

Cattle, Cover Crops, Hope

Allen R Williams, Ph.D.
Soil Health Consulting, LLC



Signs Your Neighbor Isn't Much of a Farmer

- He has to buy his own caps because nobody will give him one.
- You can't blame his cows for getting out because, in this case, the grass really is greener...
- He's the reason the local vet has caller ID.
- He's eligible for so many USDA programs, the local office has one secretary assigned to him exclusively.
- The moon sign just never seems to line up for him.
- He has a spring-calving cow herd—and summer and fall and winter.
- His dog is always trying to go home with you.
- Thankfully, his bull of unknown heritage is too weak and undernourished to jump the fence.
- The parts guy is forever explaining to him that he can't spell the name of his tractor let alone get parts for it.

Our Problem

Satellite View of Massive Dust Storm

AREA OF BLOWING DIRT

Near zero visibility

*Winds gusting to
60 mph*

Last Updated: 12:23 PM MST

Friday, January 11, 2013

National Weather Service - Goodland, Kansas



View of Same Dust Storm From Ground Level



Tampas, CO June 12, 2014



April 14, 1935



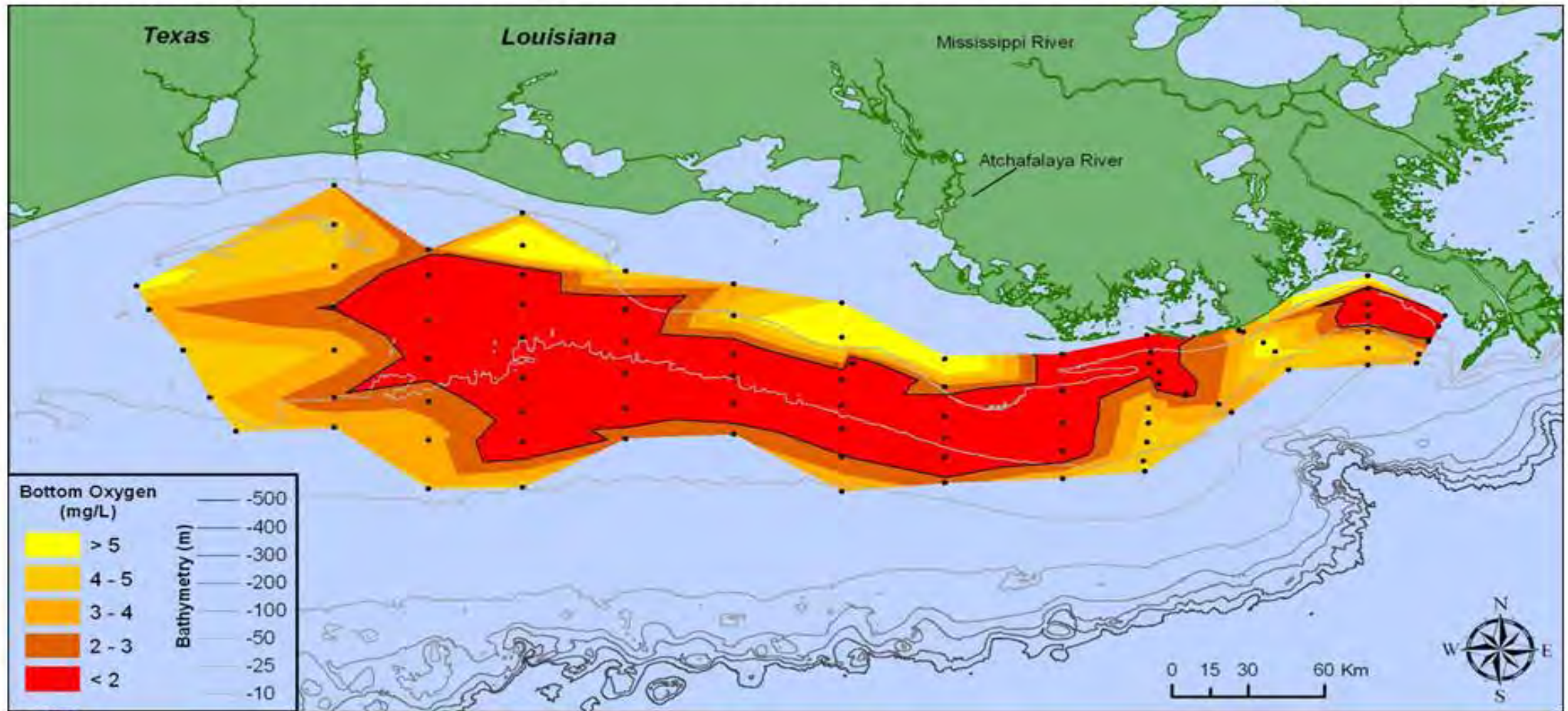


“Our rivers and bays are full of conservation and nutrient management plans” **Ray Archuleta**



The Hypoxia Problem

Bottom-water dissolved oxygen across the Louisiana shelf from July 22-28, 2013



Data source: N.N. Rabalais, Louisiana Universities Marine Consortium, R.E. Turner, Louisiana State University
Funded by: NOAA, Center for Sponsored Coastal Ocean Research



NOAA

Which is Better?

■ Farming or Cattle??

Farming

















Cattle





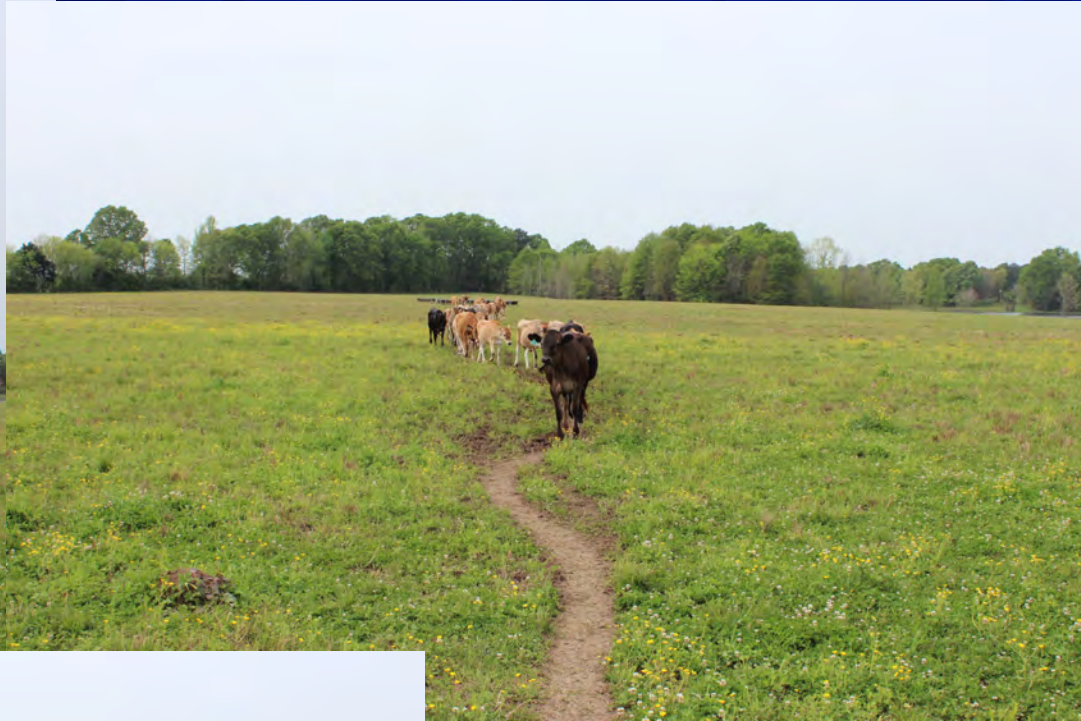
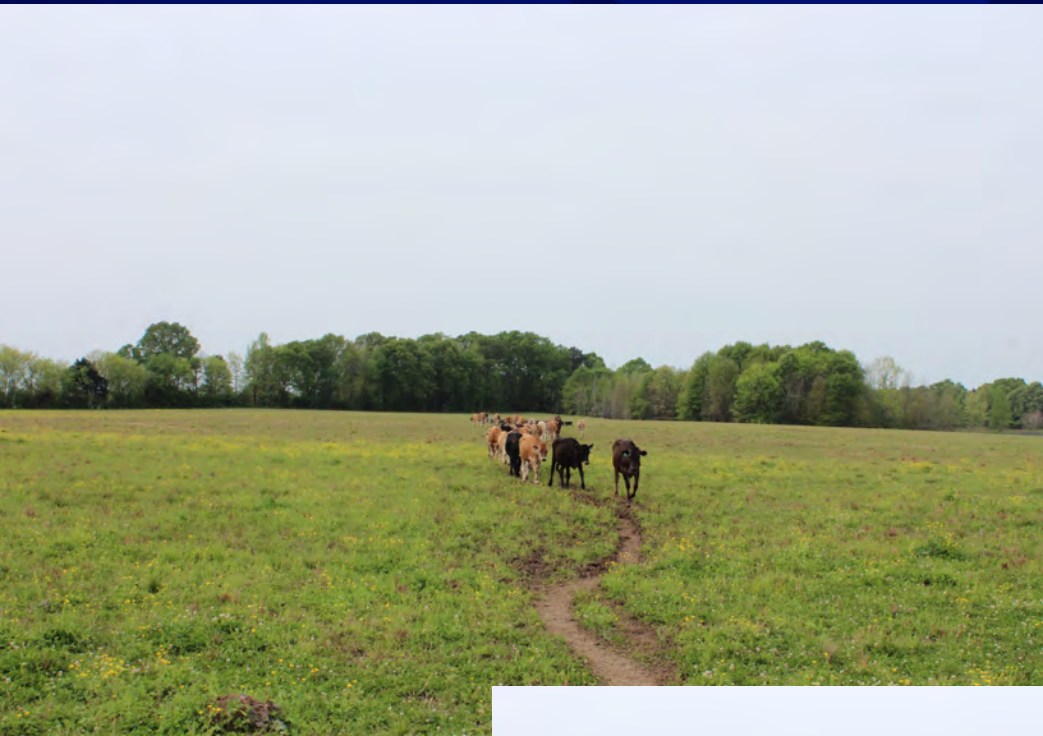


Progression of a Cow Path





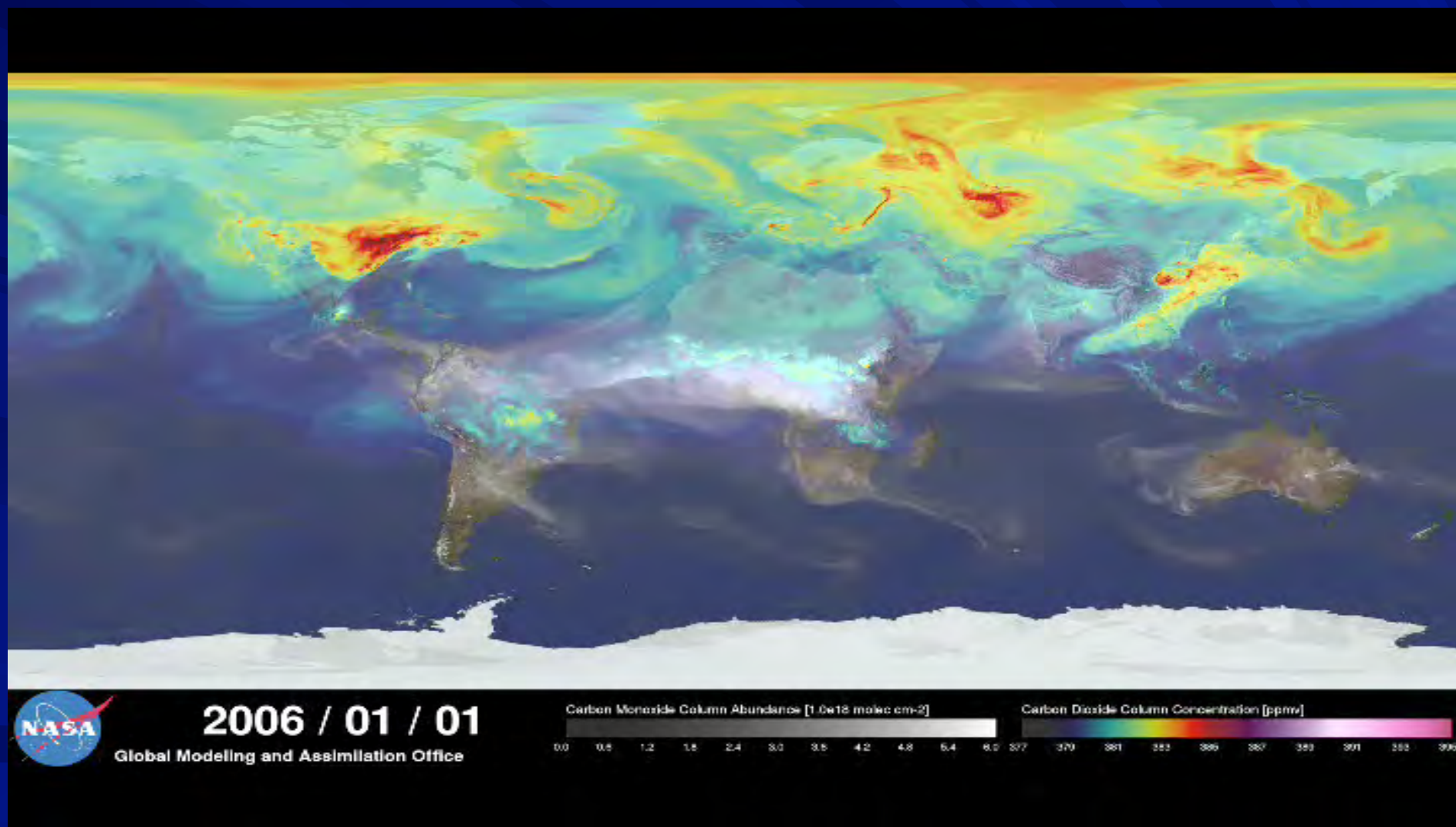


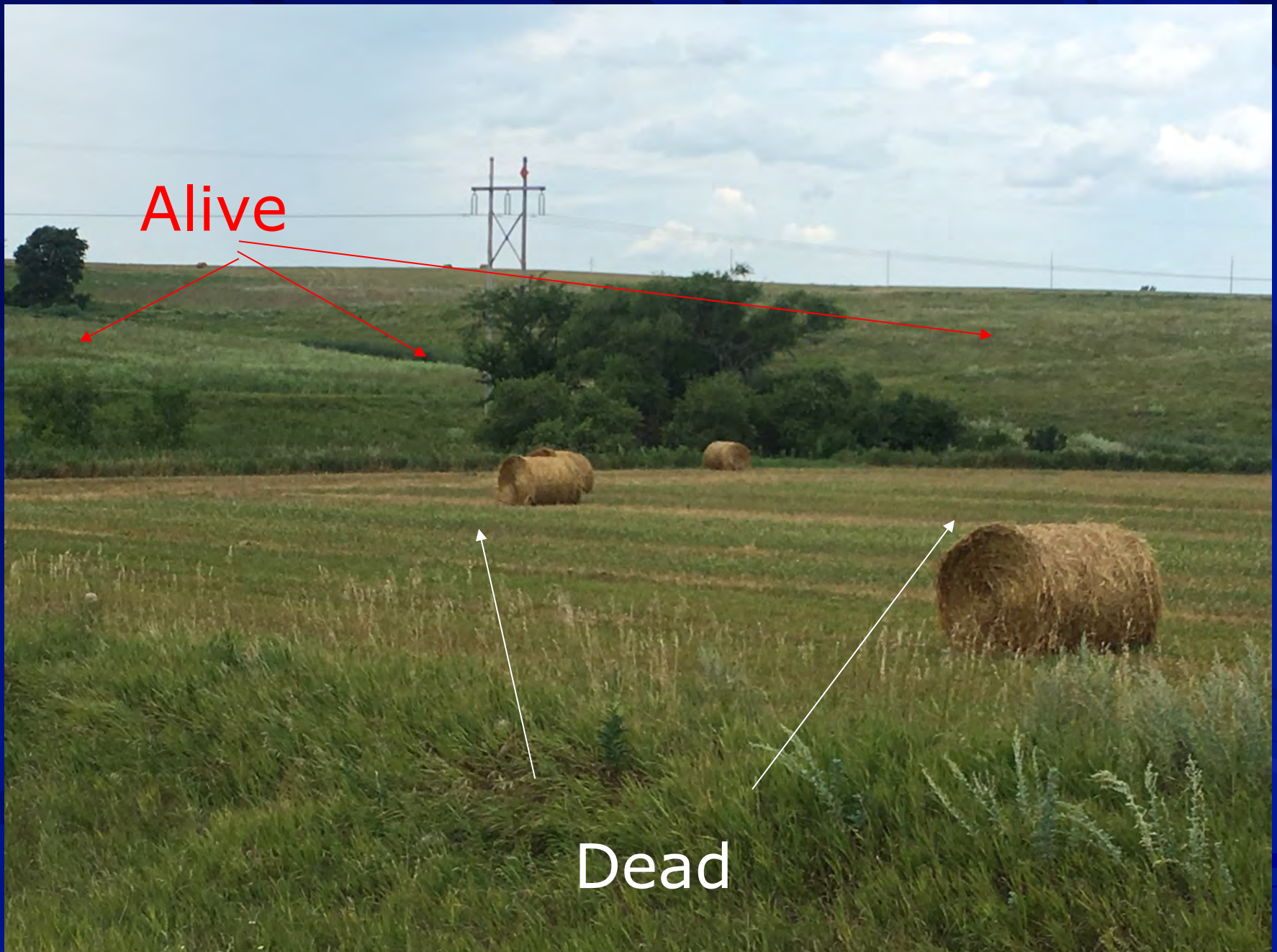


Farm vs. City?









50 feet Apart

Dead

Alive





LIFE!!!





Ladybugs of South Dakota

All across North America certain species of native ladybugs are disappearing: in just the last 50 years some of these little red predators of lawn and garden pests have become extremely rare. This rapid decline is of great concern. If we can find where the seven-spots, spiny-backed, and Transverse ladybugs and twelve-spots are still out there, we can help them survive. From the Lost Ladybug Project website: lostladybug.org, you can learn how to collect, photograph, and send images of ladybugs and be part of the database. Every ladybug you find (over 400 species in the United States), size or common, native or exotic, is important! Even if you collect 20 of the same species we would like to see them all because that tells us how common those ladybugs species are in your area and how rare other species are. The project will continue for years to come. Collections from the same locations over the years will be especially useful.

The Lost Ladybug Project gives kids (and adults) a chance to be real citizen scientists. The pictures you send will contribute to ongoing scientific research and will help us find out where the ladybugs have gone and why they have gone. All *lostladybug.org* members find educational materials ranging from printed guides and instructions for home-made survey nets, to data sheets and mapping. Parents and youth leaders will find this a fun way to convey concepts of biodiversity and conservation.

www.lostladybug.org



Conundrum

■ USA Today Article

– Monsanto – Bayer Merger

- Farmers fear further price control
- Yet – Hopeful that merger will produce new GM crops and chemicals that will increase yield.

■ Houston Chronicle Article

– “*Bumper Yields Plow Farmers Under*”

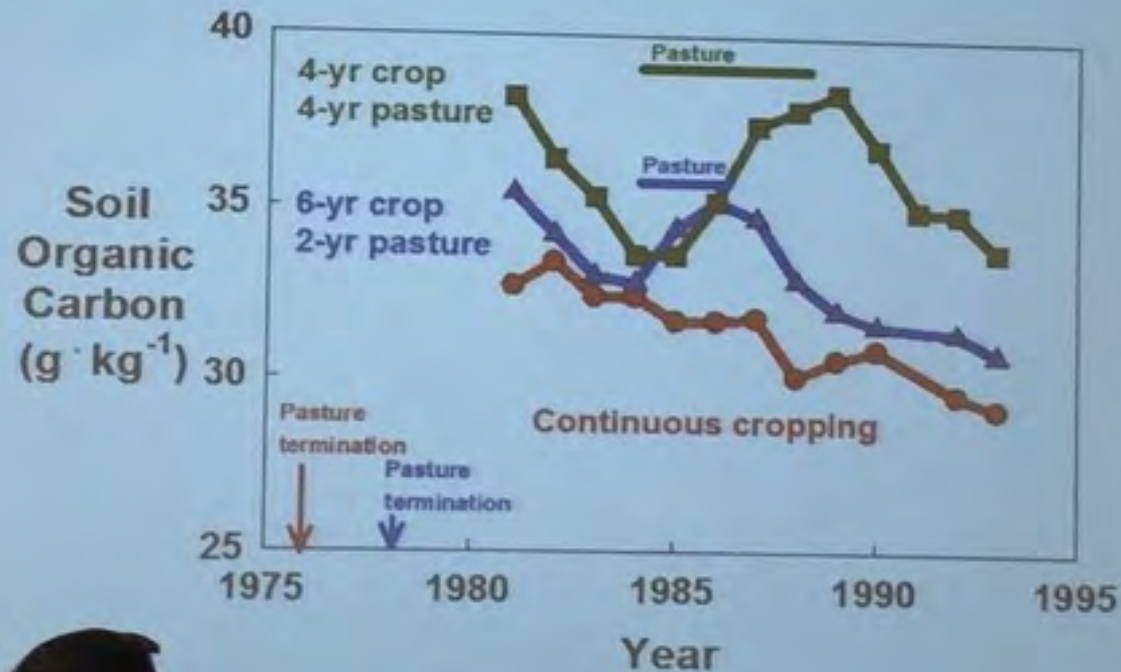
Omaha World-Herald

■ *“More Crop, Less Cash”*

- Farm economics deteriorating, land values falling, loan defaults rise.....
- U.S. farmers again produce record corn & bean crops.
- Farm income down 42% since 2013.
- Rest of world has amped up production.
- Farmland values expected to fall by 20% by 2018.
- Loans not being paid as agreed more than doubled.
- Grain & feedlot industries hit hardest.
- Farm debt will be 5 times larger than net income, and net farm income will slip to 7 year low.

Soil organic C response to pasture-crop rotation

Argentina



Data from GA, Echeverría, Casanovas EM (1997) Soil Sci. Soc. Am. J. 61:1466-1472

- Research published in the **Journal of Applied Ecology** shows that soil in urban allotments – the small patches in towns and cities that people cultivate by hand – contains a third more organic carbon than agricultural soil and 25% more nitrogen. These allotment holders produce between 4 and 11 times more food per acre than do conventional farmers.
- <http://onlinelibrary.wiley.com/doi/10.1111/1365-2664.12254/full>

Deforestation

■ Brazil – Early 1500's

- Guanabara Bay – Mountains covered in forests. Trees cut for building, firewood, plantations.
- Soil washed away from slopes leaving bare, exposed rock.
- By early 1700's the land's fertility had crashed.
- By early 1800's people knew problems were linked to deforestation.
- King Dom Pedro II ordered trees planted resulting in restoration of springs and rivers.

Deforestation

- 1864 Book – ***Man and Nature*** – George Marsh
 - Cataloged numerous examples of deforestation.
 - *“When the forest is gone, the great reservoir of moisture stored up in its vegetable mould (soil/humus) is evaporated, and returns only in deluges of rain to wash away the parched dust into which that mould has been converted. The well-wooded and humid hills are turned into ridges of dry rock”.*

Deforestation

■ Vermont Agency of Natural Resources

- European settlers dispensed of more than half the state's forest cover by the close of the 19th century. Result:
“Cleared land froze more deeply in winter and thawed more quickly in the spring. Spring brought floods and summer brought drought, leaving streams and rivers dry.”

■ Historian Samuel Williams – 1794

- Wrote that cleared land *“became warm and dry, while streams and brooks no longer supplied water. Soil erosion contributed to the situation of damaging streams, ponds, and lakes, and gave rise to changes in fish and animal populations”*.

***“Nature”* Articles**

- 2013 – Jasechko, et. al.
 - Between **80-90%** of continental atmospheric moisture comes from plants.
 - Extraordinary since previous estimates put it at 20-60%.
 - Includes accounting for evaporation from ground surfaces, lakes, and rivers.

***“Nature”* Articles**

- 2012 – Spracklen, et. al.
 - Used satellite data to monitor movement of air and rain.
 - Found that winds that moved across forested areas tended to generate more than twice as much rain when compared with winds that moved across open areas, especially land being row cropped.

■ William Clark on July 4, 1804

- *"The Plains of this countrey are covered with a Leek Green Grass, well calculated for the sweetest and most norushing hay [7]—interspersed with Cops [copses] of trees, Spreding their lofty branches over Pools Springs or Brooks of fine water. Groops of Shrubs covered with the most delicious froot is to be seen in every direction, and nature appears to have exerted herself to butify the Senery by the variety of flours (raiseing) Delicately and highly flavered raised above the Grass, which Strikes & profumes the Sensation, and amuses the mind throws it into Conjecterng the cause of So magnificent a Senerey [several words illegible, crossed out] in a Country thus Situated far removed from the Sivilised world to be enjoyed by nothing but the Buffalo Elk Deer & Bear in which it abounds & [page torn] Savage Indians."*
- Recorded in Doniphan County, KS (far northeast) from a point overlooking the Missouri near St Joseph, MO.
- <https://lewisandclarkjournals.unl.edu/item/lc.jrn.1804-07-04>

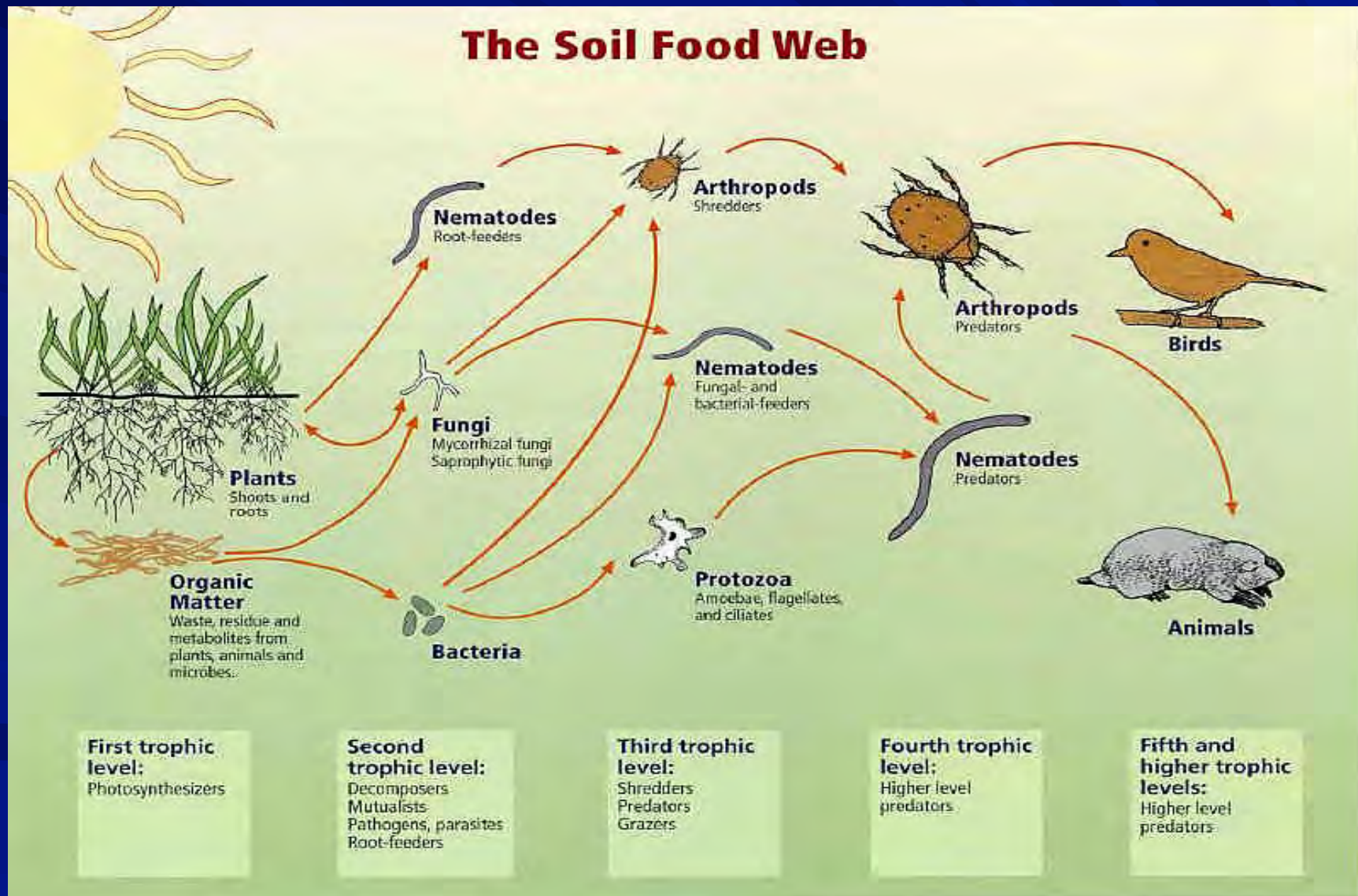
Lewis & Clark

- Encountered immense herds of animals.
- Ate very well:
 - Averaged one bison, two elk, and four deer per day.
 - Berries, Plants, Roots, Fish

**Start With the
Foundation:**

Healthy Soil

The Soil is Alive!!





- 90% of soil function is mediated by microbes.
- Microbes depend on plants.
- So, how we manage plants is critical.

- Plant growth & health highly correlated with how much life & what kind of life is in the soil!
 - **Microbes Matter!!!**
 - **Microbial community structure crucial.**
 - **Highly Important**
 - **Fungi to Bacteria ratio**
 - **Predator to Prey ratio**

Optimum Soil Health

Type of Organism	number/acre	lbs/acre
Bacteria	800,000,000,000,000,000,000	2,600
Actinobacteria	20,000,000,000,000,000	1,300
Fungi	200,000,000,000,000	2,600
Algae	4,000,000,000	90
Protozoa	2,000,000,000,000	90
Nematodes	80,000,000	45
Earthworms	40,000	445
Insects /arthropods	8,160,000	830

Soil Food Web

Role of Microbes

- Produce **Glomalin – “Soil Glue”**.
 - Arbuscular mycorrhizal fungi (AMF)
- Glomalin creates soil aggregates vital to nutrient exchange and water movement.
- Reduces ponding and runoff.
- Without underground “highways” created by glomalin, crops require more fertilizer for same yields.
- Slows down rate of water entering aggregate.
- Soil aggregates are soil carbon vault.
- Stores carbon where slow-acting microbes live.

Additional Roles

■ Fungal Hyphae:

– Help **create fine roots**

- More efficient at grabbing nutrients.
- Require less carbon as fuel (lower mpg).
- Unlock chemical bonds to release P, S, N.
- Fungi take up P 6 X's faster than root hairs.

– **Connect roots from different plants.**

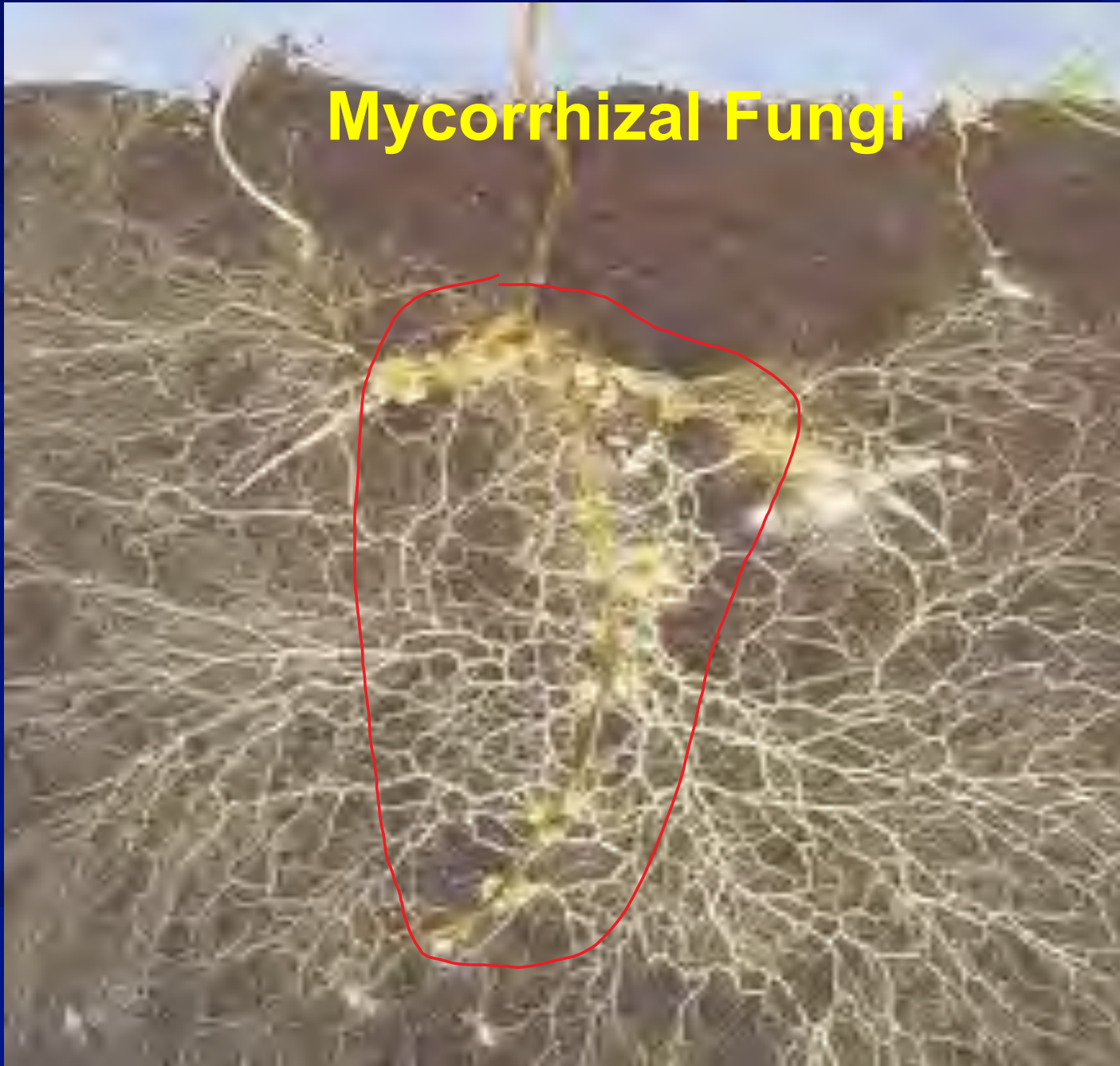
- Transfer N and other nutrients from legume nodule to non-legume root.

- **10,000 – 50,000** microbe species in one gram of soil.
- Nutrient cycling services worth up to **\$20 Trillion** annually!
- World's most valuable ecosystem!
- “Soil livestock” more numerous & diverse than tropical rain forest species.

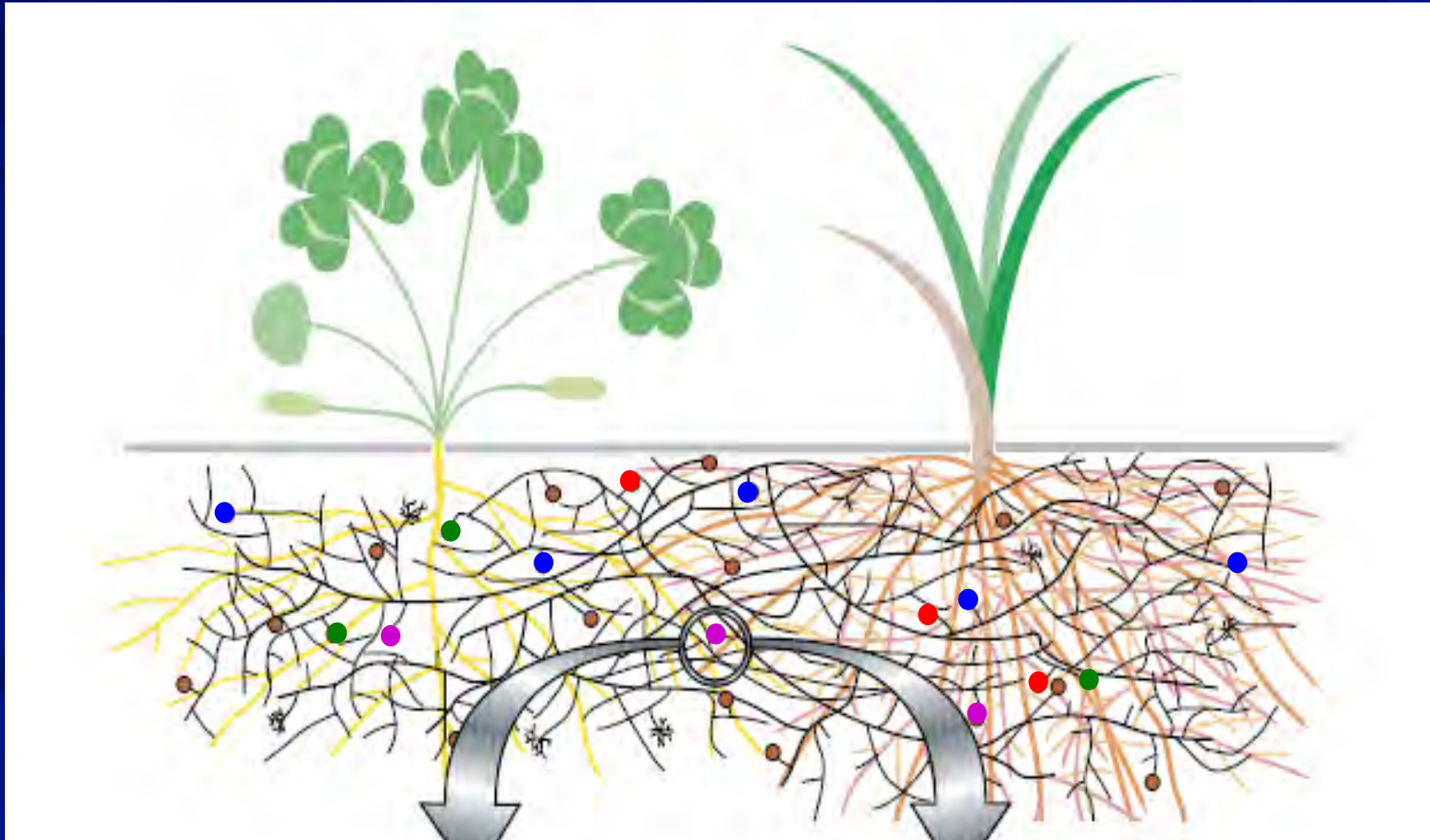
Bacteria



Mycorrhizal Fungi

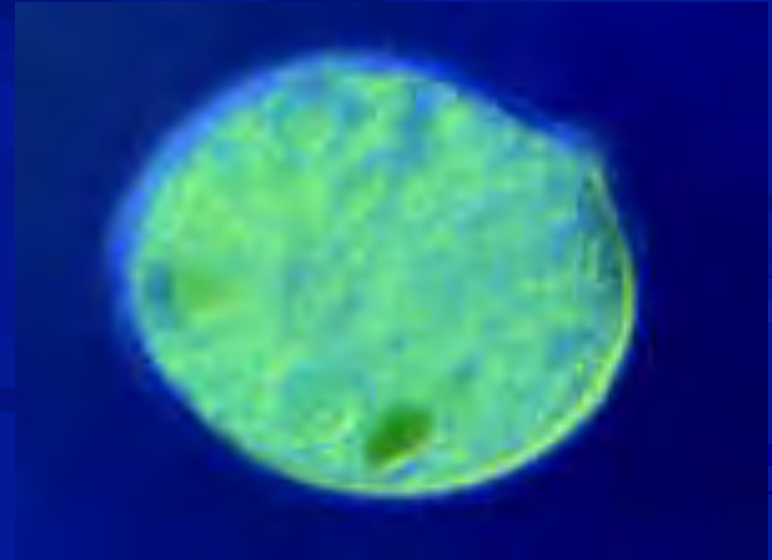


Interconnecting Mycorrhizal Mat



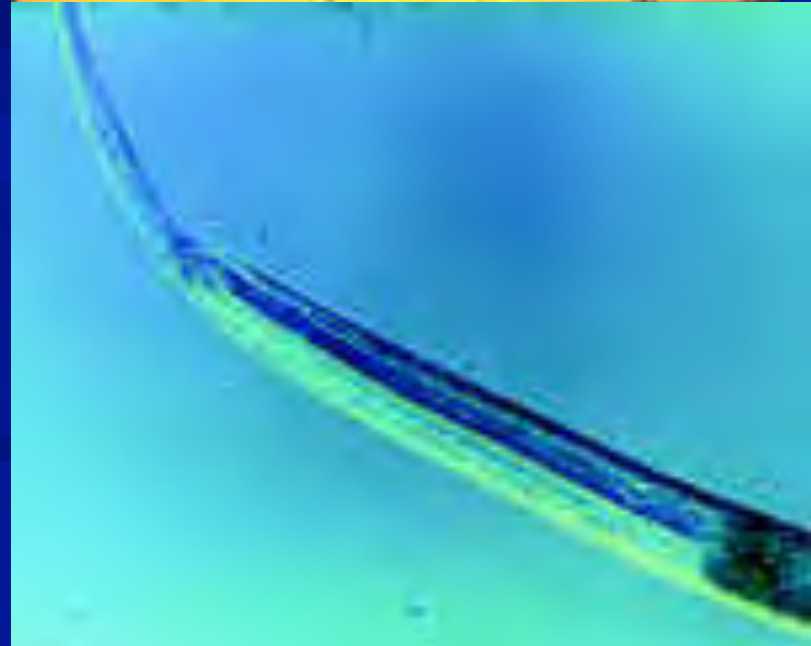
Protozoa

- Regulate bacterial populations
- Mineralize nutrients
- Release NH_4^+ (ammonium)
- Nutrient cycling



Nematodes

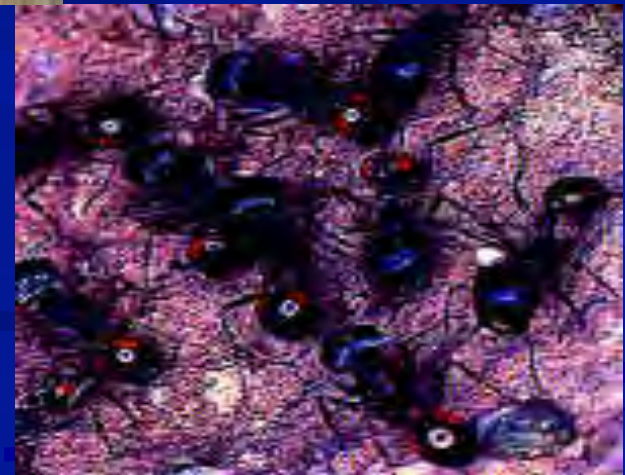
- Four Types of Free-living nematodes:
 - Bacterial Feeders
 - Fungal Feeders
 - Predatory nematodes
 - Omnivores
- Beneficial nematodes help control disease & cycle nutrients.
- Stimulate prey populations.
- Disperse microbes.
- Food source – higher predators.
- Disease suppression & Development.





Indicator Species

Insects/Arthropods





Earthworms



Dung Beetles



Dung Beetles

I Tunnelers

II Dwellers

III Rollers or Tumblers

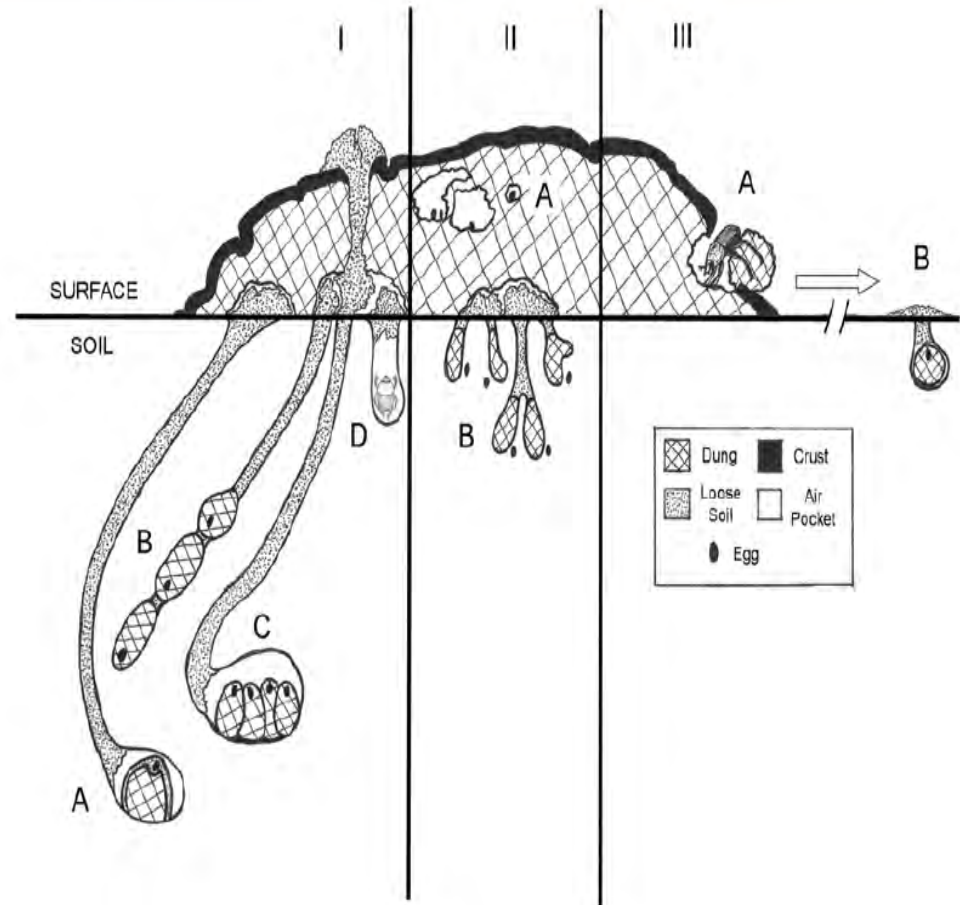


Figure 1. Cross section through dung pat depicting three nesting types:

Tunnelers I-A. *Phanaeus vindex* tunnel with single, soil-coated brood ball in single chamber; B. *Onthophagus* species tunnel with multiple brood masses; C. *Copris minutus* multiple brood balls; D. beetle excavating new tunnel (note subsurface soil is pushed through the dung pat crust)

Dwellers II-A. *Aphodius pseudolividus* eggs are laid singly or in groups inside dung pat; B. *Aphodius erraticus* bury dung under pat with eggs laid beside brood masses.

Rollers III-A. *Canthon pilularius* adult carving out dung into a ball; B. ball rolled a distance away from pat and buried shallowly.

Figure 3. Picture Guide to Dung Beetles Associated with NC Pastures

Males are indicated by the symbol ♂ and females ♀

Photographs by Matt Bertone



Aphodius distinctus
Size: 1/8-3/16"



Aphodius erraticus
Size: 1/4-3/8"



Aphodius fimetarius
Size: 1/4-3/8"



Aphodius pseudolividus
Size: 1/8-3/16"



Geotrupes blackburnii
Size: 3/8-3/4"



Onthophagus gazella (♀)
Size: 3/8-1/2"



Onthophagus gazella (♀)
Size: 3/8-1/2"



Onthophagus gazella (♂)
Size: 3/8-1/2"



Onthophagus gazella (♂)
Size: 3/8-1/2"



Onthophagus hecate (♀)
Size: 1/4-3/8"



Onthophagus hecate (♂)
Size: 1/4-3/8"



Onthophagus hecate (♂)
Size: 1/4-3/8"



Onthophagus pennsylvanicus
Size: 1/8-1/4"



Onthophagus taurus (♀)
Size: 1/4-3/8"



Onthophagus taurus (♂)
Size: 1/4-3/8"



Onthophagus taurus (♂)
Size: 1/4-3/8"



Phanaeus vindex (♀)
Size: 3/8-7/8"



Phanaeus vindex (♂)
Size: 3/8-7/8"



Phanaeus vindex (♂)
Size: 3/8-7/8"



Canthon pilularius
Size: 1/2-5/8"



Dichotomus carolinus
Size: 3/4 - 1 1/4"

Pronunciation guide: There are no common names of these beetles. To make their names easier to understand, a pronunciation guide is provided.

Aphodius distinctus: A-fo-di-us dis-tink-tuss

Aphodius erraticus: A-fo-di-us e-rat-i-kus

Aphodius fimetarius: A-fo-di-us fim-a-tary-us

Aphodius granarius: A-fo-di-us gran-air-e-us

Aphodius pseudolividus: A-fo-di-us sue-doe-liv-i-dus

Canthon pilularius: Kan-thon pie-loo-lary-us

Copris minutus: Koe-pris mi-nu-tus

Dichotomus carolinus: Dik-o-to-mee-us carolin-us

Geotrupes blackburnii: Geo-troop-eze black-burny-eye

Onthophagus gazella: On-tho-fa-gus ga-zell-a

Onthophagus hecate: On-tho-fa-gus heck-ate

Onthophagus pennsylvanicus: On-tho-fa-gus pen-sill-van-i-kus

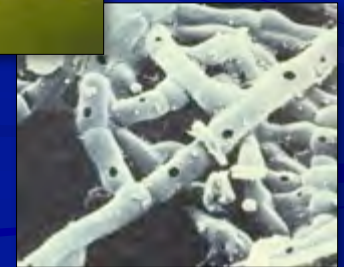
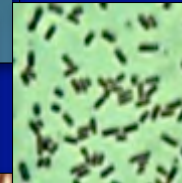
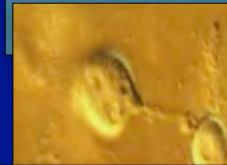
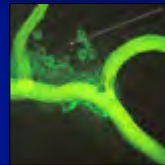
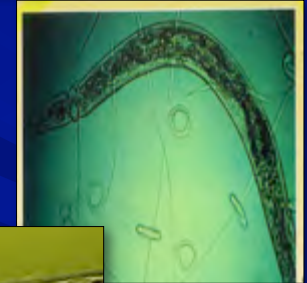
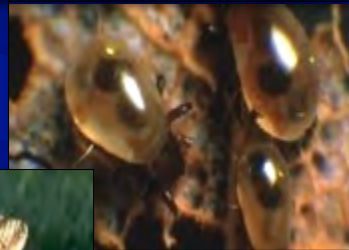
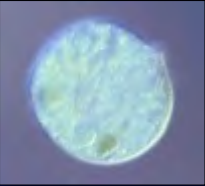
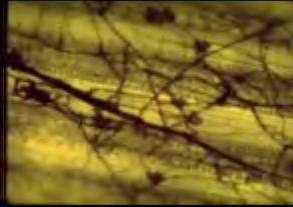
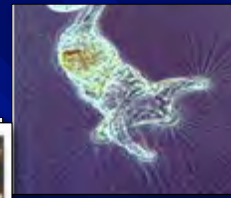
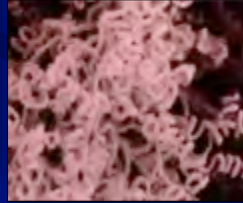
Onthophagus taurus: On-tho-fa-gus tore-us

Phanaeus vindex: Fan-ny-us vin-dex (Rainbow beetle)

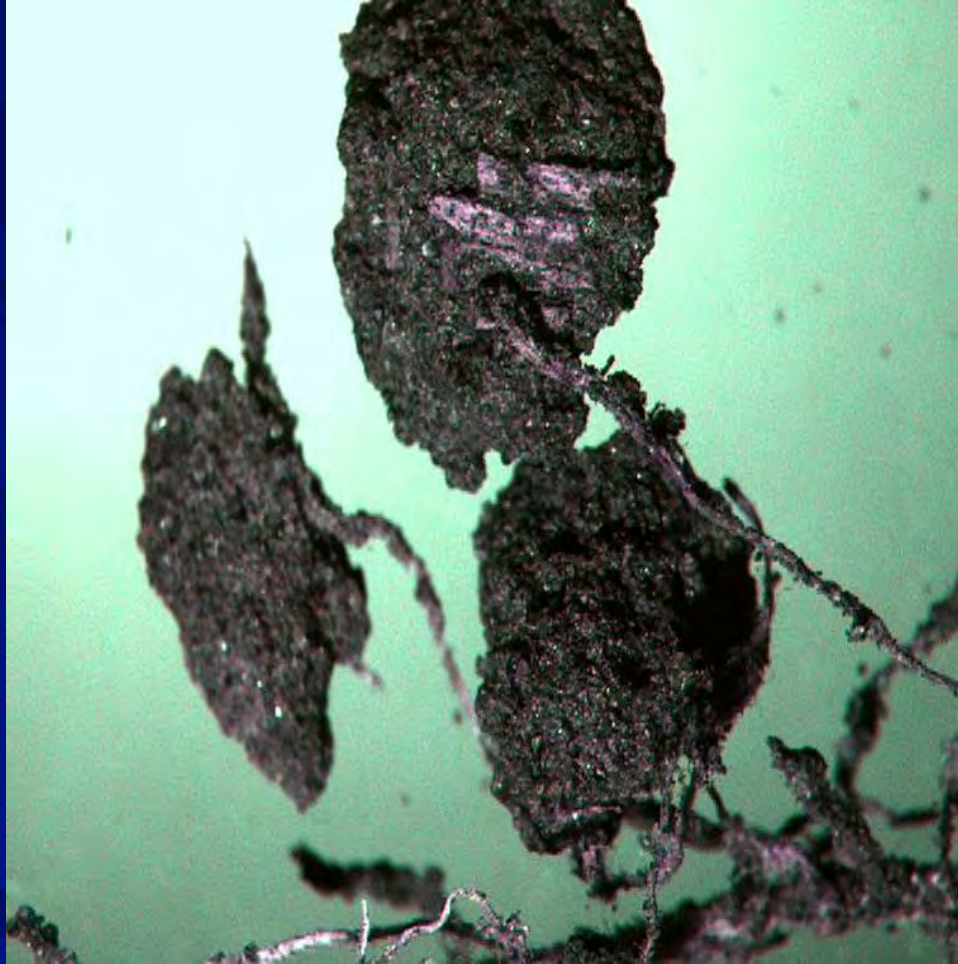
Pollinator Insects



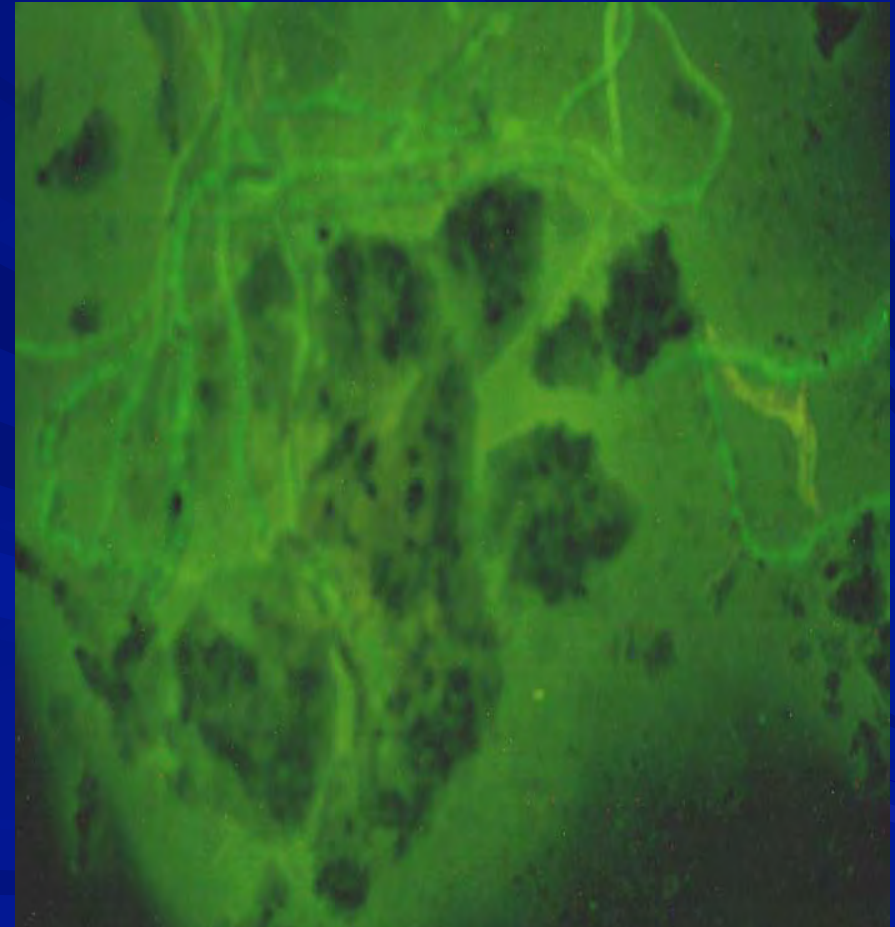
Soil Food Web (Soil Livestock)



Enlarged Soil Aggregates

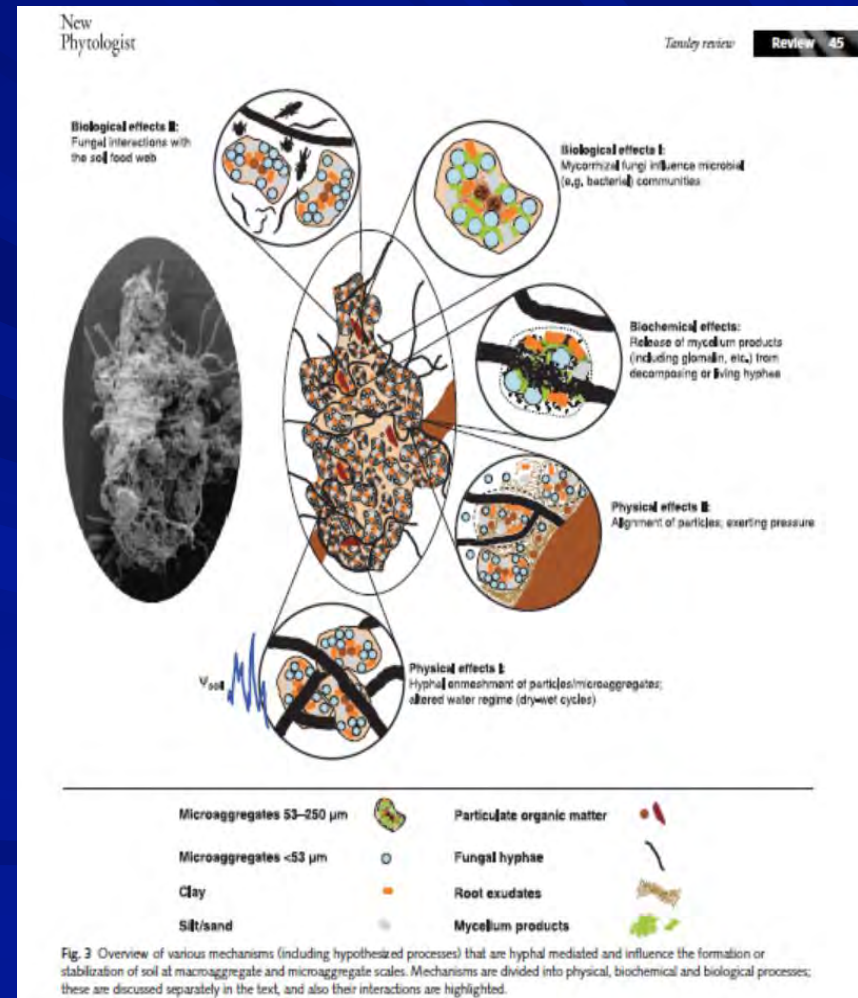
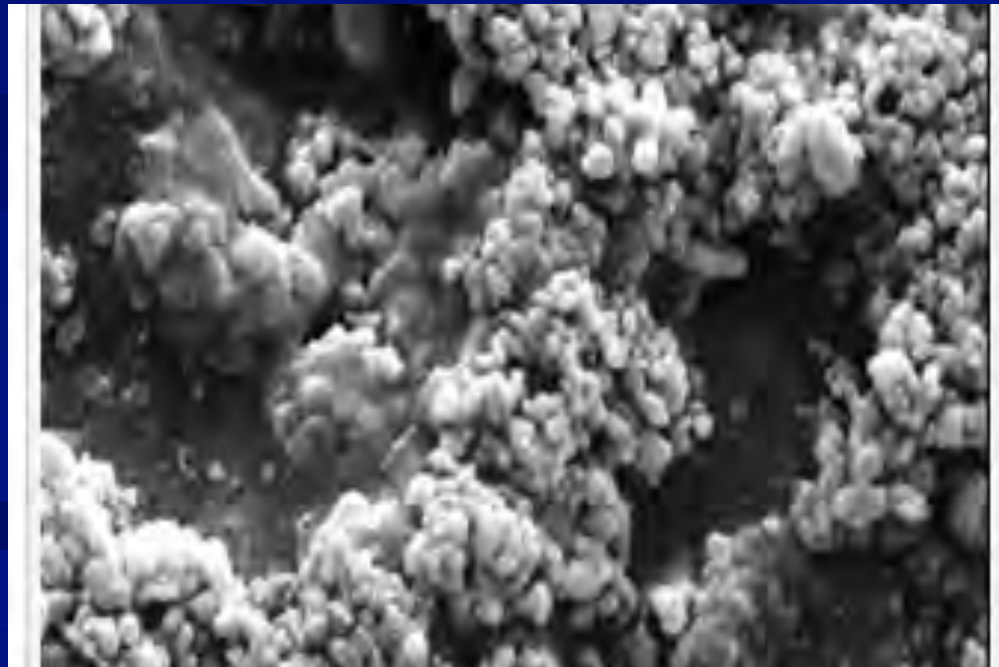


Glomalin and hyphae



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

The Aggregate: Lungs of the soil



Keys to Plant Health

■ Four Stages:

– Stage One

■ Successful Photosynthesis

- Plants convert simple sugars to complex carbs and polysaccharides.
- Creates resistance to basic soil-borne pathogens.

– Stage Two

■ Plant synthesizes complete proteins

- Many crop pests (aphids, whiteflies, larval insects) cannot digest complete proteins.
- Adds layer of protection to plants.

Keys to Plant Health

■ Stage Three

- Surplus energy is stored as lipids, fats, and oils.
- Creates stronger cell membranes.
- Plants can now resist airborne pathogens, like blight, mildew, and many bacterial threats.

■ Stage Four

- Plants now produce high levels of “plant secondary metabolites”.
- These are highly aromatic compounds, similar to essential oils.
- Critical to high level plant immunity, attracting pollinators, neutralizing toxins, withstanding stressors.

Soil is to the Plant as the Rumen is
to the Cow

The Value of Soil Organic Matter

Value of Soil Organic Matter (1.0% SOM Nutrients/Acre)

<u>Nutrients</u>	<u>Nutrient (Lbs)</u>	<u>Unit Value/lb</u>	<u>Value/Acre</u>
Nitrogen	1000	\$0.56	\$560
Phosphorus	100	\$0.67	\$67
Potassium	100	\$0.54	\$54
Sulfur	100	\$0.50	\$50
Carbon	10000	\$0.037	\$20
Value of 1.0% SOM in Nutrients/Acre			\$751

Source: J. Soil and Water Conserv. B. Hudson. 49 (2) 189-194

5.0% SOM = \$3755

Beneficial properties of SOM

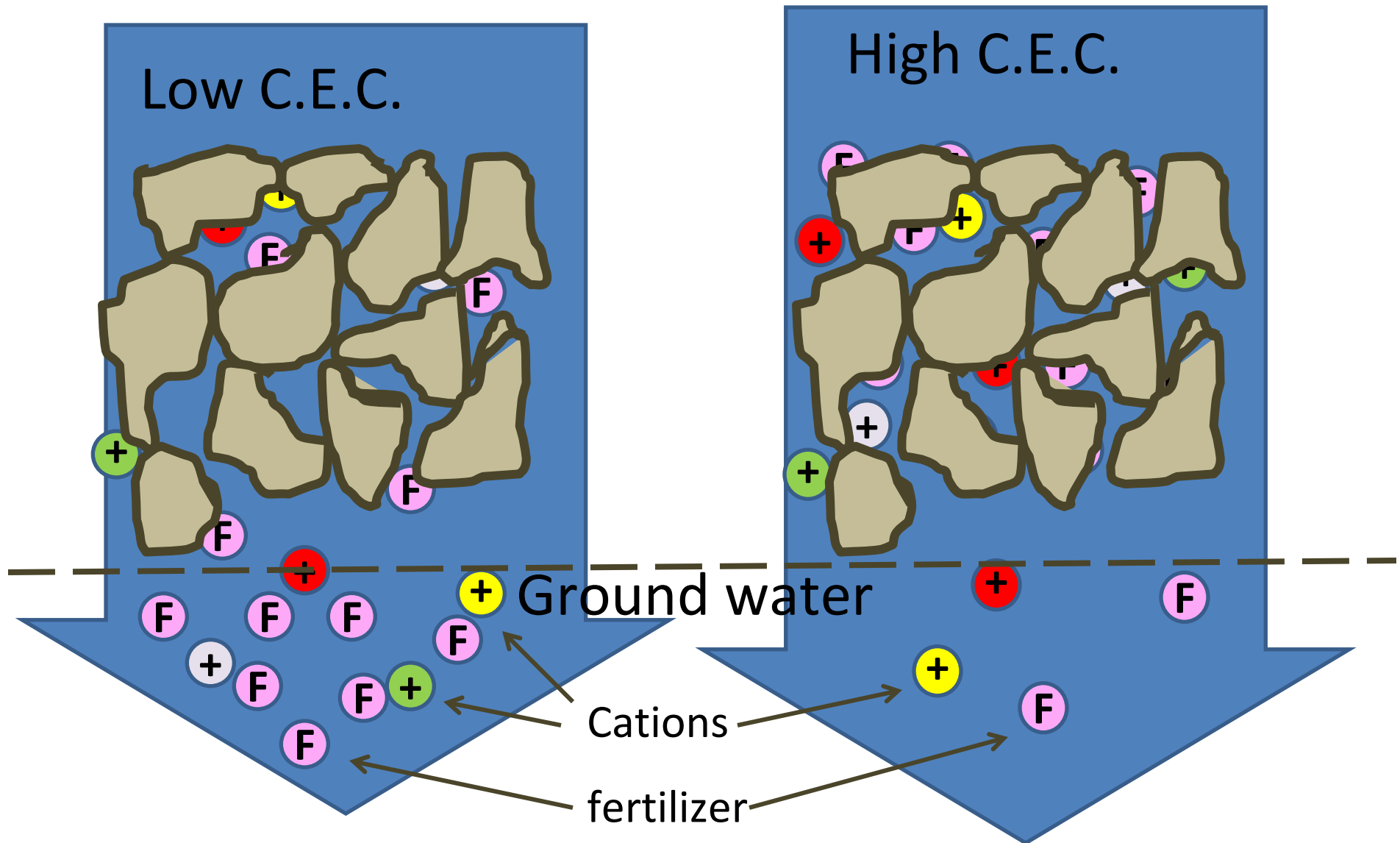
- **Biological properties**
 - A source of slowly available carbon-based energy to support large, diverse and active microbial communities
- **Physical properties**
 - Improves soil structure and aggregation
 - Decreases bulk density and increases % pore space
 - Increases infiltration and water-holding capacity
 - Increases heat absorption in early spring due to dark color

Beneficial properties of SOM

- Chemical properties
 - **Increases the Cation Exchange Capacity (CEC) of soil**
 - Buffers pH change
 - Slow-release form of N, P, S and micronutrients
 - Enhances chelation and bioavailability of trace elements
 - Accelerates rock weathering and aids solubilization of minerals
 - Has a high adsorptive capacity for organic compounds, including many contaminants

Beneficial properties of SOM

Increases the Cation Exchange Capacity of soil



Measuring Water Infiltration Rates



Improved Organic Matter = Reduced Runoff and Clean Water



Can we control runoff with Organic Matter (OM)?

- **2% OM** will hold 32,000 gallons of water or **21%** of a Moderate to Heavy rainfall.
- **5% OM** will hold 80,000 gallons of water or **53%** of a Moderate to Heavy rainfall.
- **8% OM** will hold 128,000 gallons of water or **85%** of a Moderate to Heavy rainfall.

Soil OC Water Holding Capacity

<u>Organic Carbon (%)</u>	<u>Water Per Acre (Gallons)</u>
1%	14,400
2%	28,800
3%	43,200
4%	57,600
5%	80,000
8%	128,000

Organic Matter and Available Water Capacity (inches water/one foot soil)

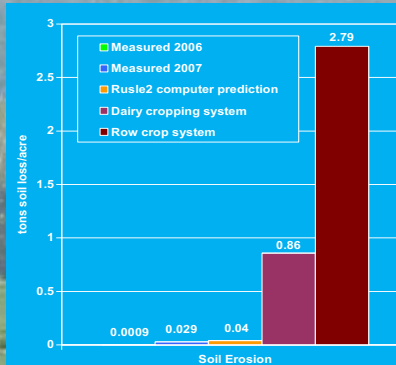
Percent SOM	Sand	Silt Loam	Silty Clay Loam
1	1.0	1.9	1.4
2	1.4	2.4	1.8
3	1.7	2.9	2.2
4	2.1	3.5	2.6
5	2.5	4.0	3.0

Source: J. Soil and Water Conserv. B. Hudson. 49 (2) 189-194.

Conserving & Improving Soil

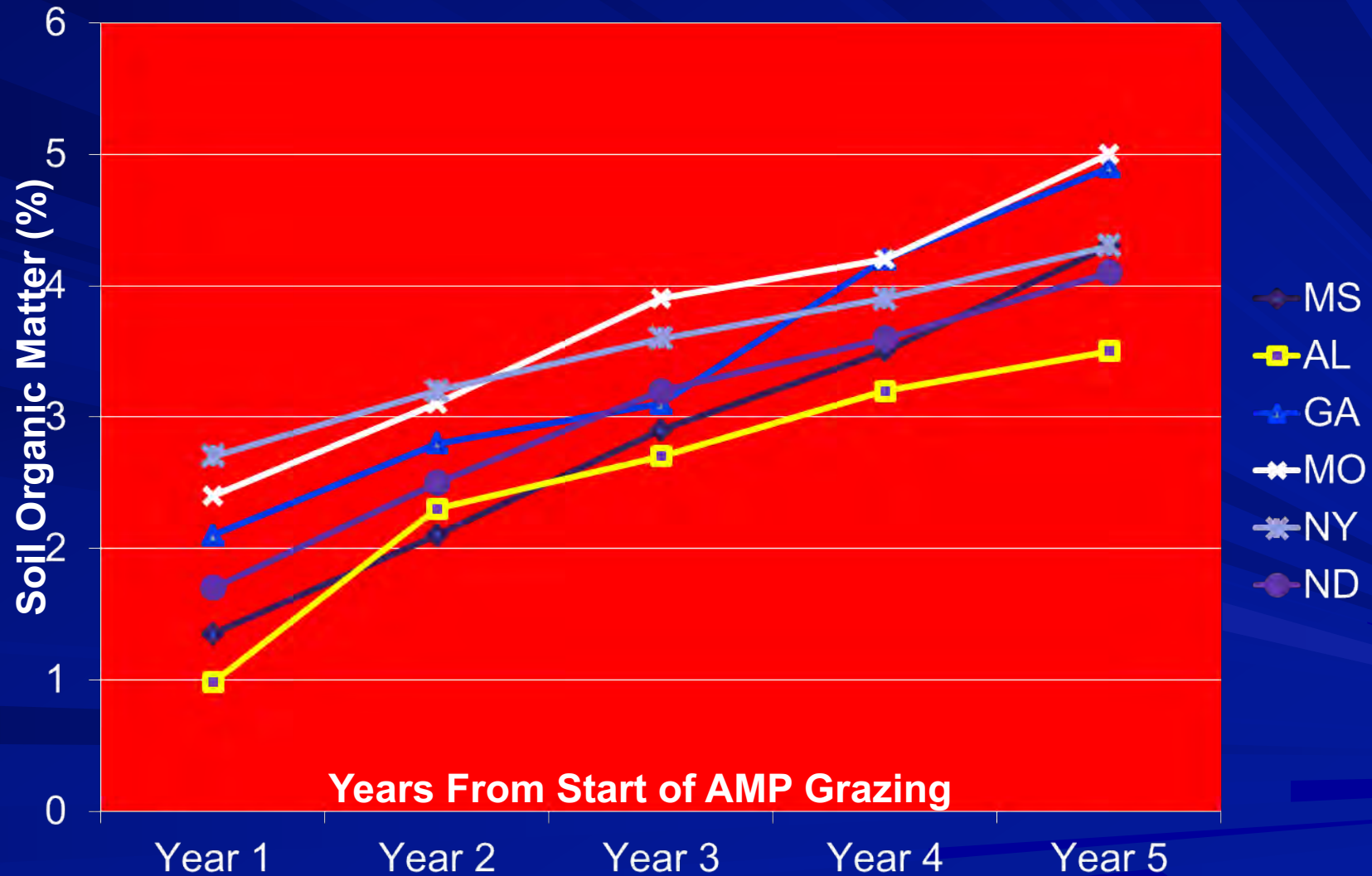
data from Breneman Discovery Farms project

Sediment
losses from
Breneman
outwintering
pastures



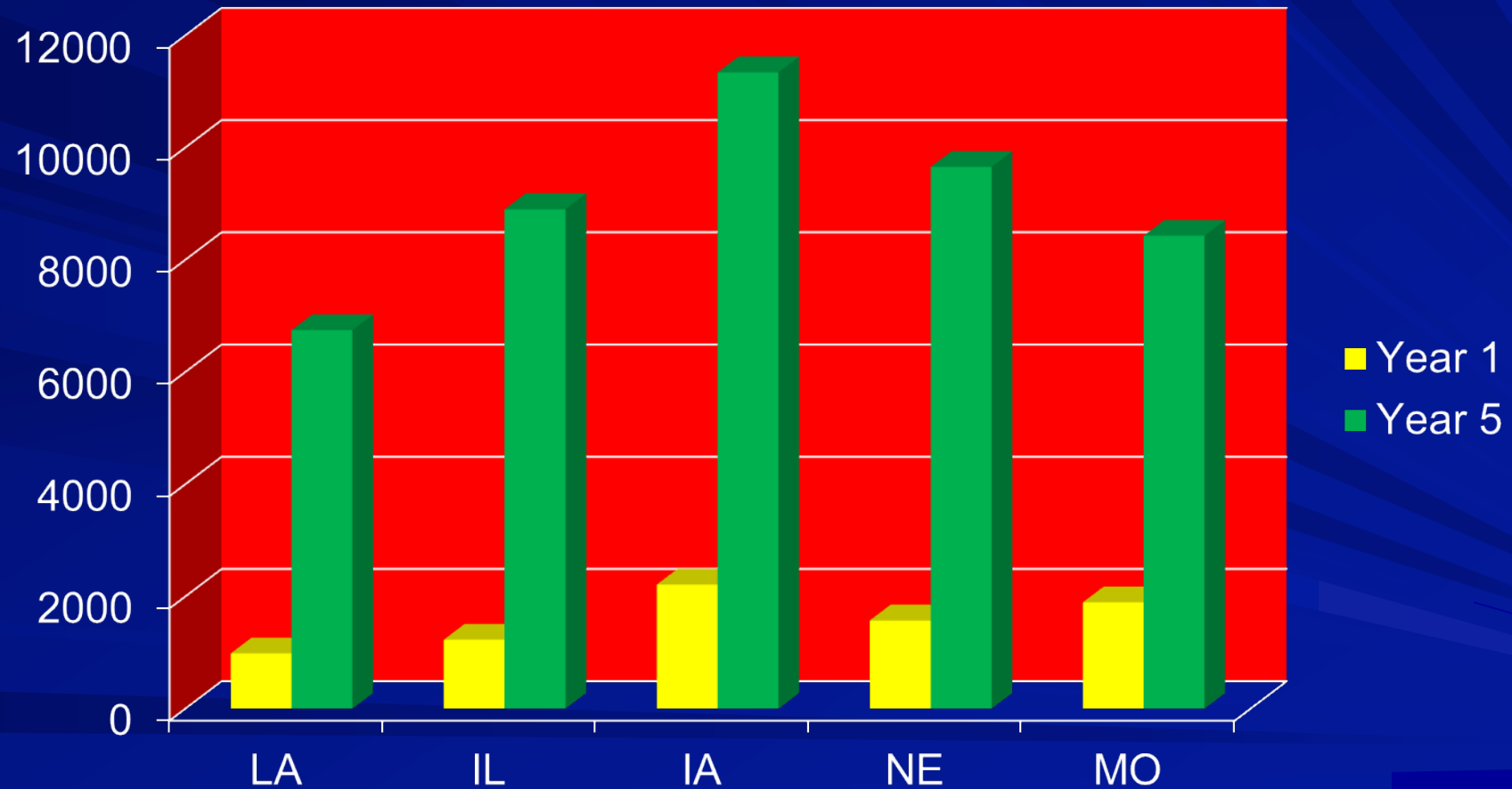
How Rapidly Can We Build New Soil Organic Matter?

Improvement in Soil Organic Matter Using AMP Grazing



Source: Grass Fed Insights, LLC

Building Microbial Biomass (ng/g of Soil)



Vibrant Soil



“Dead” Soil



Building Topsoil



Soil Insects



Earthworm Castings