC less than 2 dS/m
Soil pH		pH greater than 1.0 unit higher or lower than needed for the crop	pH 1.0 unit higher or lower than needed for the crop	pH proper for the crop
Other:(write in)				

Field Notes/Inputs

Cropping System/Rotation_____ **Support Conservation Practices**_____

Tillage system _____ **OTHER OBSERVATIONS:**_____

Fertilizer inputs_____ _____

Pesticides _____ _____

Typical Soil Test

Lab Results
lbs. per Acre

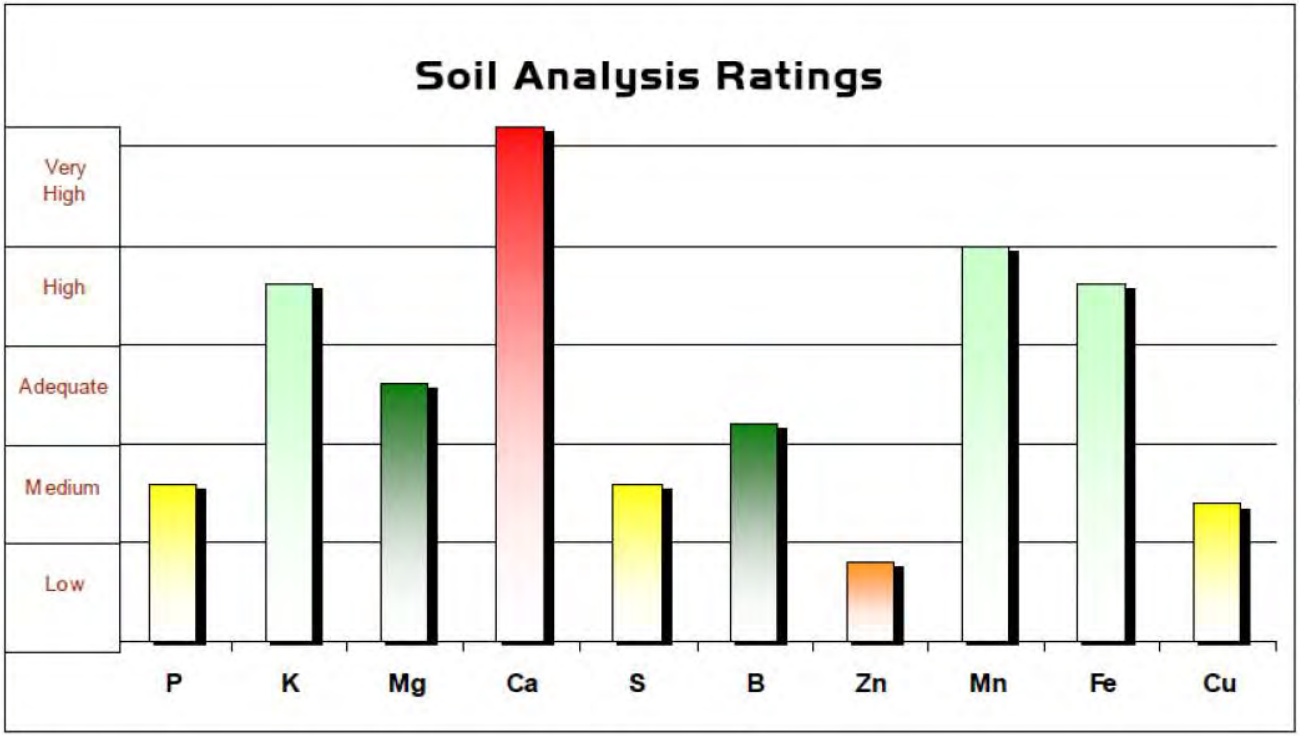
Lab Number: 135418SO

Target pH: 6.5

Test Method: Mehlich III

P Phosphorus	K Potassium	Mg Magnesium	Ca Calcium	Soil pH	Buffer pH	S Sulfur	B Boron	Zn Zinc	Mn Manganese	Fe Iron	Cu Copper
72 M	379 H	201 A	2407 VH	5.6	7.50	36 M	1.6 A	3.1 L	395 H	282 H	2.0 M

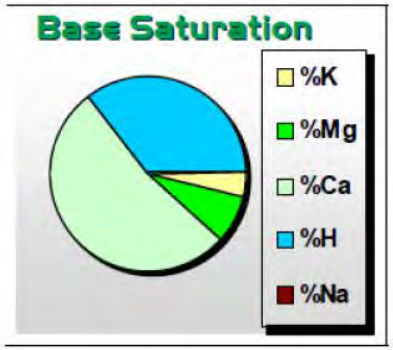
Aluminum	Sodium	Nitrate N	Soluble Salts mmhos/cm	Organic Matter	ENR
				3.02 %	60.4



Cation Exchange Capacity: 11.3 meq/100g

Base Saturation

K:	4.3 %
Mg:	7.4 %
Ca:	53.1 %
H:	35.3 %
Na:	%



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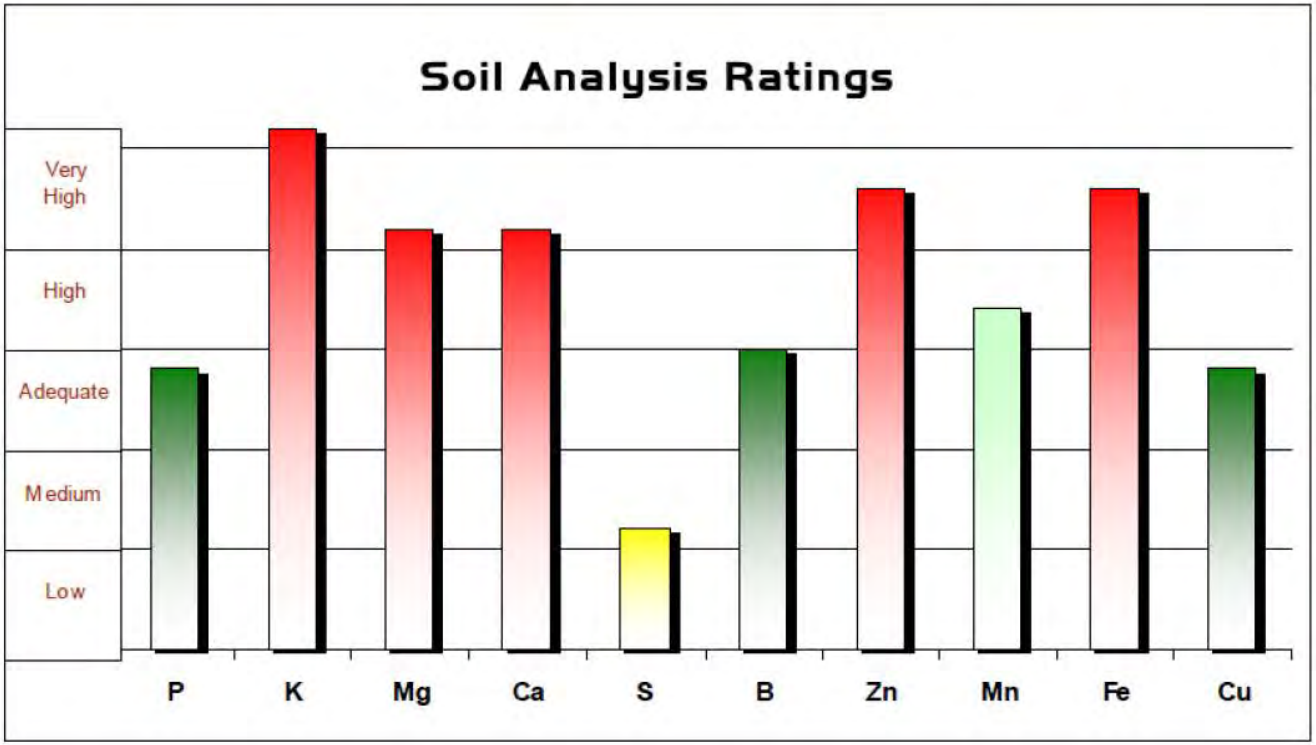
P Phosphorus	K Potassium	Mg Magnesium	Ca Calcium	Soil pH	Buffer pH	S Sulfur	B Boron	Zn Zinc	Mn Manganese	Fe Iron	Cu Copper
131 A	628 VH	309 VH	1951 VH	5.5	7.55	30 M	2.0 A	17.0 VH	260 H	509 VH	4.9 A

Aluminum	Sodium	Nitrate N	Soluble Salts mmhos/cm	Organic Matter	ENR						
				3.98 %	79.6						



Cation Exchange Capacity **10.6** meq/100g

Base Saturation

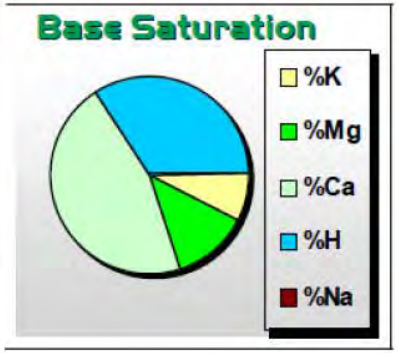
K: 7.6 %

Mg: 12.2 %

Ca: 46.1 %

H: 34.1 %

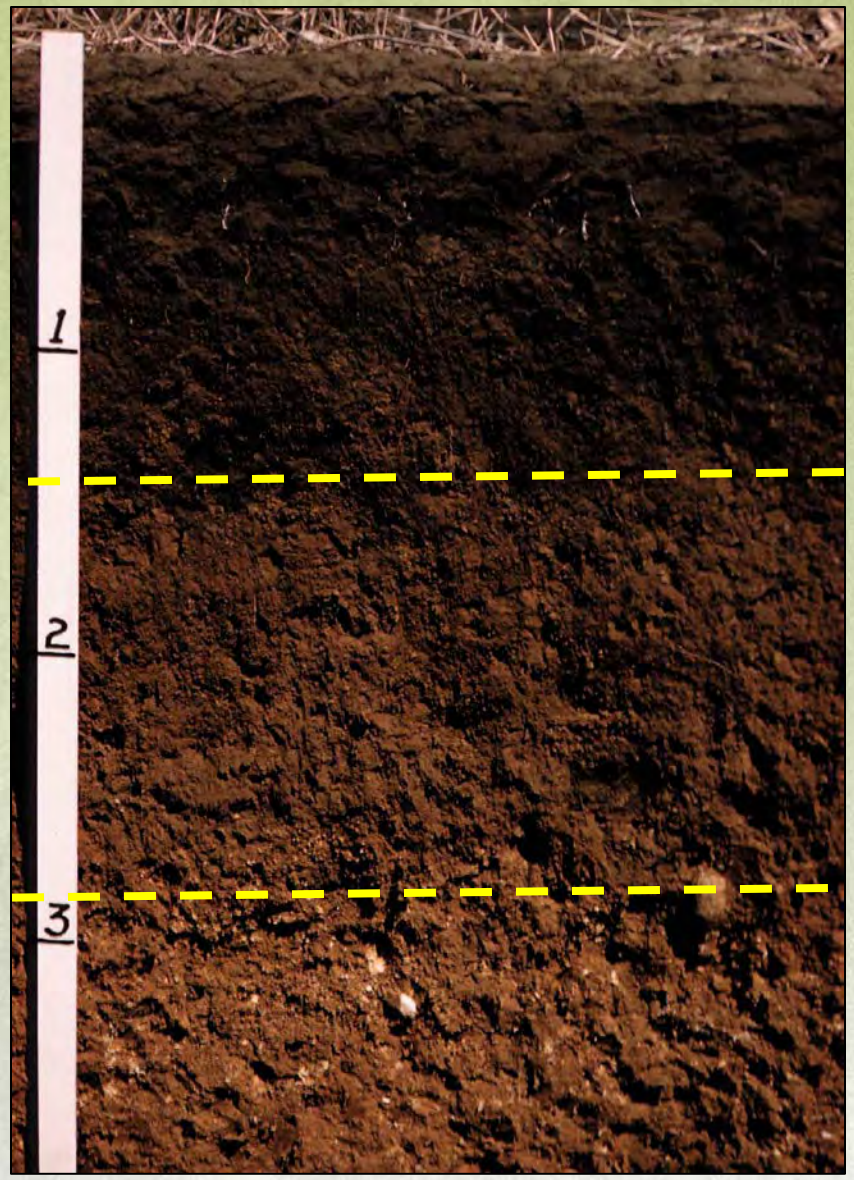
Na: %



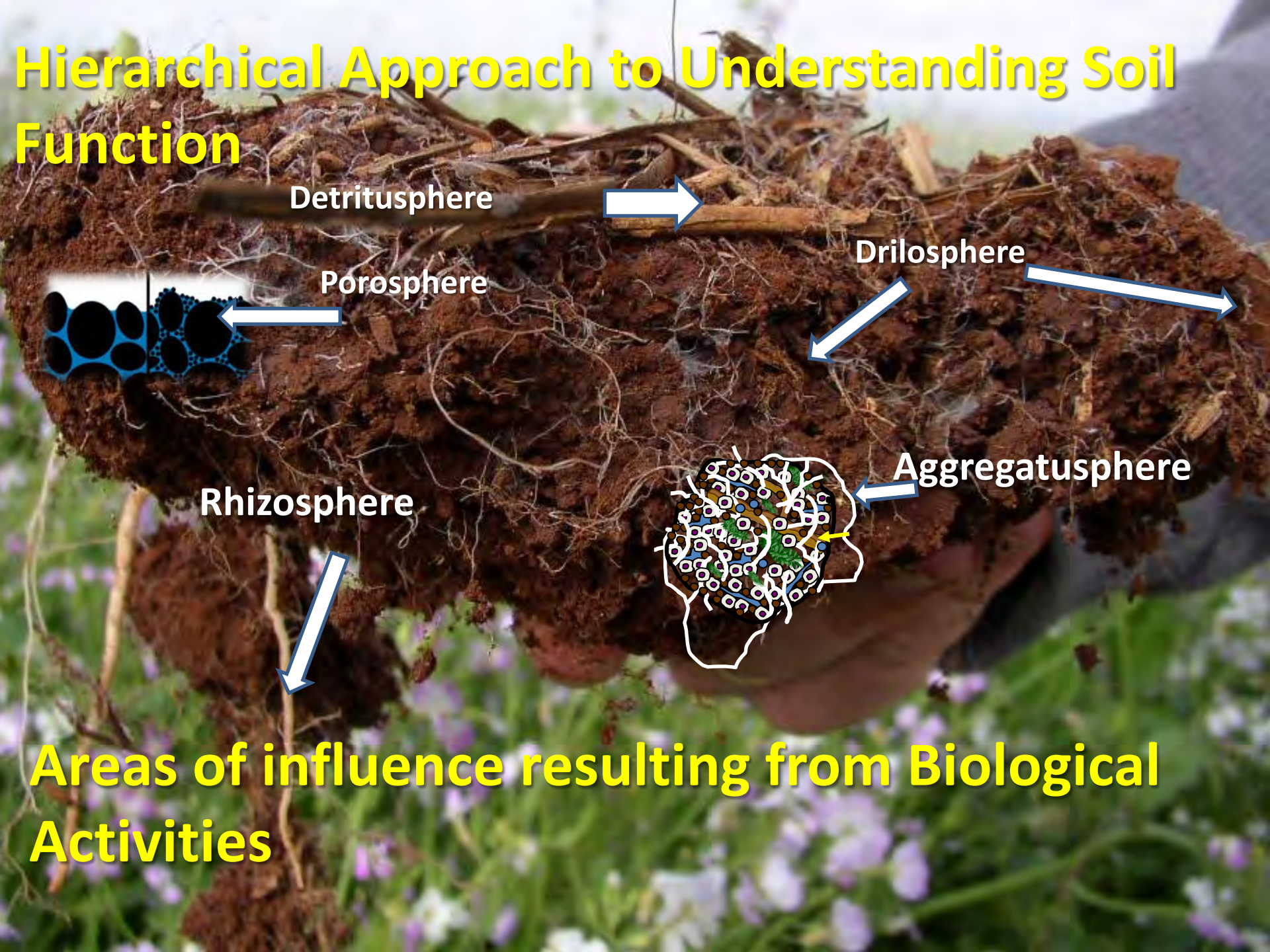
Soil Profile

Physical Characteristics

- Texture
- Structure
- Color
- Define horizon boundaries



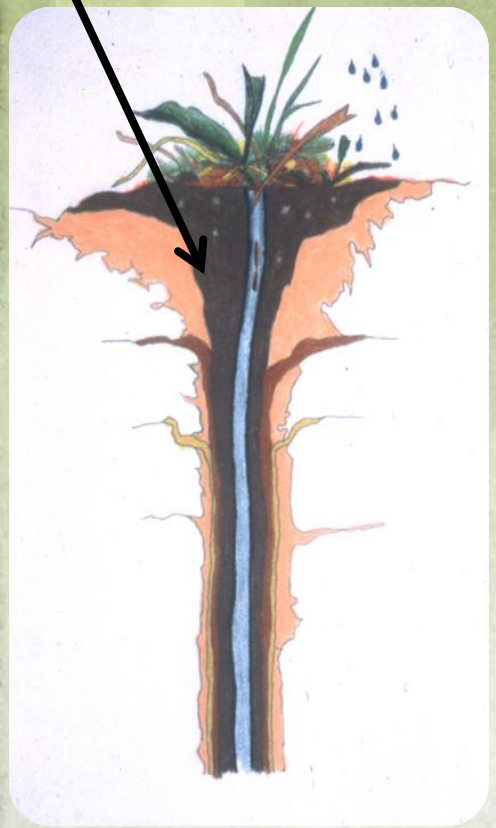
Hierarchical Approach to Understanding Soil Function



Areas of influence resulting from Biological Activities

The Detritusphere: Imfluence of residue

Drilosphere: Zone of earthworm influence



- Redistributes plant litter "Carbon" throughout the soil the profile
- Soils are enriched with N,P, and humified organic matter
- Increase water infiltration
- Provide a bio pore for plant roots
- Homogenize soil surface
- Increase bio-diversity in soils

M.H. Beare, D.C. Coleman, D.A. Crossley Jr., P.F. Hendrix and E.P. Odum (1995)

Epigeic – Red Worms (Bohlen et al 2004)
- reddish in color
- live and feed exclusively in the surface litter of the soil
- limited mixing of mineral and organic soil layers

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Anecic or Night crawlers (Bohlen et al 2004)
- 10 to 15 centimeters in size.
- Eat fresh litter at the surface of the soil
- Make burrows, sometimes up to 2 meters deep.
- Incorporate litter into the soil
- Bring mineral soil from different depths to the surface
- Soil mixing that is very different from worms

Endogeic (Bohlen et al 2004)
- whitish gray and live and feed only in the soil or under logs.
- They almost never come to the surface
- Feed on leaves or other organic material
- Soil (i.e. excrement) they leave behind are called casts.
- Reside in the mineral or mixed soil layers

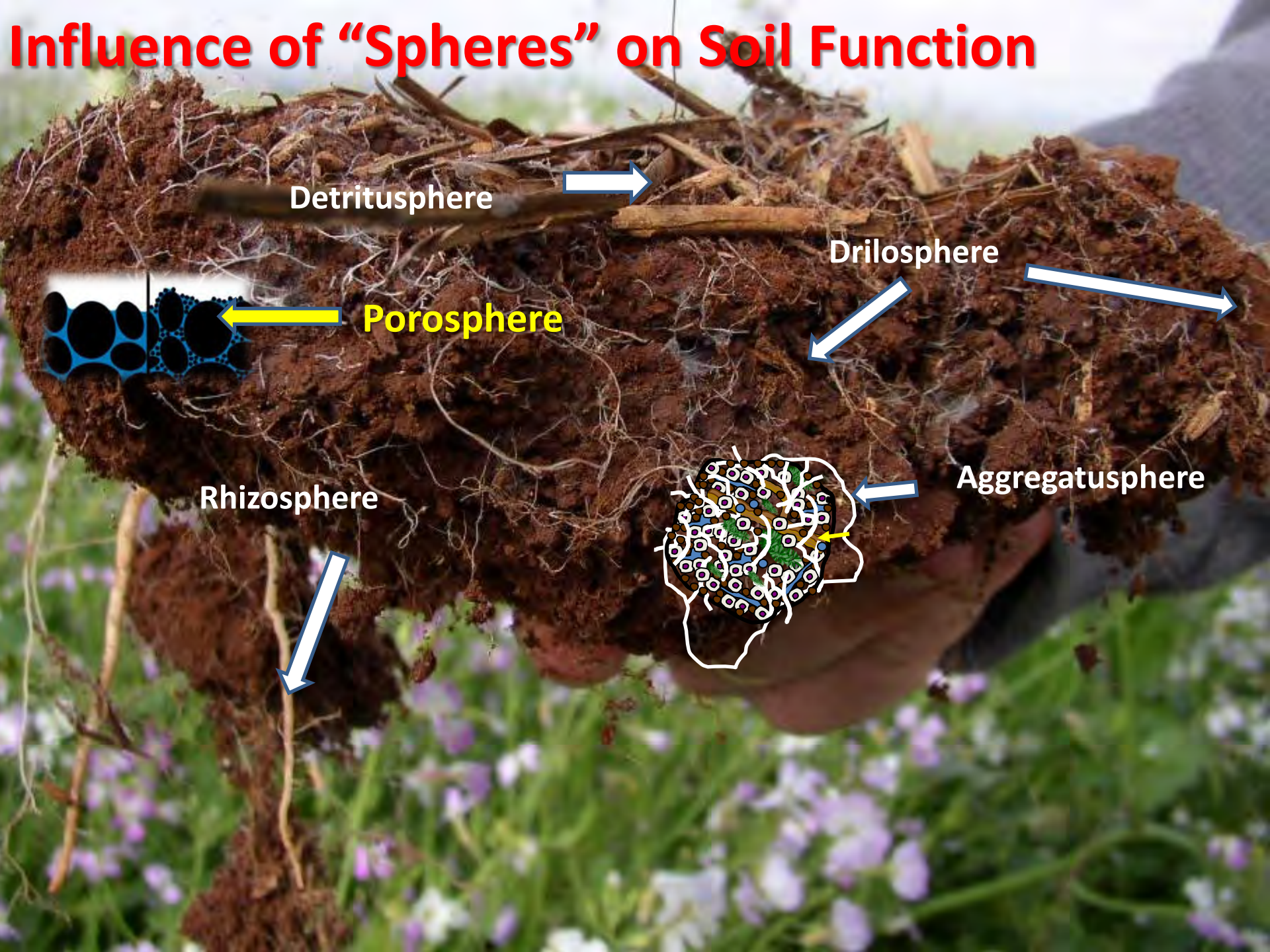
Nature’s residue managers

Earthworms

- Poor soils contain 250,000 earthworms per acre while good soils contain 1,750,000 per acre
- 1 or less per shovel indicates poor soil health
- 10 or more per shovel indicates good soil health
- Burrowing through lubricated tunnels forces air in and out of soil
- Earthworm casts contain
  - 11% of the humus
  - 7X the nitrogen
  - 11X the phosphorus
  - 9X the potash

  than surrounding soil

Influence of “Spheres” on Soil Function



Porosphere: Arrangement of Solids and Voids

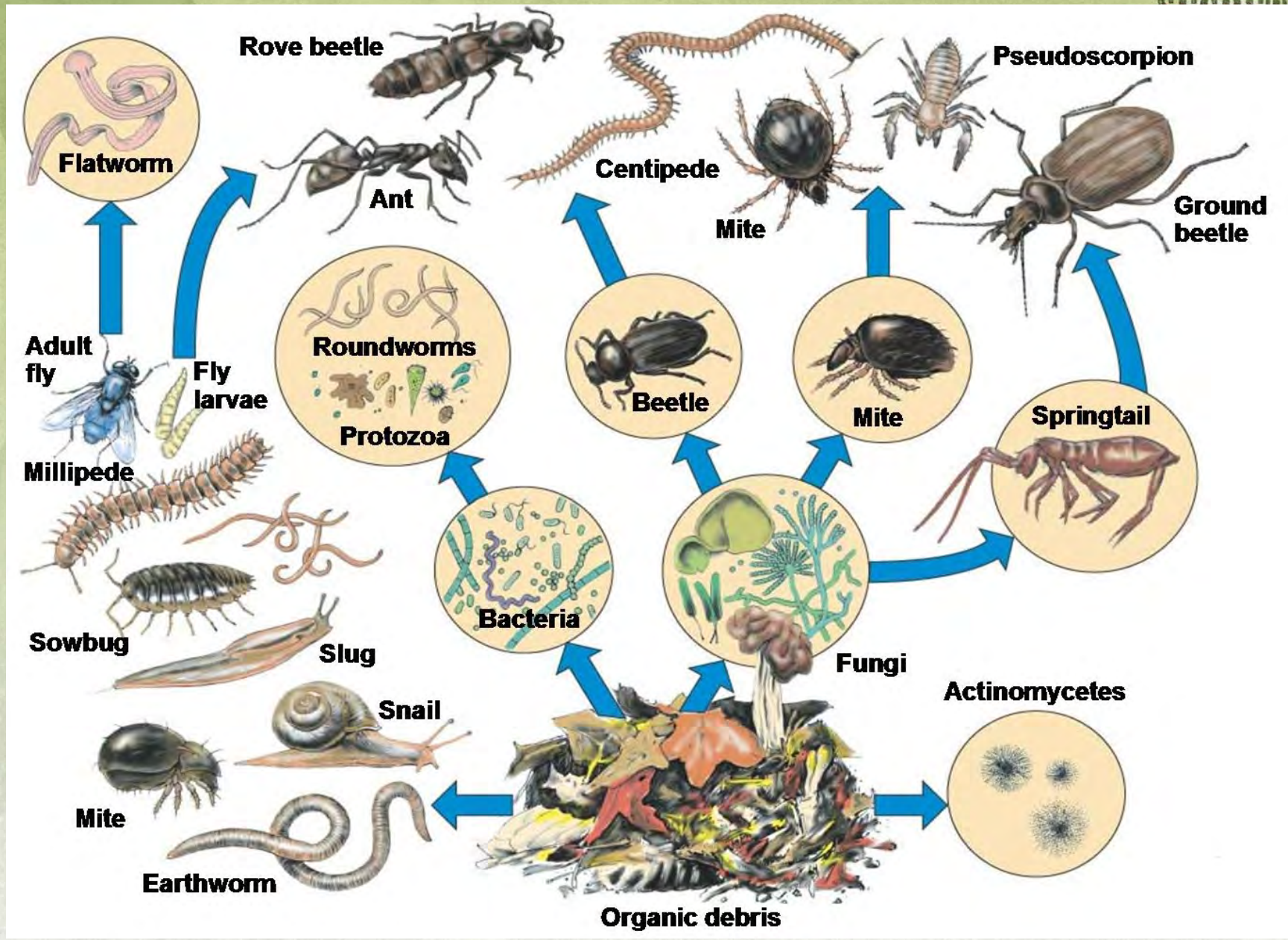
Primary an Aquatic Habitat (water films): for protozoa, bacteria, Mycorrhizae**, and nematodes**

The lungs and circulatory system of the soil:

- **Regulates water and air flow**
- **Impacts N, P Mineralization**
- **Impacts soil organism bio-mass and diversity**
- **Site of nutrient exchange**
- **Site of mycorrhizal entanglement and sequestration of water and nutrients**
- **Root interface**
- **Part of the water cycle**

M.H. Beare, D.C. Coleman, D.A. Crossley Jr., P.F. Hendrix and E.P. Odum (1995)

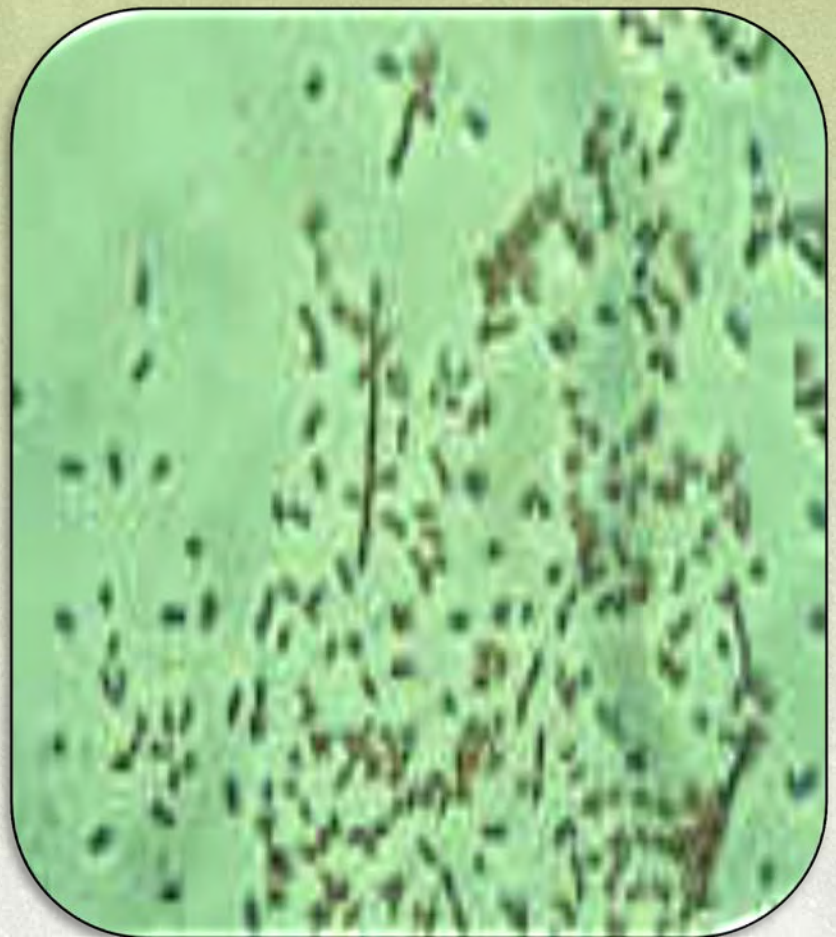
5% OF SOIL ORGANIC MATTER IS LIVING ORGANISMS



http://www.rw.ttu.edu/2302_butler/chapter6.htm

Bacteria – Services they provide

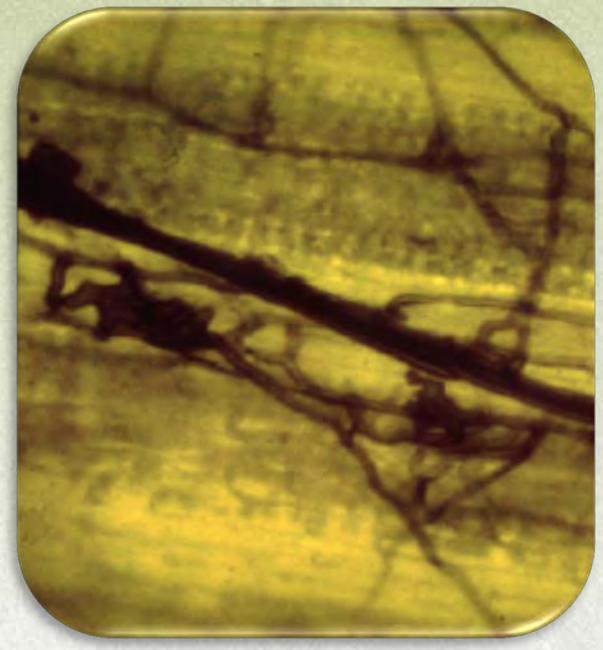
- Decomposition of OM
- Nutrient cycling
- Nitrogen fixation



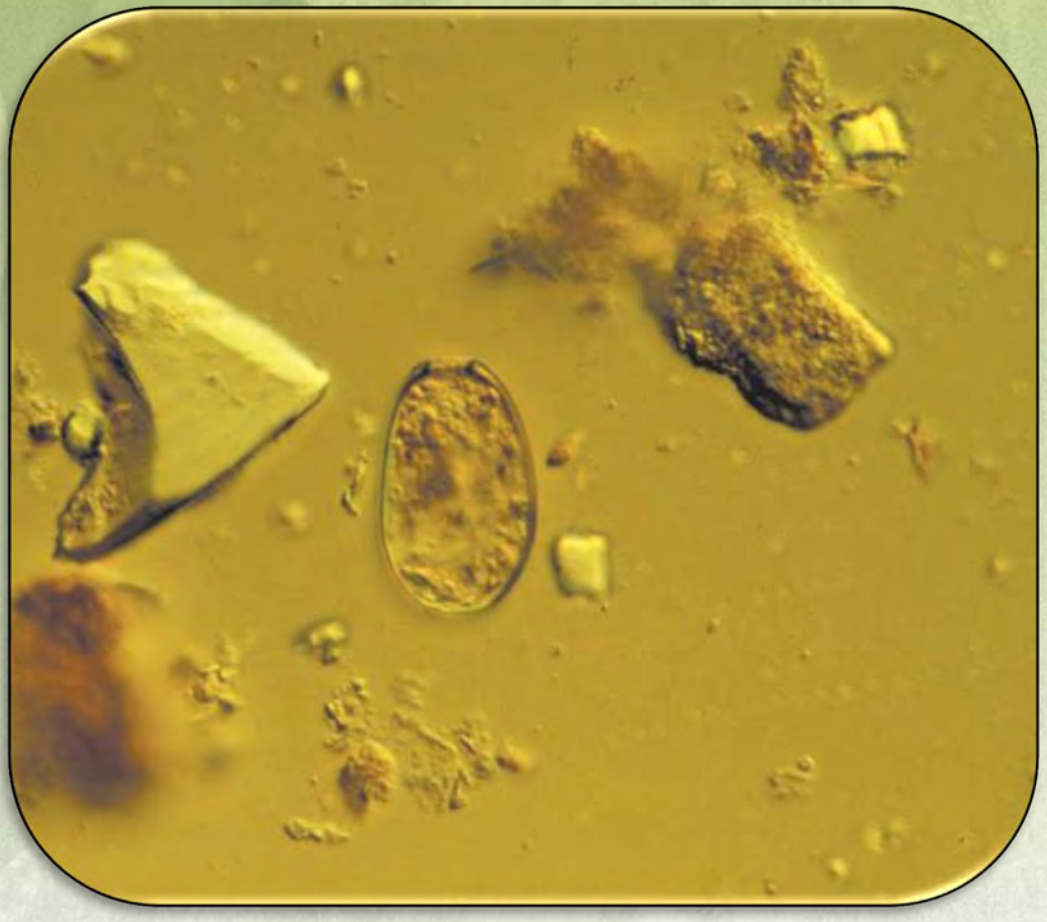
- Nitrification
- Denitrification
- Disease Suppression
- Breakdown of hard to decompose compounds

Fungi- Service they provide

- Decompose Organic Matter
- Glomalin secretion develops soil structure
- Extract nutrients
- Hold nutrients



Protozoa – Services they provide



- Nutrient mineralization
- Regulation of bacterial populations
- Food source themselves

Nematodes – Services they provide

A bacteria-feeding nematode

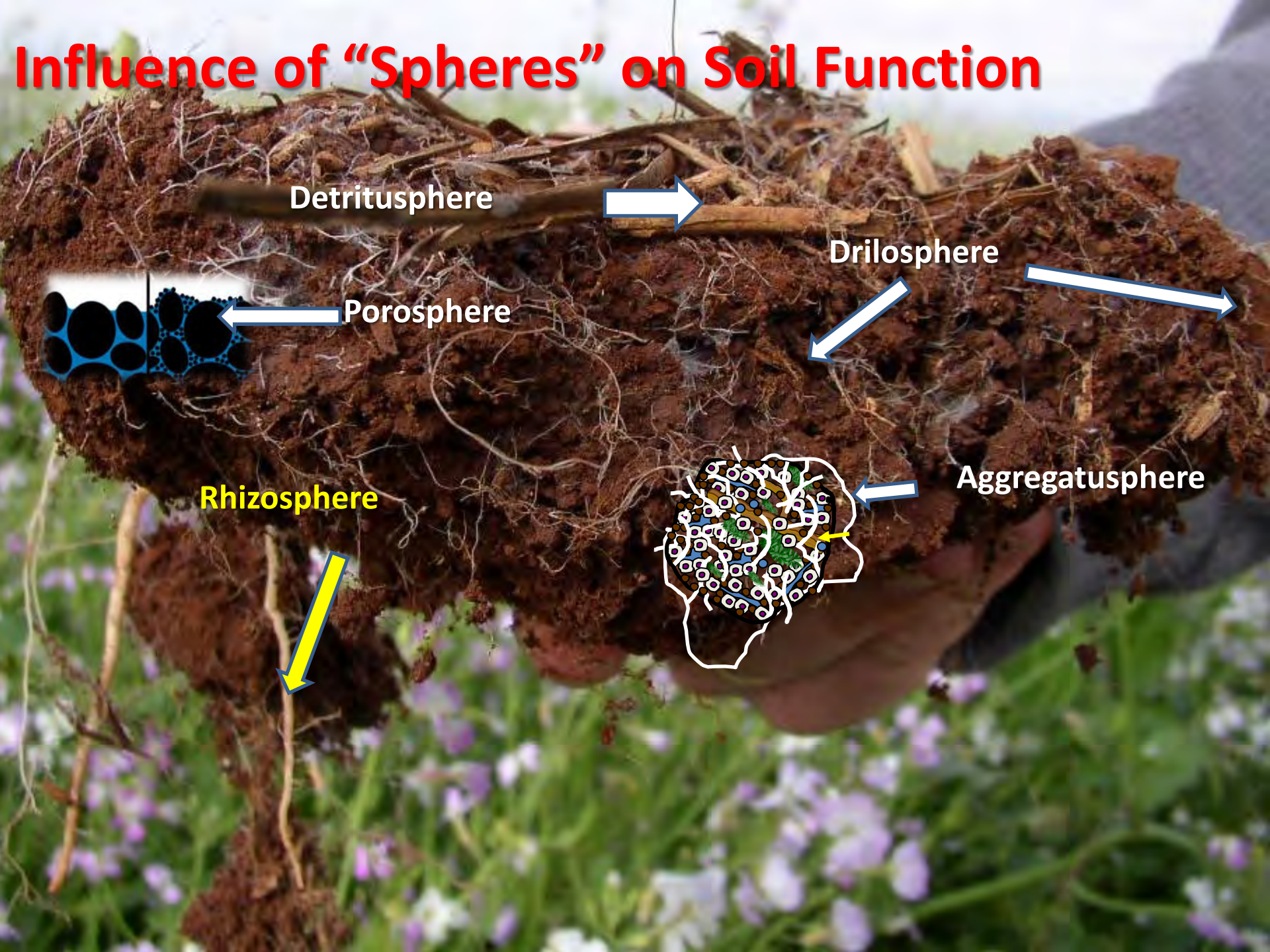
- Control disease
- Cycle nutrients
- Disperse bacteria & fungi

A fungal-feeding nematode

Bulk Density of Soils in New Jersey

Permeability Measurements of Sampled Layers within 20 " of Soil Surface		
Site	Bulk Density (g/cm3)	Permeability (in/hr)
Woods	1.42	15
Pasture	1.47	9.9
Single House	1.67	7.1
Subdivision Lawn (1)	1.79	0.14
Garage Lawn	1.82	0.13
Cleared Woods	1.83	0.13
Subdivision Lawn (2)	2.03	0.03
Athletic field	1.95	0.01
Concrete	2.4	0.00

Influence of “Spheres” on Soil Function



Rhizosphere

- Narrow region of soil directly around roots
- Living roots release many types of organic materials
- These compounds attract Bacteria that feed on the proteins & sugars

Rhizosphere

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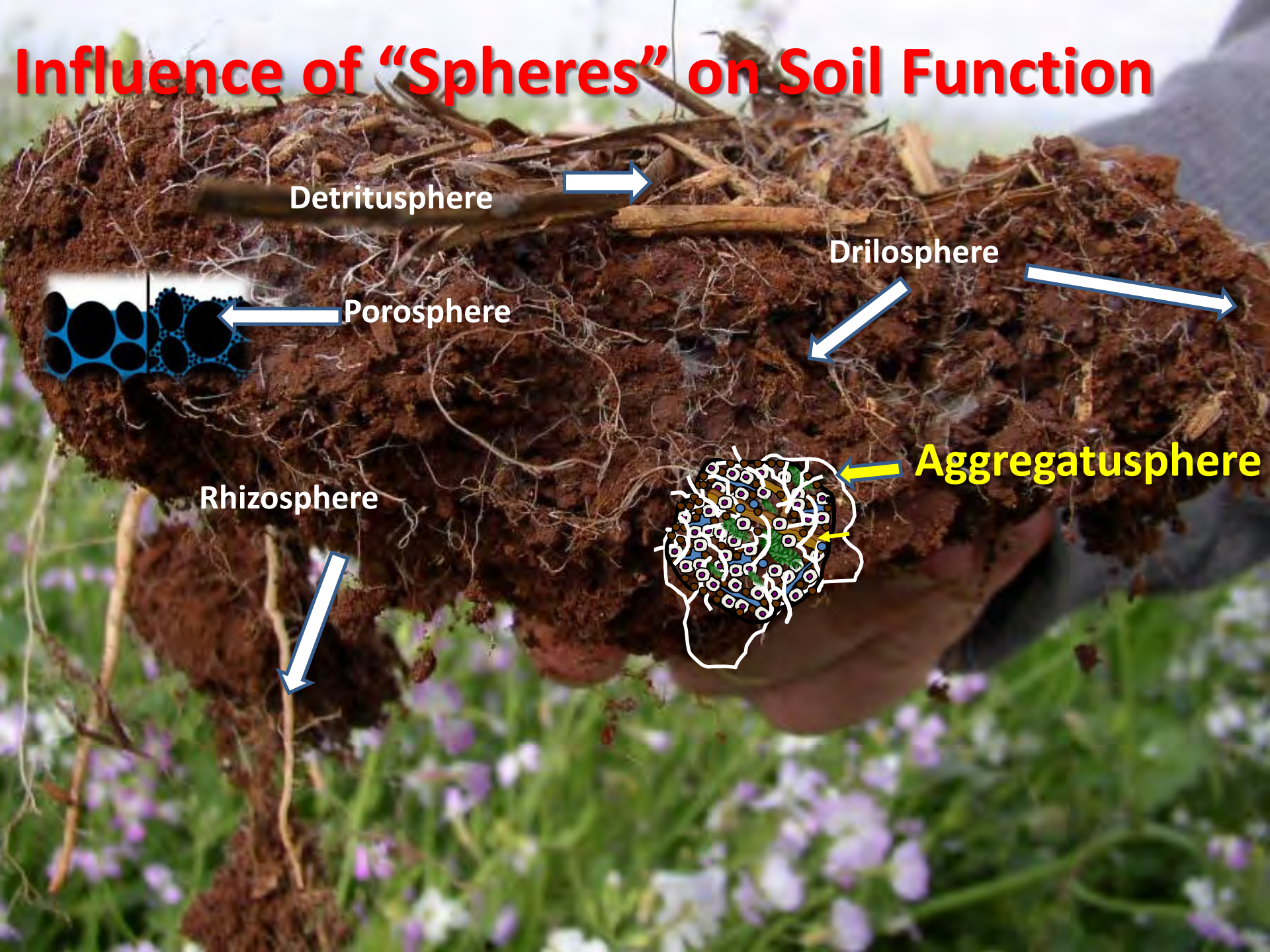
- Number of bacteria is from 5 to 2000 times larger than in the regular soil.
- Protozoa and Nematodes feed on the bacteria
- Nutrient cycling & disease suppression start right here

The root is a Leverage Point: Engineering

Influence of “Spheres” on Soil Function



Aggregatusphere : Influence of Soil Aggregates

Closed Habitat of Micropores

- Protects organic matter from decay
- Storage site for organic matter
- Habitat of Oligotrophic and Copiotrophic bacteria
- Protects and maintains the integrity of the porosphere

They are linked mainly by fungi hyphae, roots fibers, polysaccharides, Glomalin, rhizo-deposition, and aromatic humic materials

Beare, D.C. Coleman, D.A. Crossley Jr., P.F. Hendrix and E.P. Odum (1995)

Root and Mycorrhizal Fungi Association:

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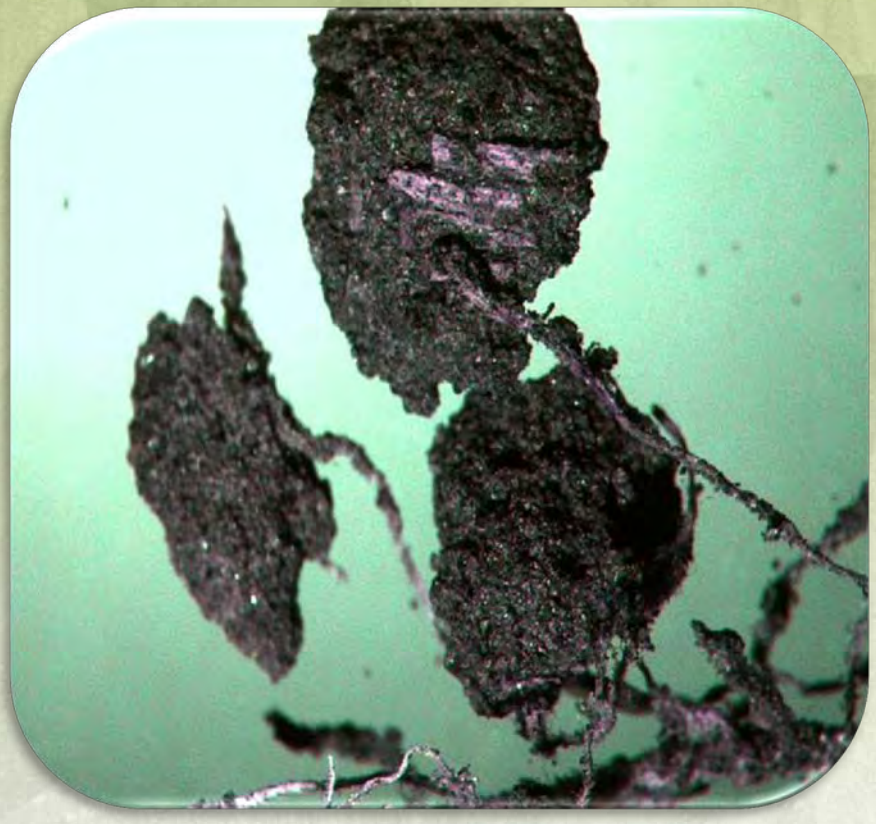
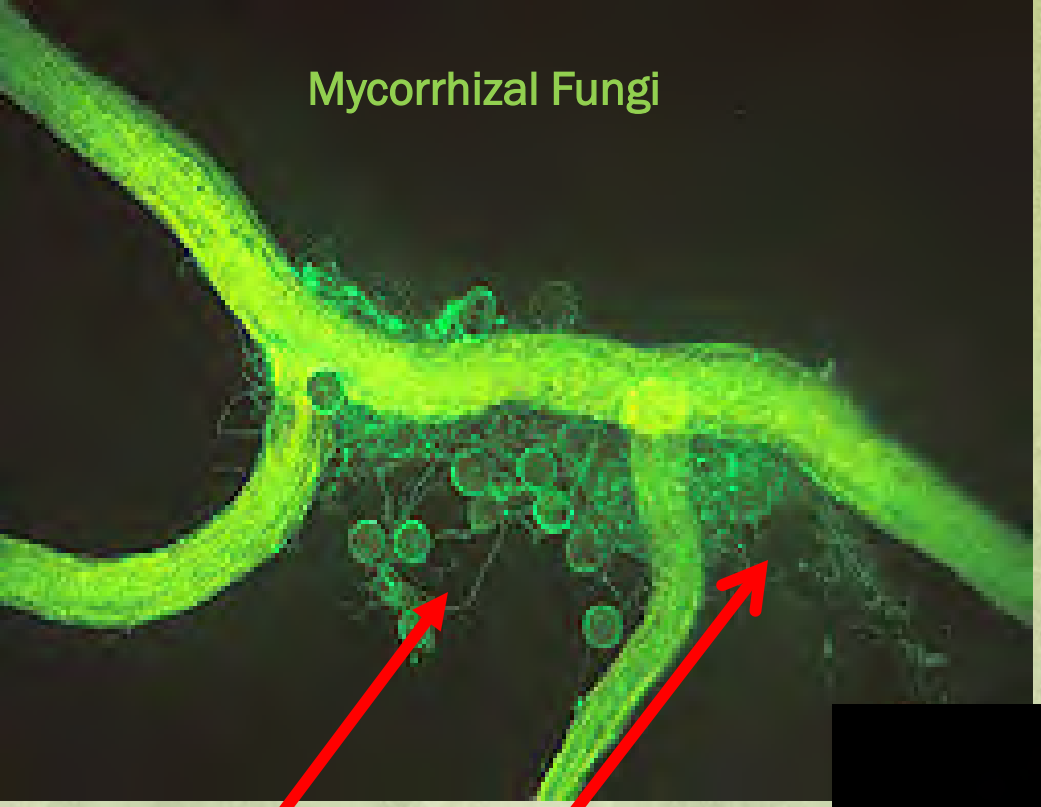
Enlarged Soil aggregates



Glomalin and hyphae

Dr. Kris Nichols, Microbiologist, ARS, Mandan, ND

Mycorrhizal Fungi



Fungal Hyphae

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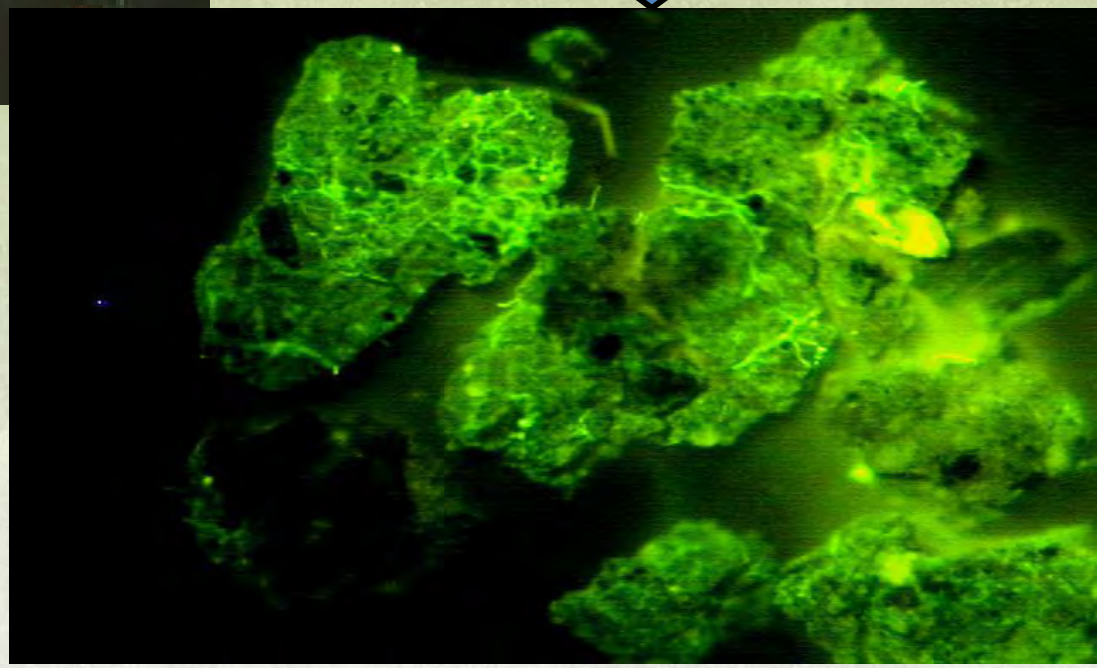
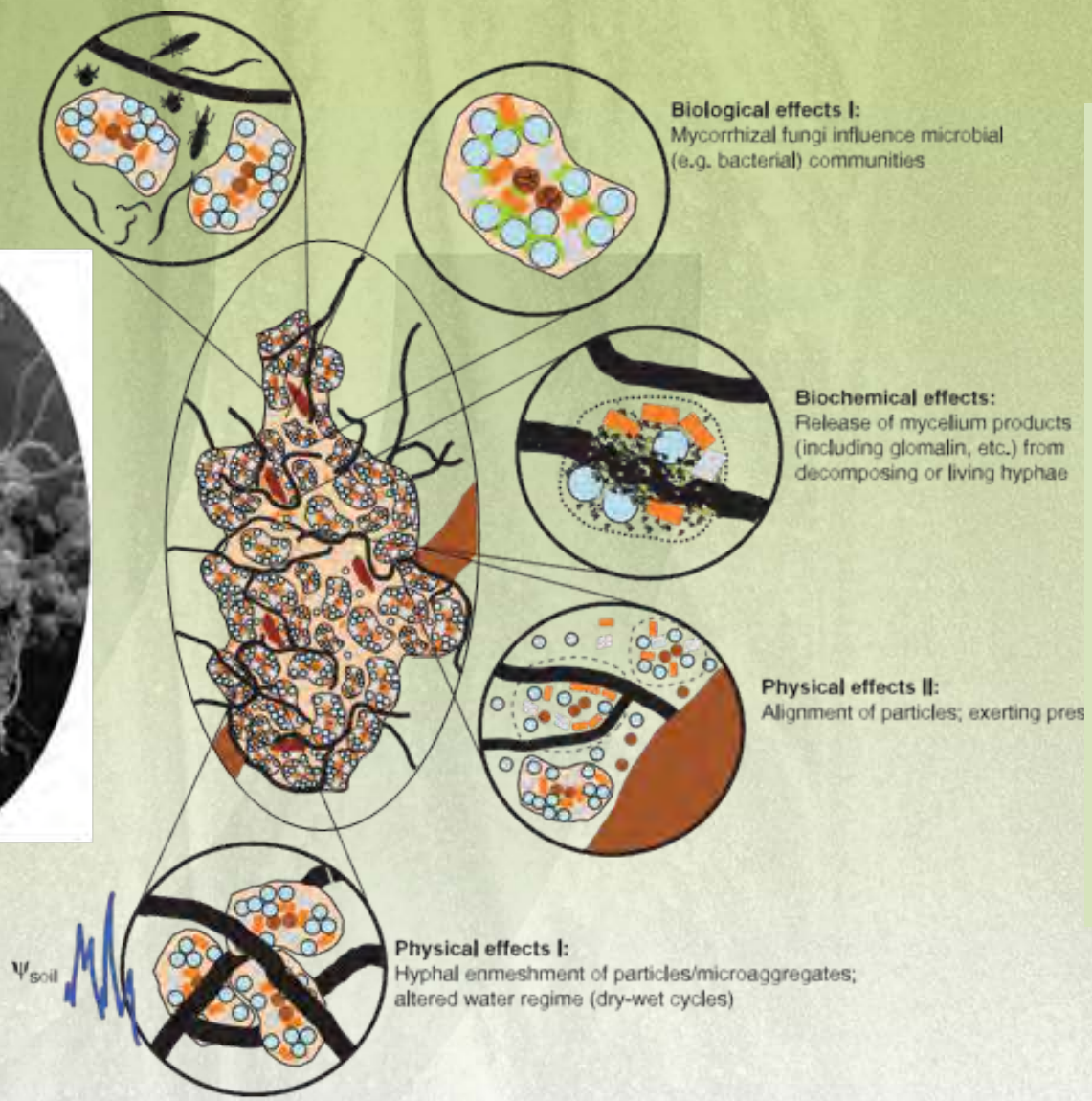
Glomalin is naturally brown. A laboratory procedure reveals glomalin on hypae and soil aggregates as the bright green material shown here.



Dr. Kris Nichols – Microbiologist - USDA ARS

BUILDING A SOIL AGGREGATE



Involves both:

Biological

- AMF communities form
- Release of Glues

Physical

- Hyphae entangle soil particles
- Create dry wet cycles
- Squeeze particle together

“Dig a Little, Learn a Lot”

Simple Test to determine soil health

In-field soil assessment what to look at:

Utilize all your senses:

- Sight
- Smell
- Touch
- Taste????

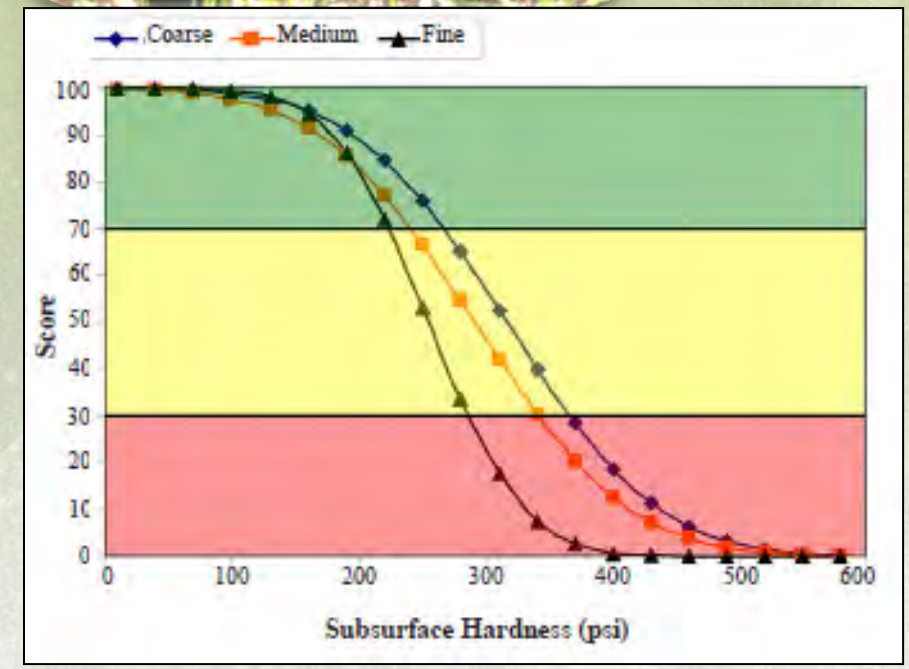
Look at:

- Residue
- Soil Surface
- Soil Profile
- Plant Roots
- ???

What do you see? Healthy or Not?

How compressed is your soil?

Penetrometer -
Measures pressure to penetrate soil



Used to identify:
- Surface crust
- Tightly packed crumbs
- Subsoil compacted layers

Effects of compaction
- Poor germination
- Reduced infiltration
- Poor root development
- Poor air exchange

From: Cornell Soil Health Manual

What's residue tell me about soil health?

Residue should be broken down and incorporated into the soil profile in a healthy soil!

Brown's Ranch

Same Field

June 16, 2009
Corn planted into previous years' cover crop residue

July 1, 2009
Rapid residue decomposition

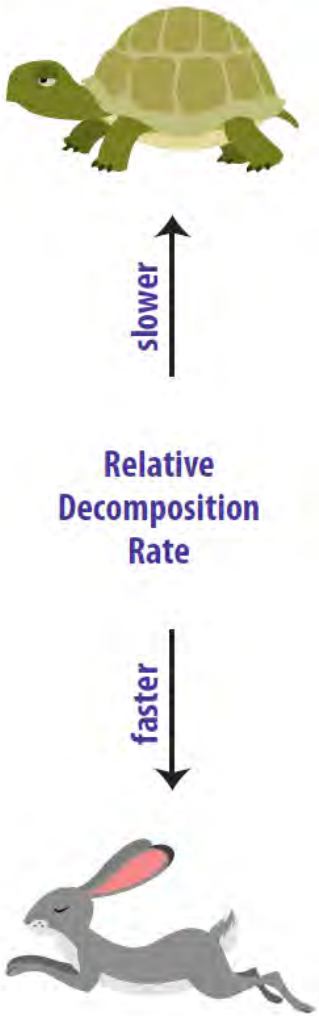
Residue Consumed by Soil Life

Managing Cover Crops to Feed Soil Microorganisms

- C:N ratio 24:1 Ideal for Microbes
- Higher C:N
  - Microbes don't get enough N result in tying up N
  - Residue doesn't decompose
  - Accumulates on the surface
  - Microbe populations decline
- Lower C:N
  - Microbes get excess N result in N being available
  - Residue decomposes quickly
  - Microbe population explode then die off
- Need to Balance C:N through cover crop mixes

C:N Ratio for Various Crops

Material	C:N Ratio
rye straw	82:1
wheat straw	80:1
oat straw	70:1
corn stover	57:1
rye cover crop (anthesis)	37:1
pea straw	29:1
rye cover crop (vegetative)	26:1
mature alfalfa hay	25:1
Ideal Microbial Diet	**24:1**
rotted barnyard manure	20:1
legume hay	17:1
beef manure	17:1
young alfalfa hay	13:1
hairy vetch cover crop	11:1
soil microbes (average)	8:1



Rye

- •High C:N
- •Ties up N
- •Compounds problem following another high C:N crop

Hairy Vetch

- •Low C:N
- •Release lots of N
- •Decomposes Fast

Rye & Hairy Vetch Mix

- •Balance C:N ratio
- •Control decomposition
- •Ideal cover crop mix

A Spade Deep, what it tells You

- Good Soil Tilth
- Sufficient depth

- Shredded Residue
- Signs of life

What About Color?

- Darker color higher OM
- Topsoil & Subsoil same color
  - Not building OM
  - Mixing of soil profiles
  - Poor soil health
- Topsoil clearly defined
  - No mixing
  - Deeper layer
  - OM is accumulating

Does your soil smell?

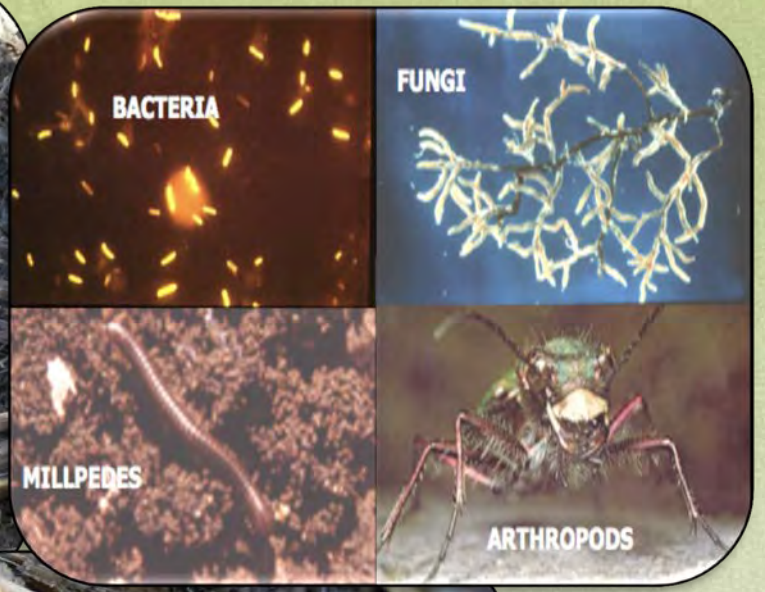
- Earthy/Sweet Smell
  - Geosmin from Actinomycetes Bacteria
  - Decompose residue
  - Cycle nutrients
  - Important part of soil foodweb
- Metallic/Kitchen sink cleanser
  - Soil dominated by Anaerobic bacteria
  - Indicate anaerobic conditions
  - Hydrogen Sulfide H2S rotten egg smell,
  - NH3 Ammonia strong urine smell
  - Drives pH low, release AL
- No soil aroma
  - Little active life in the soil
  - because it is too hot, cold, wet, dry or degraded to have many active soil organisms present at that time.
  - Poor Habitat

Do you have “Crumbly” Soil?

- Crumbles easily under finger pressure-GOOD
- Need a hammer to crush- BAD

What's under the residue?

Residue should be shredded



Cobwebs evidence of microbe activity

What do Your Roots Say?

Healthy Roots
- Uninhibited root growth
- Lots of fine roots
- White (no root pathogens)

Unhealthy Roots
- Restricted root growth
- Few fine roots
- Short thick roots
- Discolored & Lesions (root pathogens present)

Healthy Soil allows for Straight Roots

Compacted Layers

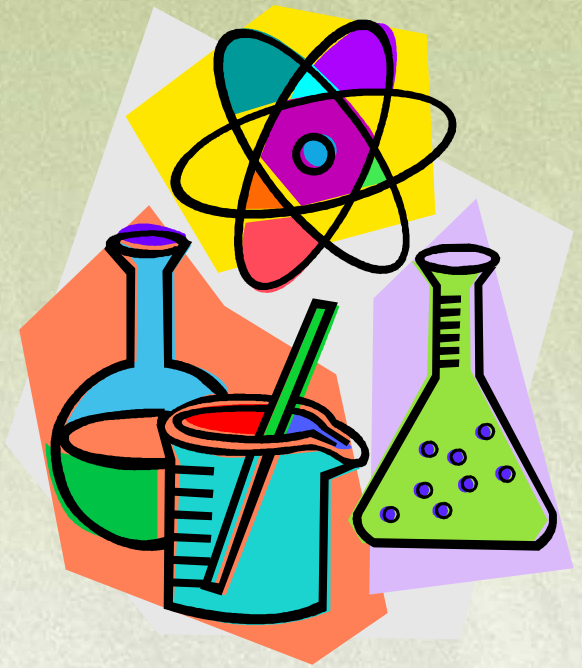
Roots run laterally on top of a compacted layer

Soil Health Testing Indicators

- Chemical
  - Soil test, e.g. P, K, pH, Salinity etc.
- Physical
  - Aggregate stability
  - Available water capacity
  - Surface &n Subsurface hardness
  - Compaction
  - Bulk Density
  - Infiltration
- Biological
  - Organic matter (soil color)
  - Active Carbon
  - Potential mineralizable N
  - Respiration
  - Microbe analysis

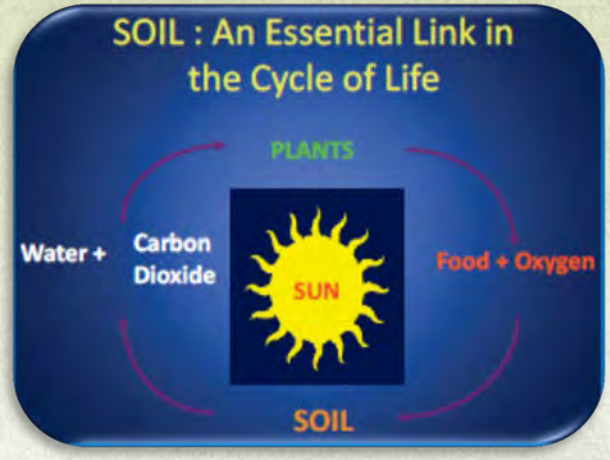
Soil Health Testing in the Lab

- Solvita CO_2 Burst Test
- Haney Test (ARS developed)
- PLFA (Phospholipid fatty acids)
- Cornell Soil Health Assessment
- Earthfort (Soil Foodweb)

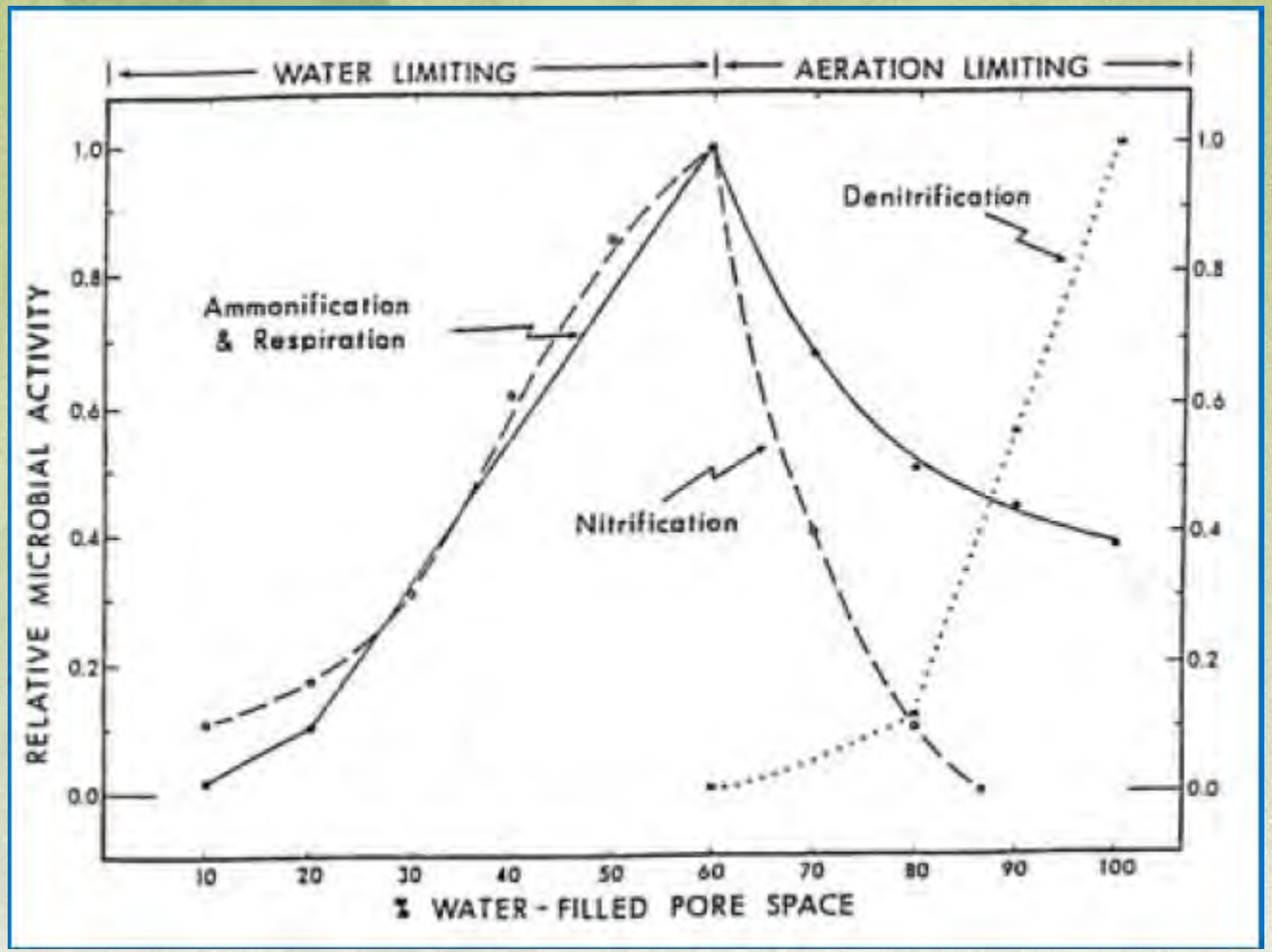


Soil CO_2 Respiration

- Measures soil respiration
  - Rate of CO_2 released from decomposition of OM by soil microbes
  - Indicates the level of microbial activity
  - Correlates to the nutrients contained in OM in forms available to plants
    - Phosphate as PO_4
    - Nitrate as NO_3
    - Sulfate as SO_4



Factor Affecting Respiration



- Respiration peaks at field capacity
- 60% of pore spaces field
- >80% pore space water filled
- Anaerobic organisms use Nitrate instead of Oxygen

Solvita CO_2 Basal Respiration

- Measure the CO_2 at field moisture conditions
- Uses paddle to trap CO_2
- Uses color system to measure

Table 2. Basic soil biological quality.

Color/Colorimetric Number				
0 - 1 Blue-Gray	1.0 - 2.5 Gray-Green	2.5 - 3.5 Green	3.5 - 4.0 Green-Yellow	4 - Yello
Soil Respiration Activity				
Very Low Soil Activity	Moderately Low Soil Activity	Medium Soil Activity	Ideal Soil Activity	Unusually Activ
Associated with dry sandy soils, and little or no organic matter	Soil is marginal in terms of biological activity and organic matter	Soil is in a moderately balanced condition and has been receiving organic matter additions	Soil is well supplies with organic matter and has an active population of microorganisms	High/Exc organic additi
***Approximate Level of CO_2 – Respiration**				
<300 mg CO_2/kg soil/wk	300-500 mg CO_2/kg soil/wk	500-1000 mg CO_2/kg soil/wk	1,000-2,000 mg CO_2/kg soil/wk	>2,000 mg soil/
< 9.5 lbs CO_2-C/acre-3"/d	9.5 - 16 lbs CO_2-C/acre-3"/d	16-32 lbs CO_2-C/acre-3"/d	32-64 lbs CO_2-C/acre-3"/d	>64 lbs C/acre-
Approximate quantity of nitrogen (N) release per year (average climate)				
<10 lbs/acre	10-20 lbs/acre	20-40 lbs/acre	40-80 lbs/acre	80- >160 l

* Source: Doran, J. (2001) USDA-ARS Soil Quality Institute correlation of Solvita® and field soil respir
Calculations based on a 3-inch soil core (7.6 cm).

CO_2 Burst
(Haney Briton Method)

- Follows a Standard Lab Protocol
- Dried, weighed samples are moistened
- Uses a specific amount of water to trigger the flush of CO_2
- CO_2 Burst is proportional to:
  - microbial biomass
  - Potential carbon
  - Nitrogen mineralization
- Uses Solvita Digital Color Reader

CO_2 Burst Results

- Soil Microbial biomass is related to CO_2 Burst
  - Generally 20 times burst
  - N released is .7 of the CO_2

Table 3. Soil respiration levels and interpretations.

Sample Site	Median 24-hr Soil or Room Temp.	Time-frame	Start Time	End Time	Gel Color & Colorimetric Number	Soil Activity Rating (Table 1)	Avg. respiration level lbs CO_2-C/acre-3"/d	Quantity of Nitrogen Released (lbs/ac/yr)
Example 1	77F (25C)	4/30-5/1/12	8 AM	8:15 AM	GryGreen – 2.5	Moderately Low to Medium	16 lbs	20 lbs

Soil Health Tool

USDA-ARS Temple, Texas
(Haney Test)

Measure soil health and NPK availability by **asking** our soil the right questions:

- What is your condition?
- Are you in balance?
- How active are your microbes?
- What can we do to help?

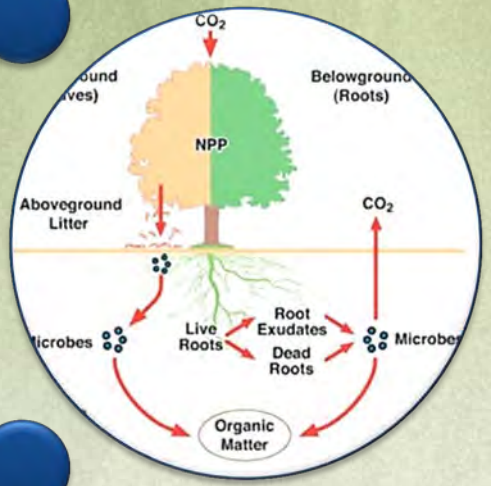
New Soil Testing Methods

soil testing in nature's image

Soil N, P, K

Extractable Organic N and P

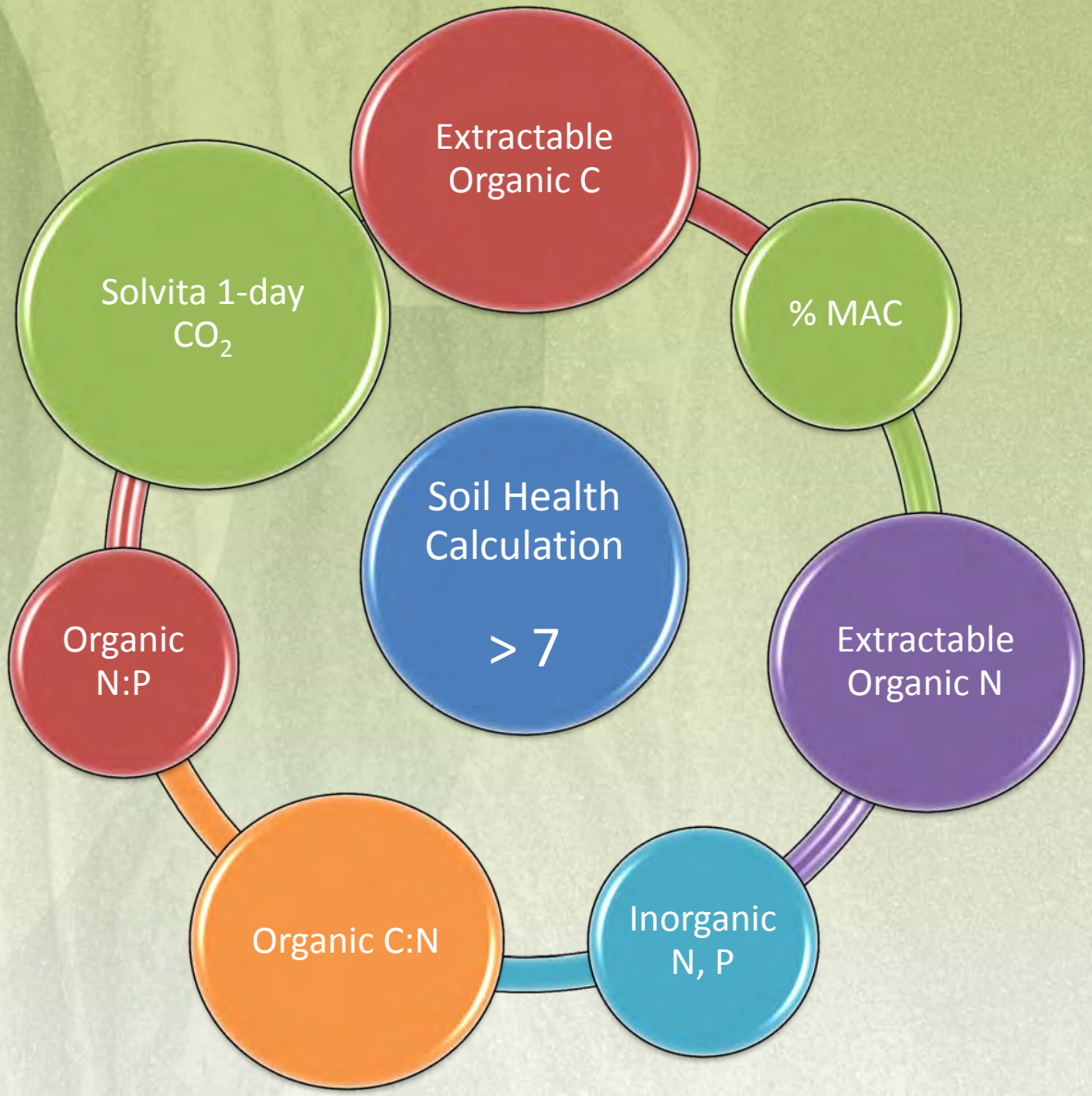
Microbial Activity



Water Extractable C

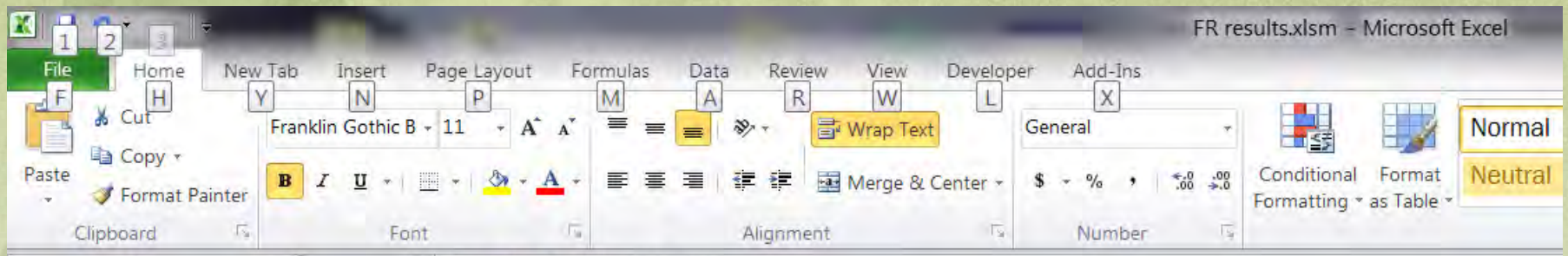
C:N balance

Soil Test Integration



Tab 1 - NPK

- **Nitrogen: from both Inorganic and Organic N pools**
- **Phosphate: from both Inorganic and Organic P pools. Converted to P2O5**
- **Potassium converted to K2O**
- **Nutrient value per acre: Current fertilizer prices multiplied by the nutrients present in your soil.**



	A	B	C	D	E	F	G	H	I	J	K	L
1	**Sample ID all lbs per acre**	N lbs per acre	P2O5 lbs per acre	K2O lbs per acre	Nutrient value per acre		Crop	Yield Goal	lbs N needed	lbs P2O5 needed	lbs K2O needed	
2	Sample 1	28.85	15.16	74.88	$72.85		grass	2	71	25	5	
3	Sample 2	25.47	14.51	89.70	$79.26	Run	cotton	2	75	45	0	
4	Sample 3	29.89	14.67	104.26	$90.76		wheat	35	12	3	0	
5	Sample 4	21.72	13.55	106.47	$86.40		sorghum	60	26	16	0	
6	Sample 5	47.71	55.41	161.20	$164.13		sunflowers	40	0	0	0	
7	Sample 6	55.66	91.54	202.80	$219.15		soybeans	40	0	0	0	
8	Sample 7	21.84	8.92	63.18	$57.26		corn	90	59	45	0	
9	Sample 8	57.70	120.25	223.60	$252.95		cotton	2	42	0	0	
10	Sample 9	58.46	197.45	165.10	$272.35		cotton	4	142	0	0	
11	Sample 10	35.62	44.31	100.75	$112.84		oats	60	6	0	0	
12												
13												

Soil Nutrient Assessment Program

SNAP Home | Optional Details | About

Field Information

State: Texas

County: Bell

Crop: Corn

Field Area (Acres): 1000

Yield Goal: 80

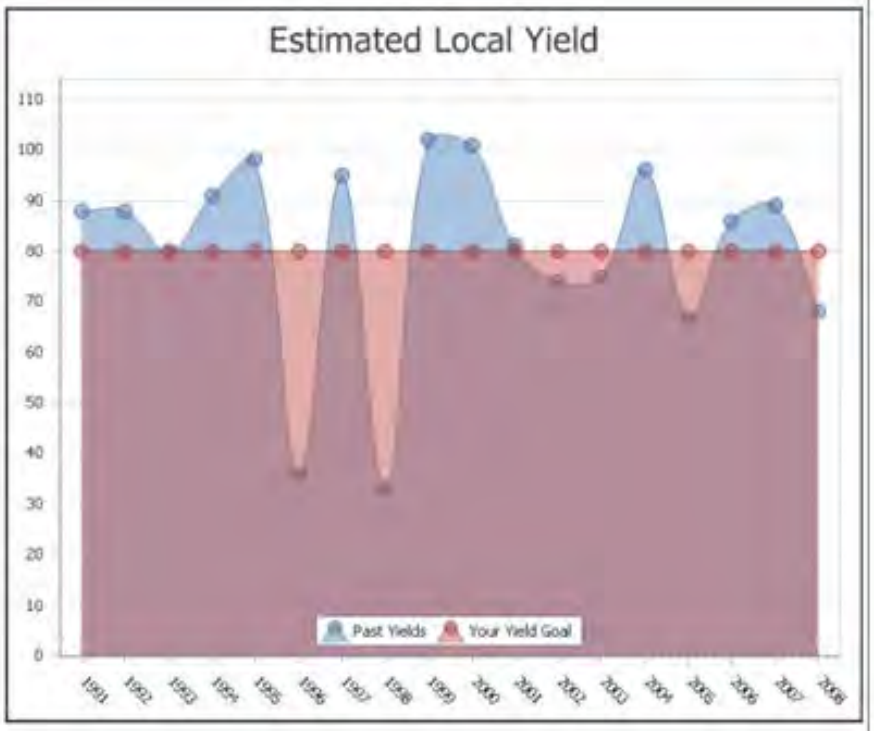
Soil Test Results

Nitrogen (lb N/acre): 25

Phosphate (lb P2O5/acre): 20

Potassium (lb K2O/acre): 50

Update



Results

	N	P2O5	K	Cost/Acre	Total Cost
Crop Requirements	80.0	40.0	40.0	$88.00	$88000
Soil Test Based Requirements	55.0	20.0	0	$44.50	$44500

Chance of Success %

http://research.brc.tamus.edu/snap/

Rick Haney

Soil Scientist

USDA – ARS

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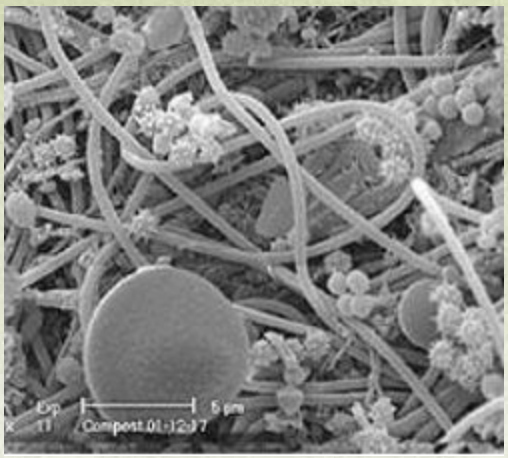

PLFA
(Phospholipid fatty acids)

- PLFA is a snapshot of soil community structure and abundance
- Based 'signature' lipid biomarkers from the cell membranes and walls of microorganisms
- Bacterial groups make 'signature' fatty acids, that can be used to characterize the microbial community
- Used to compare management techniques with respect to overall better microbial community health

Cornell Soil Health Assessment

Physical

- Aggregate Stability– ability of aggregates to resist falling apart
- Available Water Capacity – water plant can use
- Surface Hardness – penetration resistance 0”- 6”
- Subsurface Hardness - penetration resistance 6” - 18”

Biological

- Organic Matter
- Active Carbon – carbon available for microbes
- Potentially Mineralizable Nitrogen – from soil microbes
- Root Health Rating – measure quality and function of roots

Chemical

- Standard Soil Test Analysis

Cornell University
Cooperative Extension

	Indicators	Value	Rating	Constraint
PHYSICAL	Aggregate Stability (%)	17	18	aeration, infiltration, rooting
	Available Water Capacity (m/m)	0.21	85	
	Surface Hardness (psi)	48	93	
	Subsurface Hardness (psi)	214	79	
BIOLOGICAL	Organic Matter (%)	2.6	25	energy storage, C sequestration, water retention
	Active Carbon (ppm) [Permanganate Oxidizable]	615	50	
	Potentially Mineralizable Nitrogen (µgN/ gdwsoil/week)	7.8	9	N Supply Capacity
	Root Health Rating (1-9)	6.6	38	
CHEMICAL	*pH	7.0	100	
	*Extractable Phosphorus (ppm) [Value <3.5 or >21.5 are downscored]	10.0	100	
	*Extractable Potassium (ppm)	58	72	
	*Minor Elements		100	
	OVERALL QUALITY SCORE (OUT OF 100):		64.1	Medium

Measured Soil Textural Class:==> silt loam

SAND (%): 41.4 *SILT (%): 50.6* *CLAY (%): 8.0*

Location (GPS): Latitude=> Longitude=>

* See Cornell Nutrient Analysis Laboratory report for recommendations

Earthfort
(formally Soil Foodweb)

- Offers a variety of soil biology assessment packages
  - Each package contains more assays for soil organisms
- Measure the Biomass of Total Populations in general categories of the functional groups.
- Represent a comprehensive picture of the health and utility of the soil

Long Term No-Till

unlock the SECRETS IN THE SOIL

Soil Foodweb Analysis

Report prepared for:
Burleigh Co. Soil Conservation
Vicki Bailey
1511 E. Interstate Avenue
Bismarck, ND 58503-0560 US
(701) 250-4363
vicki.bailey@nd.nacdnet.net

Report Sent: 07/29/2005
Sample#: 01-100984
Unique ID: GB1
Plant: Corn
Invoice Number: 8357
Sample Received: 07/14/2005

For interpretation of this report please contact:
Local Advisor: or regional lab
Soil Foodweb, Inc
info@soilfoodweb.com
(541) 752-5066
Consulting fees may apply

Organism Biomass Data	Dry Weight	Active Bacterial (µg/g)	Total Bacterial (µg/g)	Active Fungal (µg/g)	Total Fungal (µg/g)	Hyphal Diameter (µm)
Results	**0.850**	46.3	405	**5.24**	274	2.5
Comments	To Wet	Excellent	Excellent	Low	Good	
Expected Range Low	0.45	15	100	15	100	
Expected Range High	0.85	25	300	25	300	

	Protozoa Numbers/g Flagellates	Protozoa Numbers/g Amoebae	Protozoa Numbers/g Ciliates	Total Nematodes #/g	Percent Mycorrhizal Colonization ENDO	Percent Mycorrhizal Colonization ECTO
Results	178500	**9736**	331	**4.45**	**31%**	**0%**
Comments	**High**	Low	High	Low	Low	Low
Expected Range Low	**10000**	10000	50	20	40%	40%
Expected Range High			100	30	80%	80%

Organism Biomass Ratios	Total Fungal to Total Bacterial	Active to Total Fungal	Active to Total Bacterial	Active Fungal to Active Bacterial	Plant Available N Supply
Results	**0.68**	**0.02**	**0.11**	**0.11**	200+
Comments	Low	Low	Low	Low	
Expected Range Low	0.8	0.25	0.25	0.75	
Expected Range High	1.5	0.95	0.95	1.5	

Nematodes per Gram of Soil
Identification to genus

Bacterial Feeders		
Acrobeles		0.81
Acrobeloides		0.18
Cephalobus		0.45
Cervidellus		0.18
Rhabditidae		0.45
Fungal Feeders		
Eudorylaimus		0.09
Fungal/Root Feeders		
Aphelenchoides	Foliar nematode	0.54
Aphelenchus		0.45
Ditylenchus	Stem & Bulb nematode	0.54
Filenchus		0.09

Soil Quality Bucket Overview


Soil Test Strips
Garden Care Kit
06/12/2012

Soil Health Assessments

- How do I tell if my soil is Healthy?
- Will my soil support healthy plants and be productive?
- Simple assessments can be used as indicators of physical, chemical, and biological properties, can be used to assess soil health and how well soil is functioning.
- A "Soil Quality Test Bucket" can be assembled to meet local needs and easy transport of test supplies to the field http://soils.usda.gov/sqi/assessment/educators.html.

Soil Bucket Kit Guides

- Soil Sampling for Soil Quality
- Bulk Density/Moisture/ Aeration
- Soil pH
- Infiltration
- Soil Nitrogen
- Soil Phosphorus
- Soil EC
- Soil Organic Matter
- Soil Respiration

soil Bulk Density / Moisture / Aeration

Soil Quality Kit – Guides for Educators

USDA NRCS United States Department of Agriculture Natural Resources Conservation Service

Bulk density is an indicator of soil compaction. It is the weight of dry soil per unit of volume typically expressed in g/cm^3. Total soil volume includes about 50% solids, mostly soil particles (45%), and organic matter (generally < 5%); and about 50% pore space which are filled with air or water (Figure 1). When determining bulk density, the amount of soil moisture must be determined. The amount of soil moisture that can be stored in the soil pores will vary by texture (Figure 2) and is reduced when compaction occurs. Inherent factors that affect bulk density such as soil texture cannot be changed. However, bulk density can be managed by using measures that limit compaction and build soil organic matter.

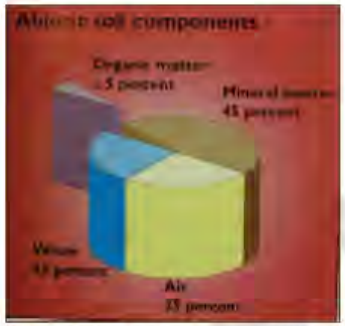

Figure 1. Four major components of soil volume (Michigan Field Crop Ecology, 1998, E-2646, p. 13).

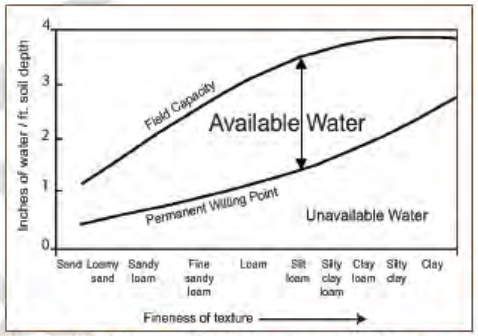

Figure 2. Relationship between available water and texture (Ohio Agronomy Guide, 14th Ed. Bull. 472-05).

Inherent Factors Affecting Bulk Density and Soil Moisture

Bulk density is dependent on soil organic matter, soil texture, and the density of soil mineral (sand, silt, and clay) and their packing arrangement. As a rule of thumb, most rocks have a density of 2.65 g/cm^3 so ideally, a silt loam soil has about 50 percent pore space and a bulk density of 1.33 g/cm^3. Generally, loose, well-aggregated, porous soils and those rich in organic matter have lower bulk density. Sandy soils have relatively high bulk density since total pore space in sands is less than that of silt or clay soils.

Bulk density typically increases with soil depth since subsurface layers are more compacted and have less organic matter, less aggregation, and less root penetration compared to surface layers, therefore contain less pore space.

Soil moisture available for crop growth and available water capacity (Figure 2) is affected by soil texture, presence and abundance of rock fragments, soil depth and restrictive layers.


No-till

Other Assessments

- Soil temperature
- Aggregate stability comparisons
- Compaction assessments (wire flag, spade to look at soil structure and roots)
- Soil texture (hand feel)
- Soil moisture (feel and appearance)

What are we assessing?

- Chemical, Physical and Biological Indicators
  - Nutrient cycling
  - Water (infiltration & availability)
  - Filtering and Buffering
  - Physical Stability and Support
  - Habitat for Biodiversity

USDA Natural Resources Conservation Service

Indicator	Test	Function
C	F	F/N

Soil Quality Indicators

Soil pH

Soil pH generally refers to the degree of soil acidity or alkalinity. Chemically, it is defined as the $\log_{10}$ hydrogen ions (H^+) in the soil solution. The pH scale ranges from 0 to 14; a pH of 7 is considered neutral. If pH values are greater than 7, the solution is considered basic or alkaline; if they are below 7, the solution is acidic. It is important to recognize that because the pH scale is in logarithmic units, a change of just a few pH units can induce significant changes in the chemical environment and sensitive biological processes. For example, a soil with pH 5 is 10 or 100 times more acidic than a soil with pH 6 or 7, respectively. Sources of H^+ ions in soil solution include carbonic acid produced when carbon dioxide (CO_2) from decomposing organic matter, root respiration, and the soil atmosphere is dissolved in the soil water. Other sources of H^+ ions are root release, reaction of aluminum ions (Al^{+3}) with water, nitrification of ammonium from fertilizers and organic matter mineralization, reaction of sulfur compounds, rainwater, and acid rain. Certain soils are more resistant to a drop or rise in pH (buffering capacity)

Phosphorus deficiency in corn. Source: R.L. Croissant, Bugwood.org

soil becomes neutral or alkaline. Soils with coarse textures may acidify easily compared to clay soils, because they have low organic matter content, a low buffering capacity, a low cation-exchange capacity (poor cation retention), and high rates of water percolation and infiltration. Clay and organic matter in mineral soils act as buffers to resist pH variations. Soil parent material influences soil properties including pH as shown by the contrasting pHs of soil

8-8-13

Individual Soil Quality Bucket Test Kit Contents and Details (*= volume discount provided)

Photo	Item	Quantity	Specs	Use	Ap
	Binder of Soil Quality Kit Guides for Educators and Associated Materials	1 each	NRCS led development based on original soil quality test kit guide expanded to include interps, management, and other details about interpreting and education on individual tests	Provide Guidance for soil quality sampling and eight field soil quality tests (respiration, soil organic matter, pH, EC, infiltration, BD, N, & P)	Edi Soi (Pri the http wat or http edu
	Bucket Kit 'fishing' Bucket and Seat – 6 gal. – padded top	1each	Model # 02933300118	Container for all kit contents	$14
	Willow creek fishing vest Cabela's comes in sizes L, XL & 2XL	1per Vest	Model # 940239	Holds field soil health quick test equipment and materials shown in this document.	Cab labe plac test

Questions

Mike Kucera

Agronomist NRCS

michael.kucera@lin.usda.gov

Soil Quality Bucket Info:

http://cropwatch.unl.edu/web/cropwatch-youth/soil_lessons