



team

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# Keys to the kingdom of improving soil health

## ■ **Understand your Context**

## ■ **Protect the Soil Habitat**


Manage more by Disturbing Soil Less  
Keep the Soil Covered as Much as Possible

## ■ **Provide Diverse Food (carbon)**

Diversify with Crop Diversity  
Grow Living Roots Throughout the year

# Understanding Soil Health: The Brown Revolution!





The greatest roadblock in  
solving a problem is the human  
mind!

TALKS

# Janine Benyus shares nature's designs

TED2005, Filmed Feb 2005; Posted Apr 2007



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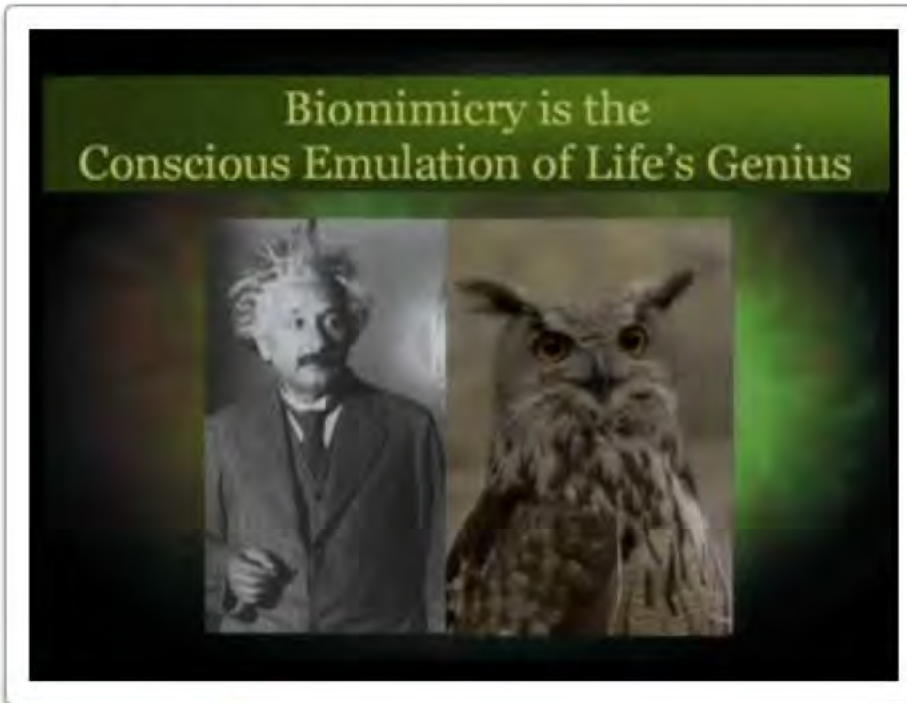
Player controls: 06:31 | 23:16

Subtitles Available in: 21 languages [Off]

TALKS

# Janine Benyus shares nature's designs

TED2005, Filmed Feb 2005; Posted Apr 2007



06:57 | 23:16


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Interactive transcript 

TALKS

# Janine Benyus shares nature's designs

TED2005, Filmed Feb 2005; Posted Apr 2007



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Interactive transcript 

TALKS

# Janine Benyus shares nature's designs

TED2005, Filmed Feb 2005; Posted Apr 2007



5. Quenching Thirst



QinetiQ/Univ of Bath/  
Biomimicry Guild/ Rocky  
Mountain Institute



16:00 | 23:16


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Interactive transcript 






TALKS



# Janine Benyus shares nature's designs

TED2005, Filmed Feb 2005; Posted Apr 2007



Progress bar: 

  21:56 | 23:16 [Share](#) [Rate](#)

Subtitles Available in: 21 languages [Off]  [Interactive transcript](#) 



# SOIL QUALITY/HEALTH is

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



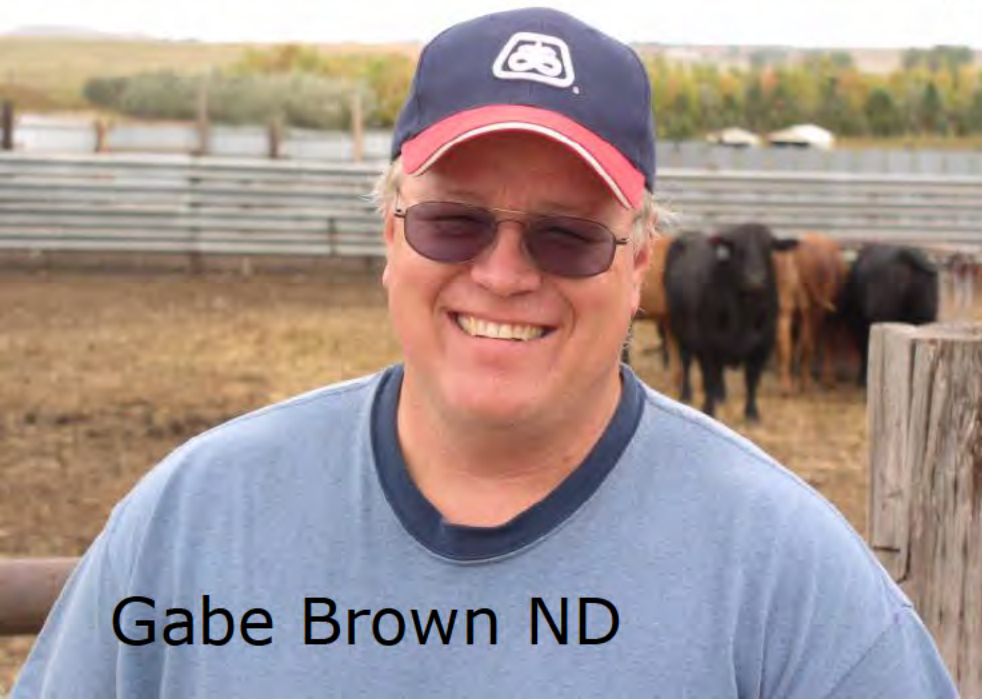
Ray Styer NC



Dave Brandt  
OH



Steve Groff  
PA



Gabe Brown ND

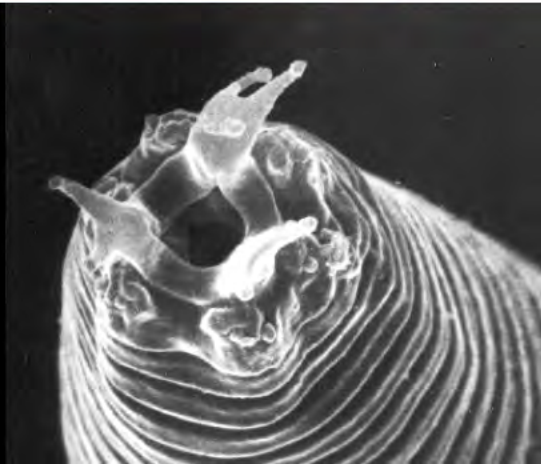


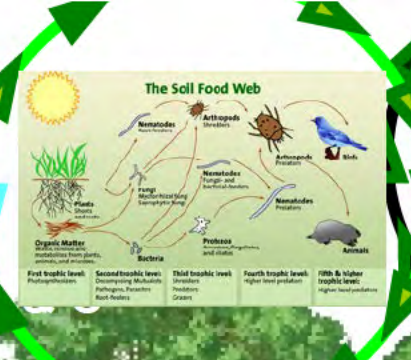
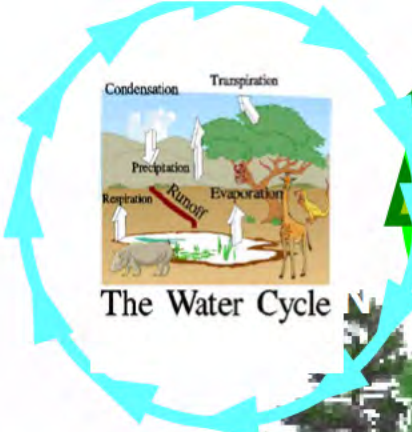
Ray McCormick IN



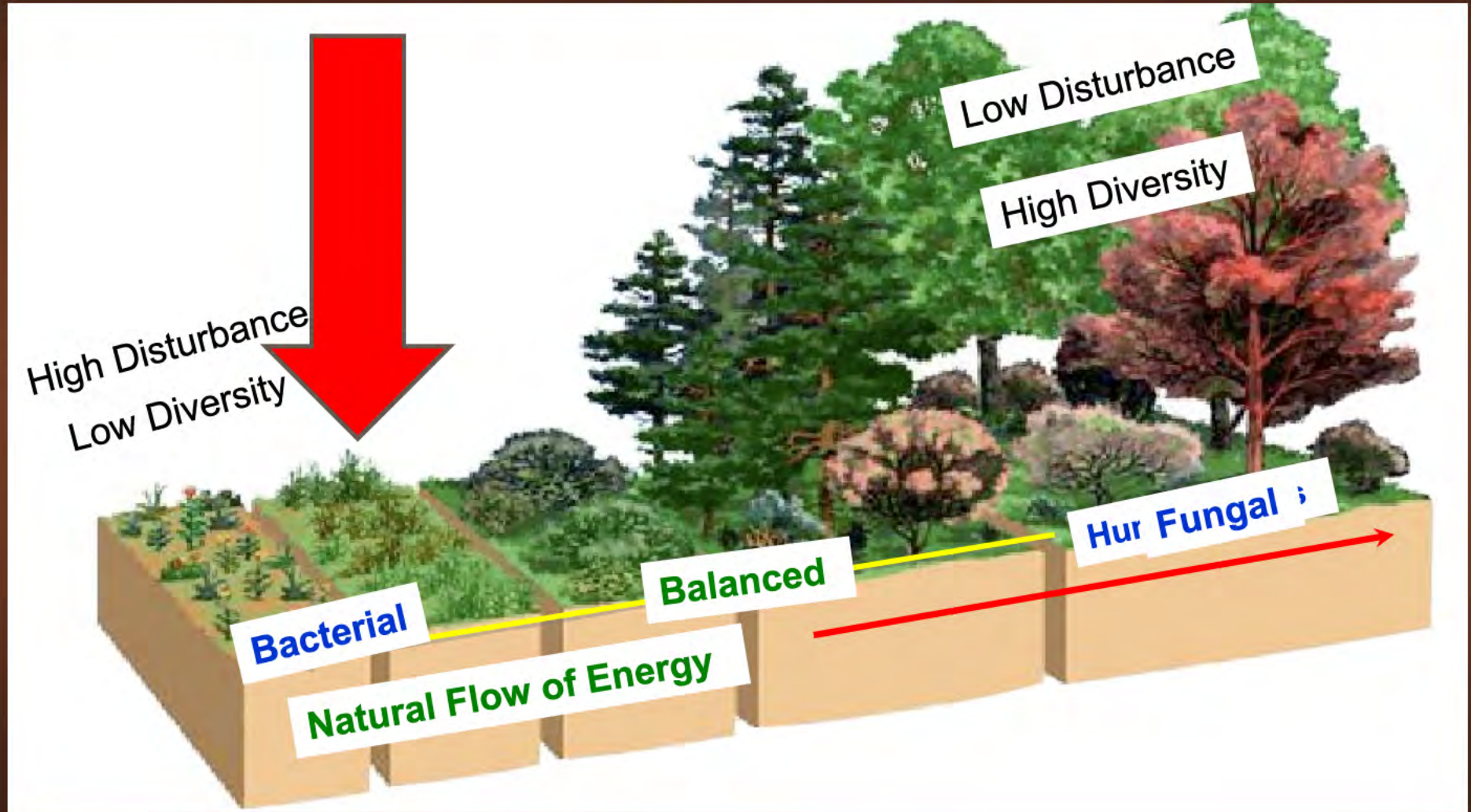
**Ecology:**  
the study of  
relationships between  
people, animals, and  
plants, and their  
environment.  
**Interconnectedness**

Soil Surface





# Natural Succession of Plants & Soil

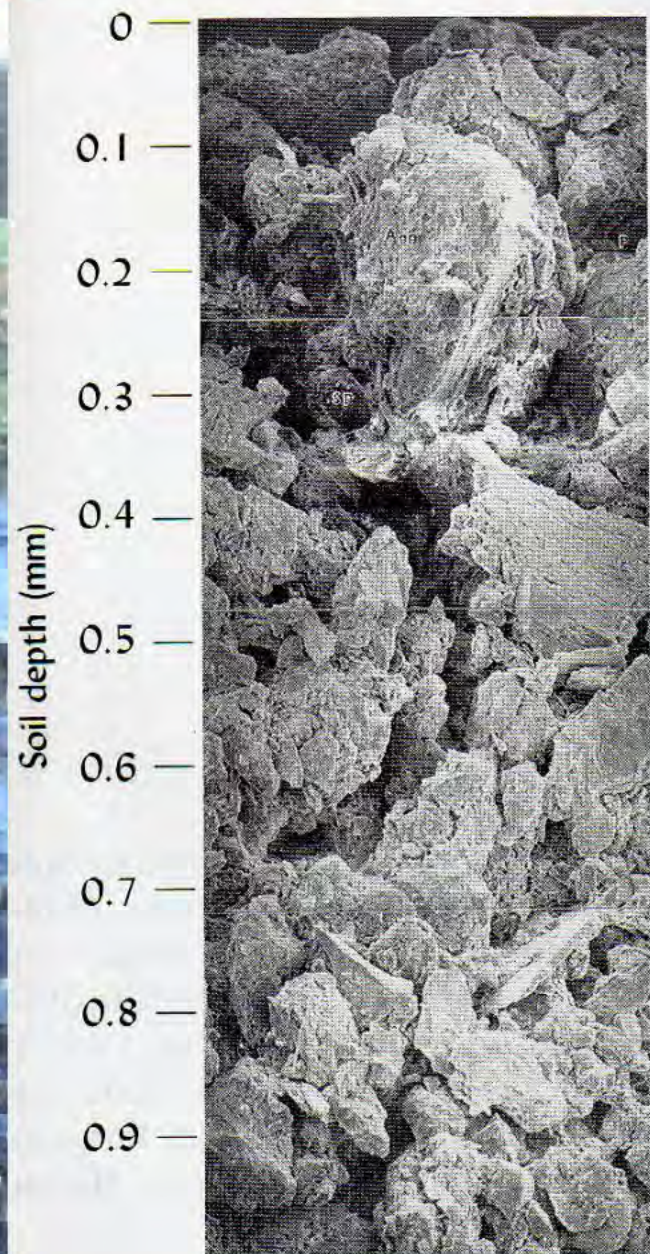




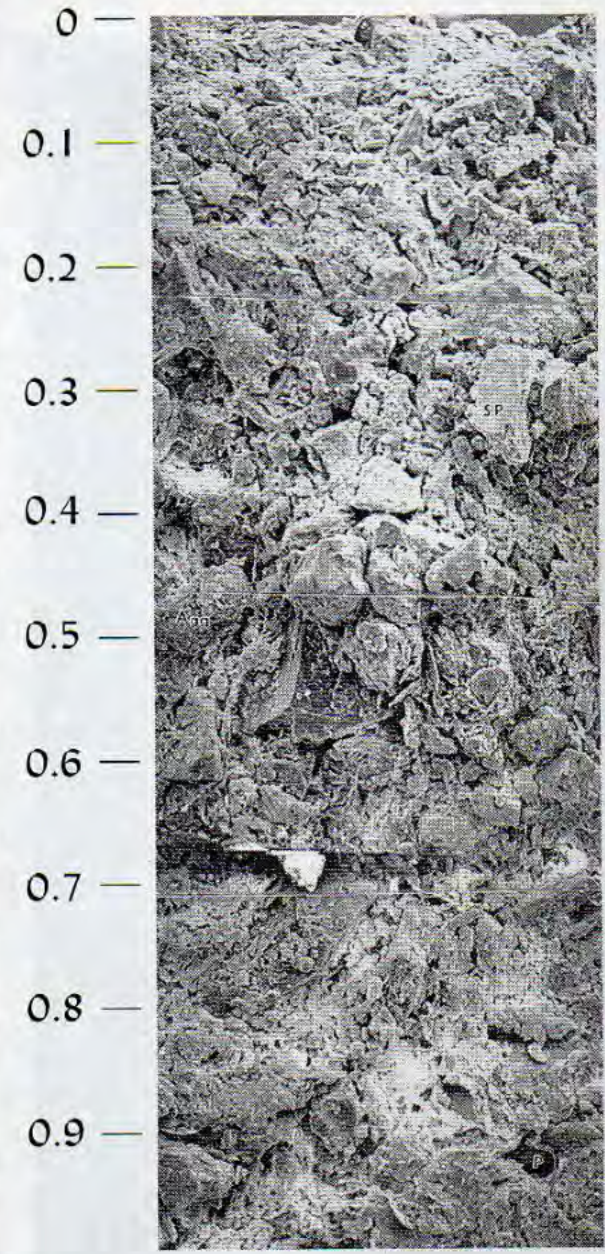
# Disrupted Soil Ecosystem

**This soil is naked, hungry, thirsty and running a fever!**

# Battle Starts Here



(a)



(b)



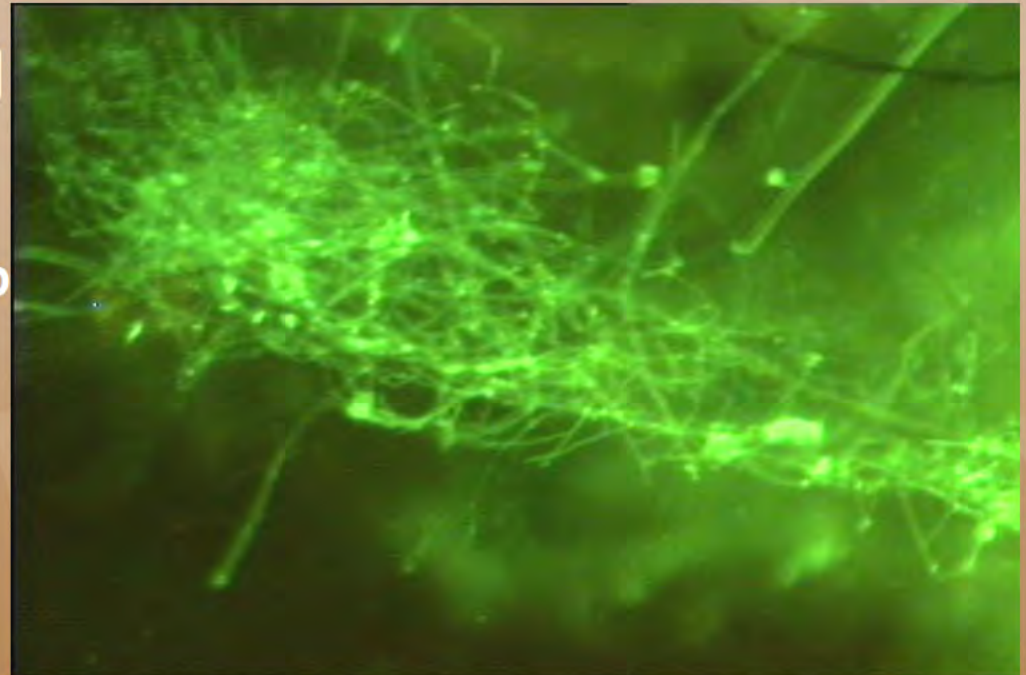


# What is GLOMALIN?

- Gycoprotein (Sugar Protein)
  - 4-6% sugar
- Coats and protects hyphae

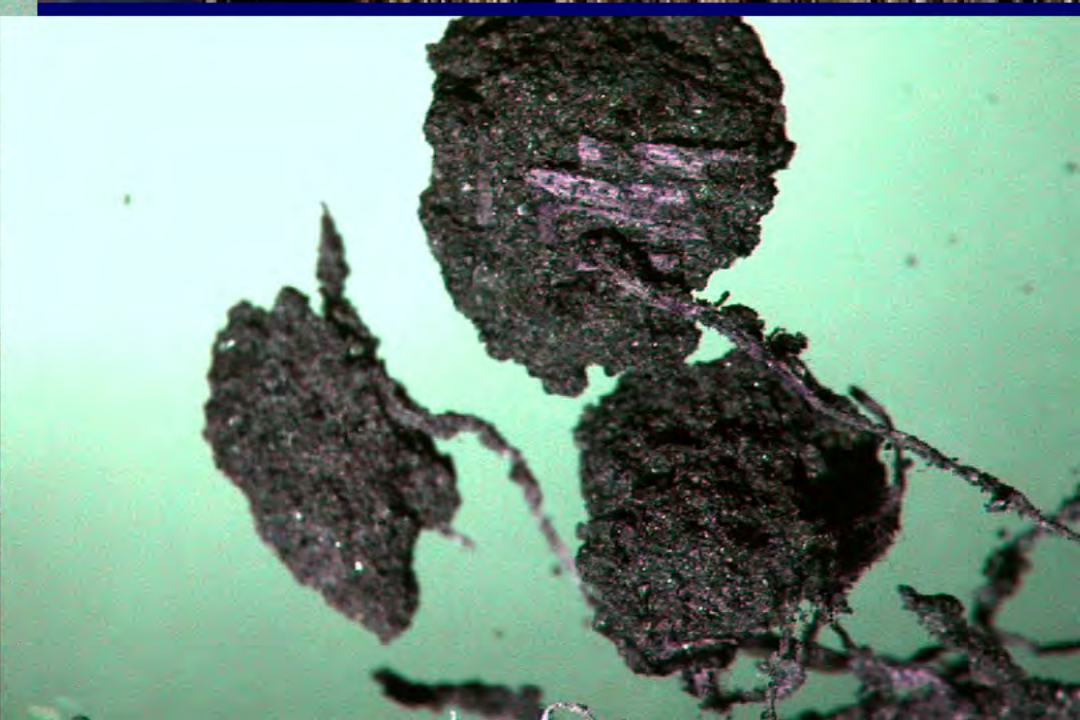
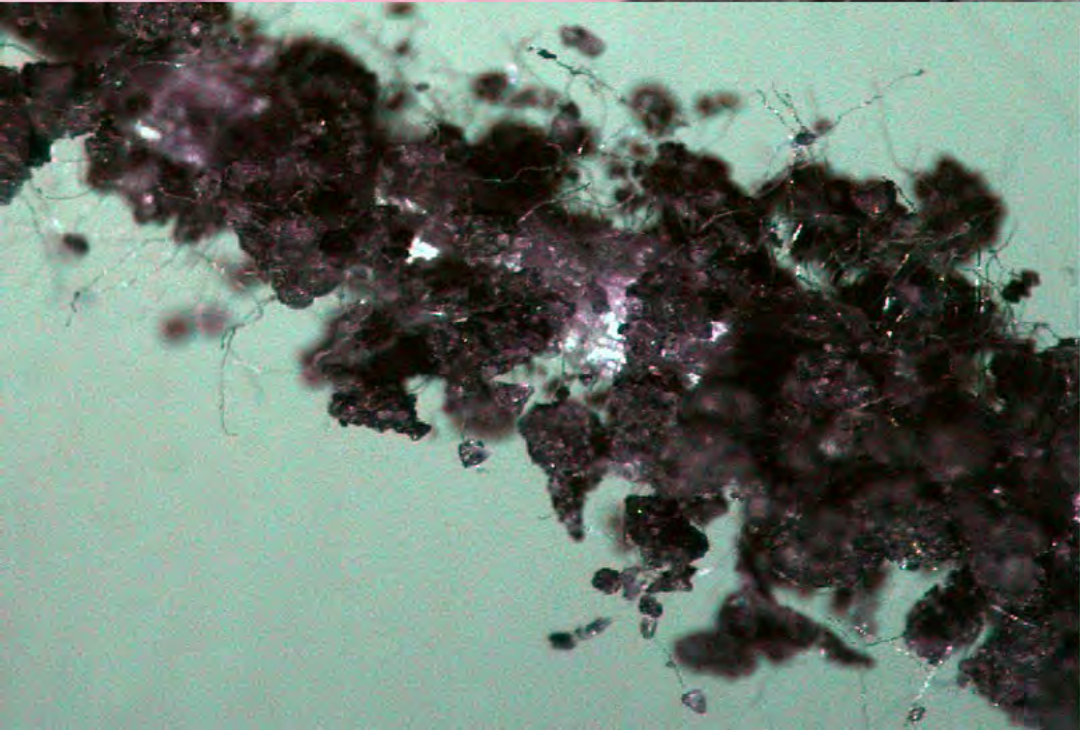


Hyphae from a pot culture of *Gi. gigantea* at 90X under bright field.



Same picture, except under fluorescence.

# Soil Aggregates



Erosion from bare fields  
5/2007



Is the Buffer working?  
6/2007



Australia



Lubbock Texas Oct.  
17, 2011



Where's the "Pore" Space?

# "Pore" Management



# Bulk Density of Soils in New Jersey

Table 1.

Permeability Measurements of Sampled Layers within 20 of Soil Surface		
Site	Bulk Density (g/cm <sup>3</sup> )	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	0.04
Cleared Woods	1.83	0.13
Subdivision Lawn 2	2.03	0.03
Athletic Field	1.95	0.01

Reference: Bulk Density for Concrete is 2.4 g/cm<sup>3</sup>



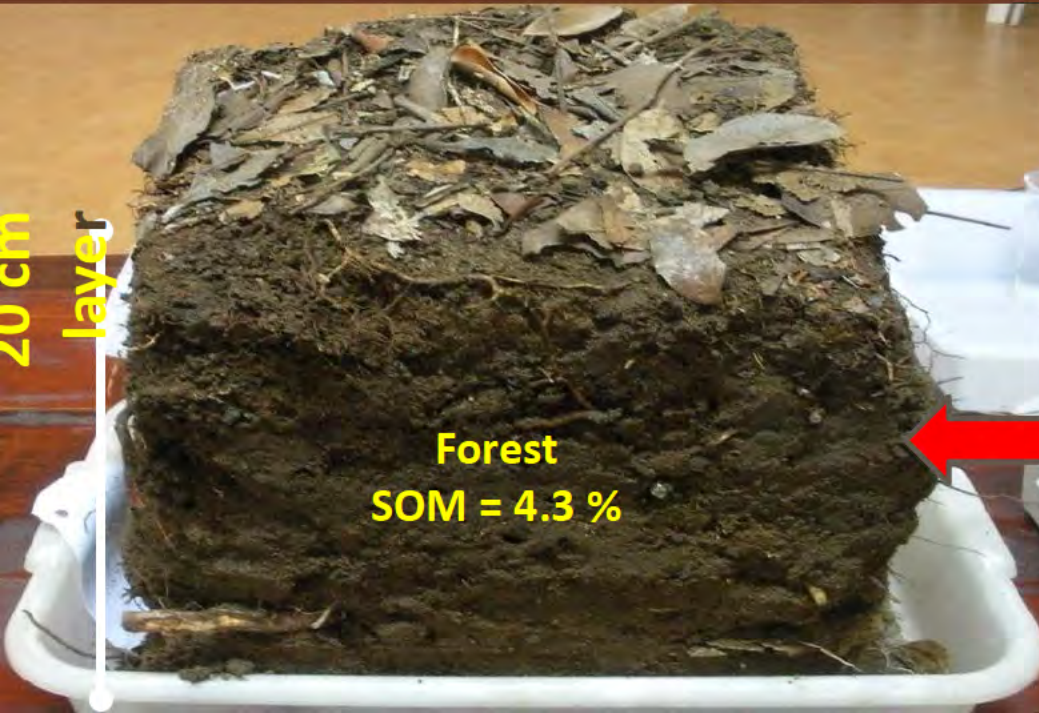
# North towards New Jersey: 2008



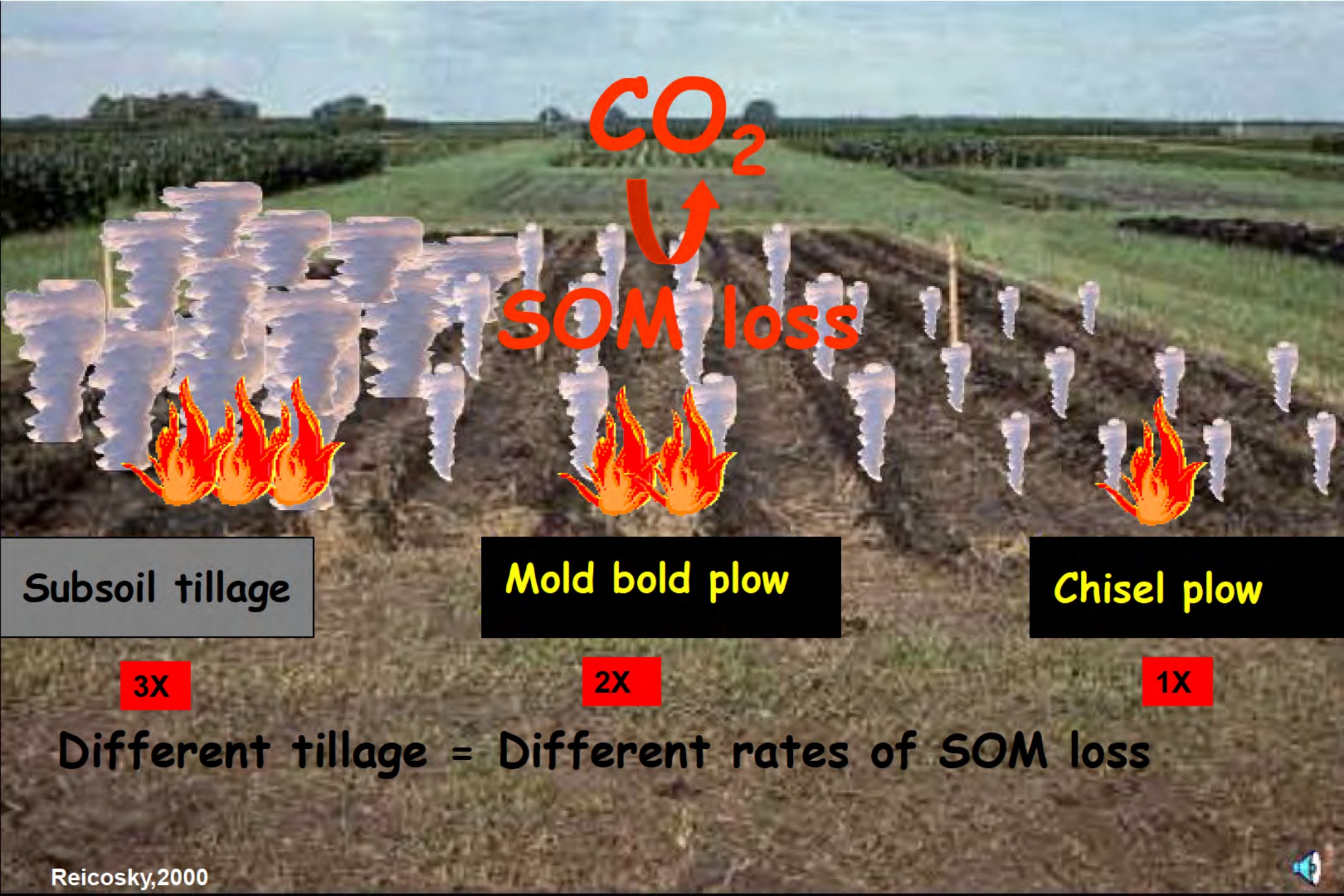
# Same Soils: Dynamic Soil Properties Changed!



62.8% loss of  
SOM after 17  
yr intensive  
tillage







$CO_2$



SOM loss

Subsoil tillage

Mold board plow

Chisel plow

3X

2X

1X

Different tillage = Different rates of SOM loss

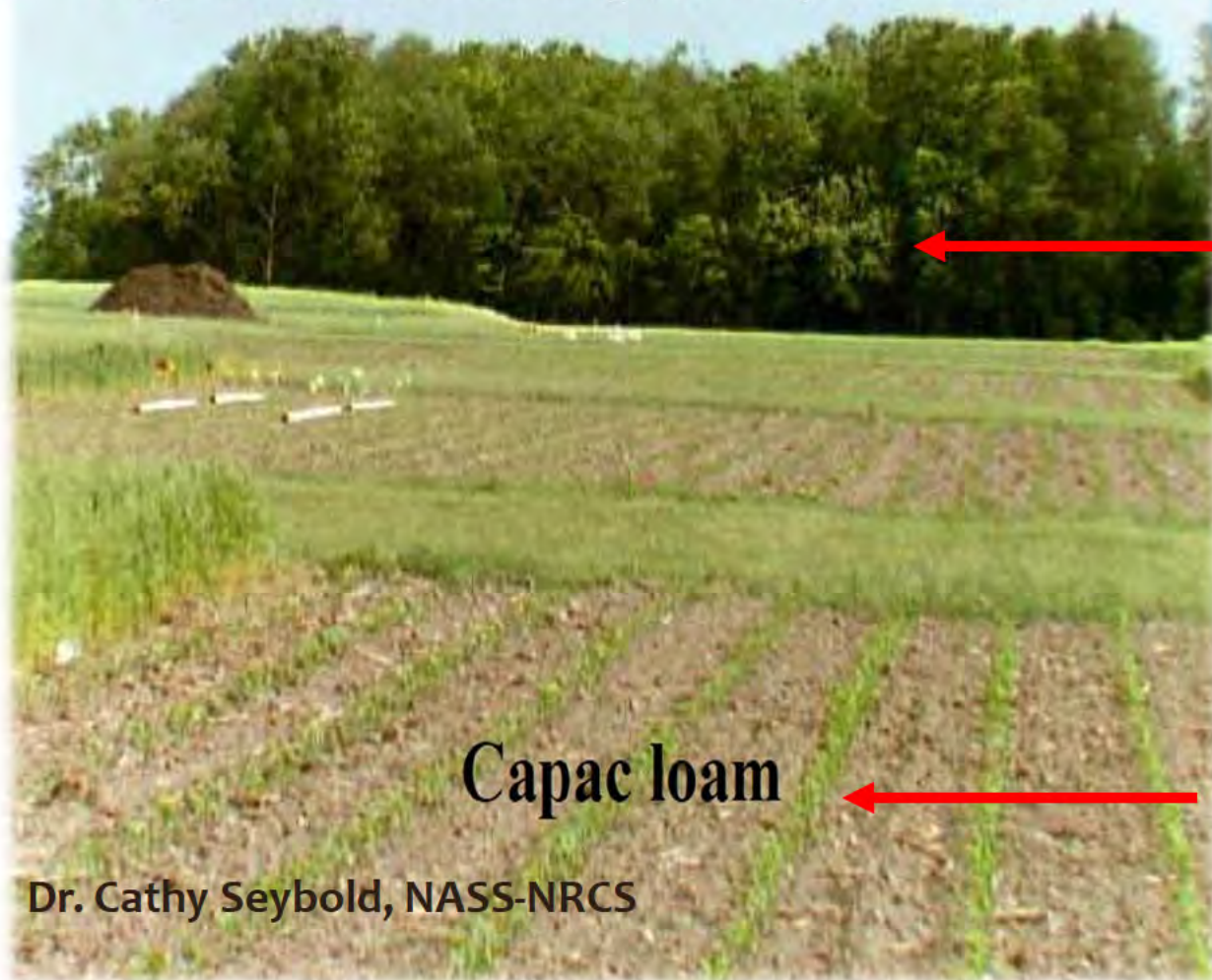


# Study: Use-dependent Soil Properties

Land uses:

Woodland

Cropland: Conventional tillage, corn-soybean rotation



Wooded Soil: Bulk Density- 1.01 g/cm<sup>3</sup>

Infiltration rate	Soil Nitrate loss
50 in./hr	1.8 lbs. N/ac.

Conventional Tillage- Corn-Soybean:  
Bulk Density- 1.40 g/cm<sup>3</sup>

Infiltration rate	Soil Nitrate loss
.50 in./hr	15 lbs. N/ac.

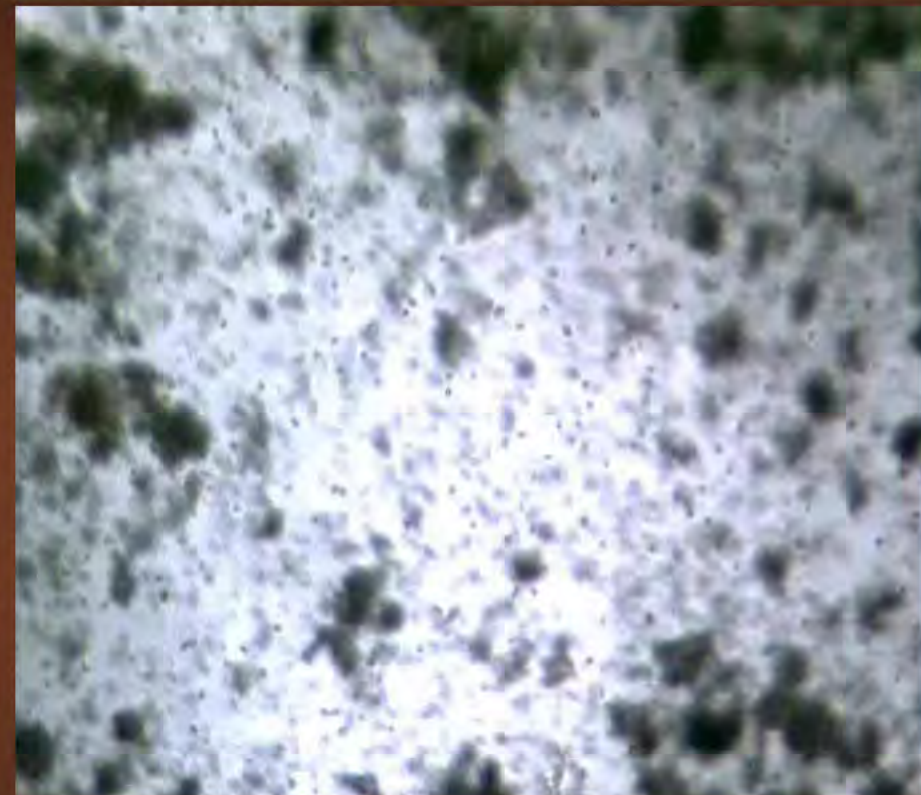
Capac loam

# *Inorganic Based Soluble State*



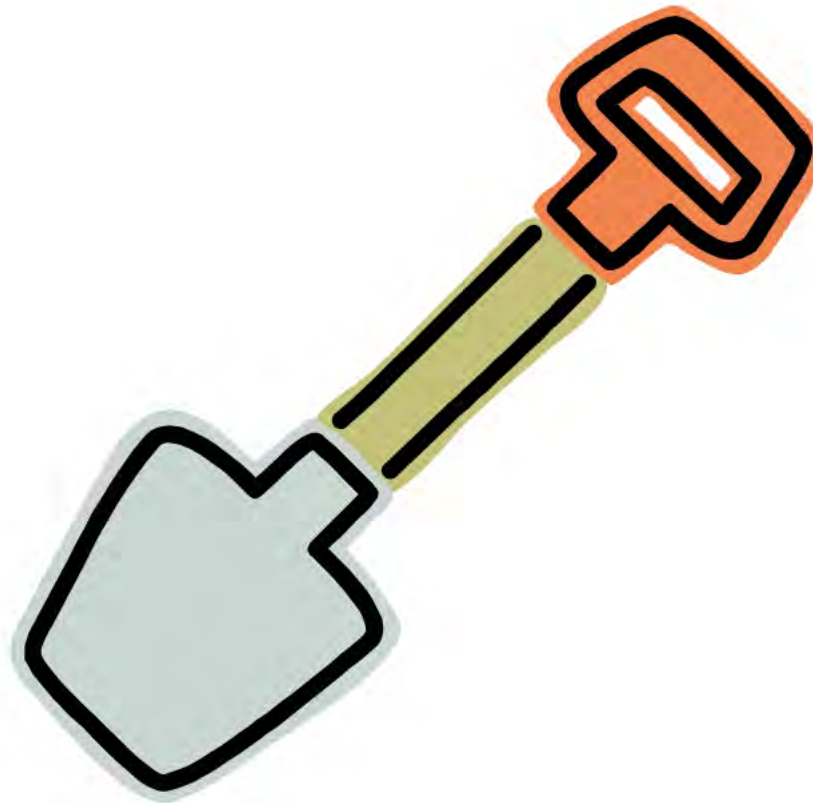
- 40 to 60 % N and P Loss  
Cassmen 2002
- Bare fallows 4-8 months
- Decoupled C,N,P cycle
- Dr.Drinkwater, Dr. Swift

# *Ecologically Based*

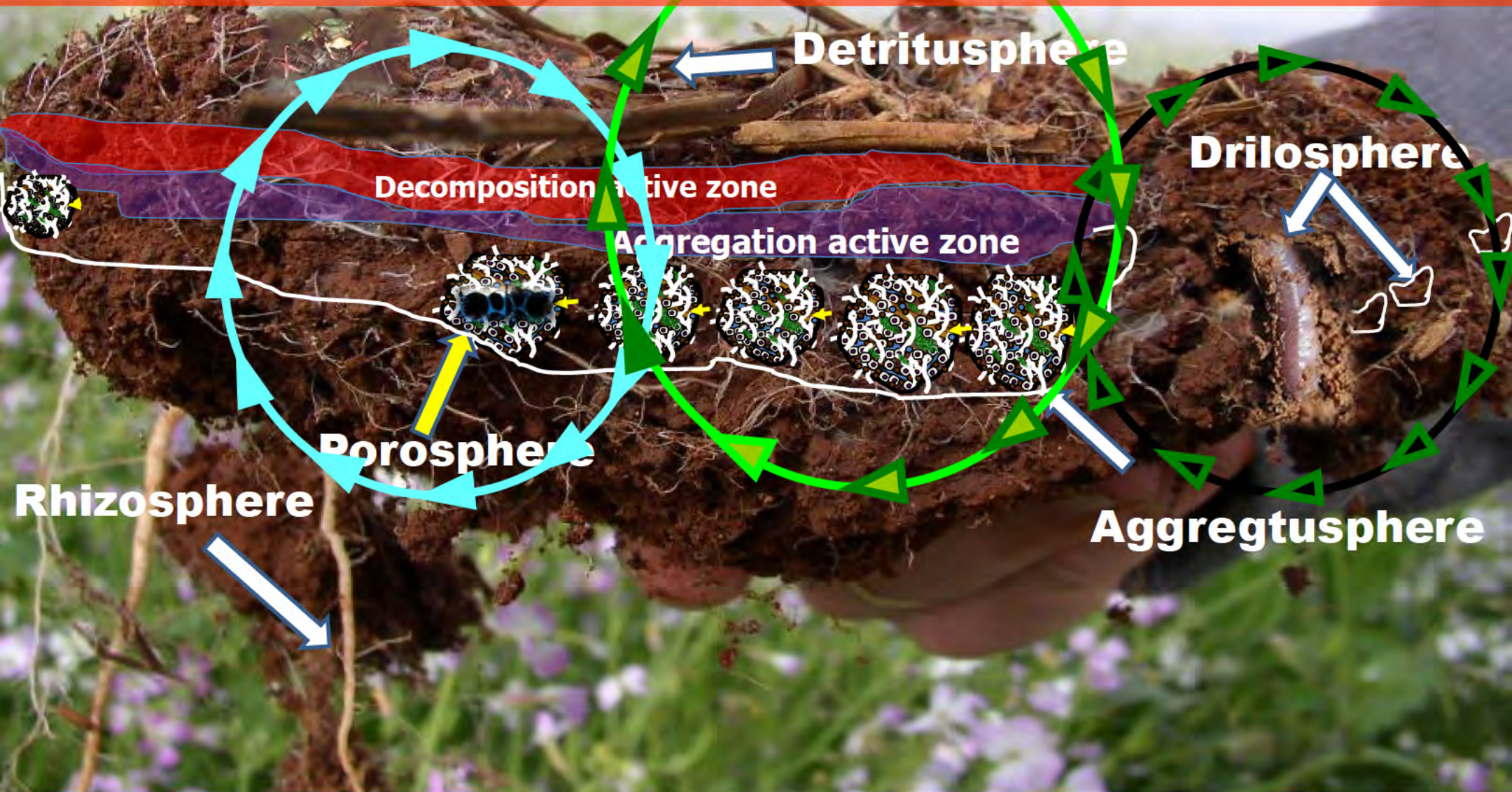


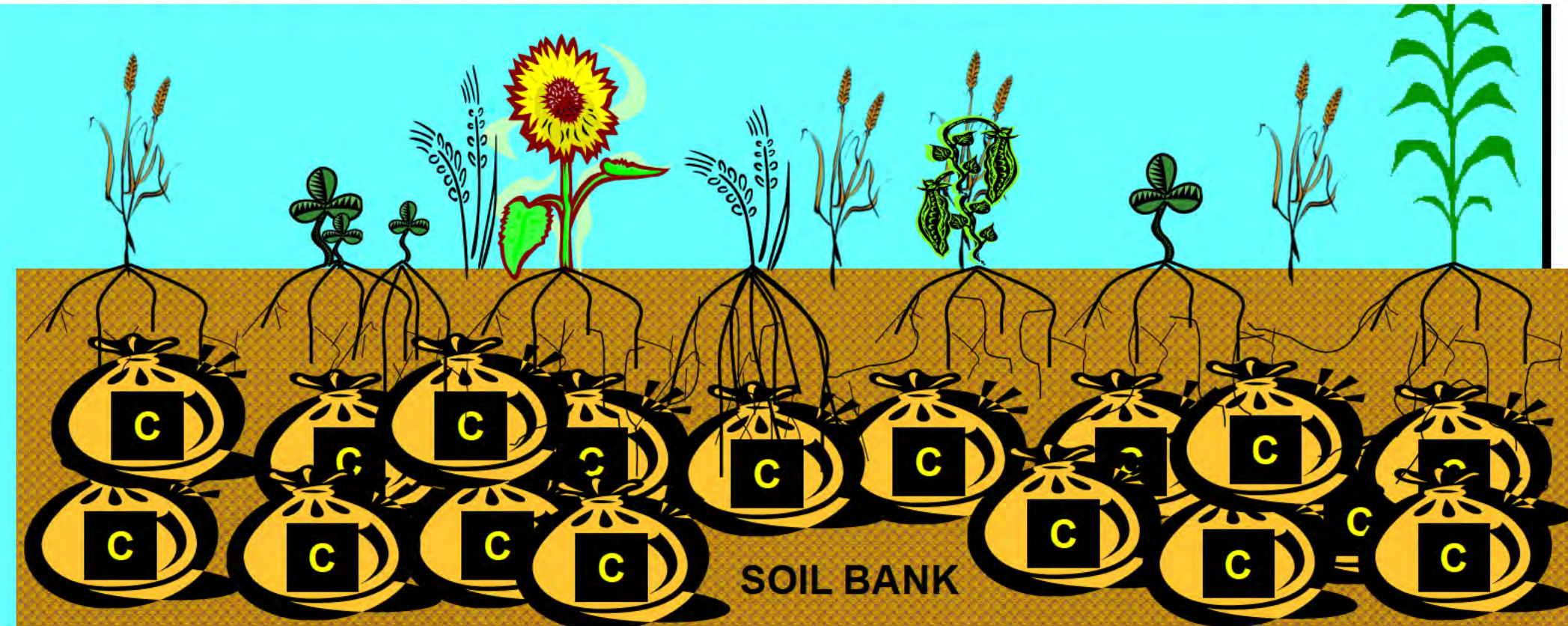
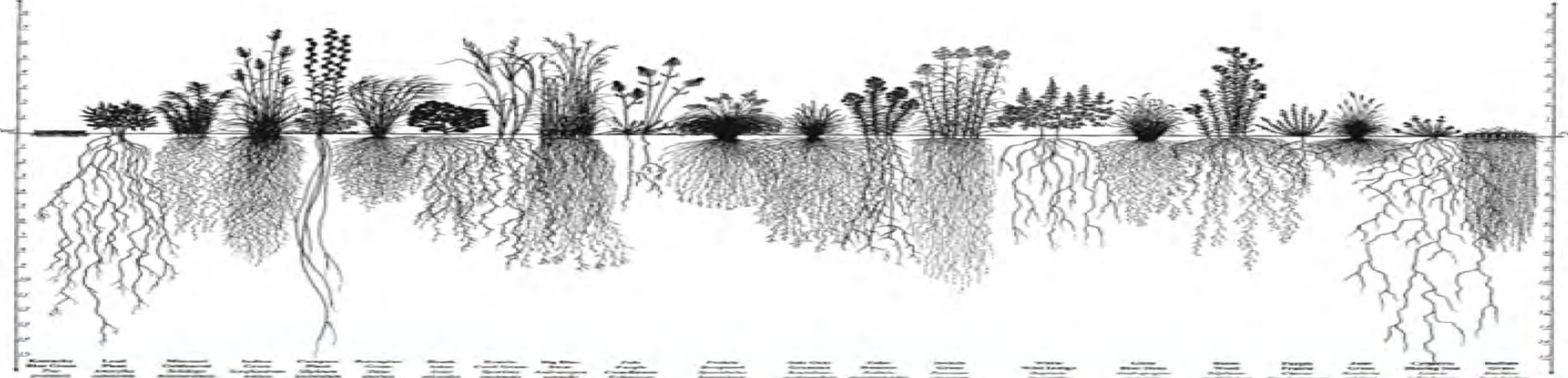
- Organic-mineral pools
- Microbially plant mediated process
- Strategic use of variable nutrients sources

# Shovel: A Tool to determine soil health



# A hierarchical approach to evaluating the significance of soil biodiversity to biogeochemical cycling

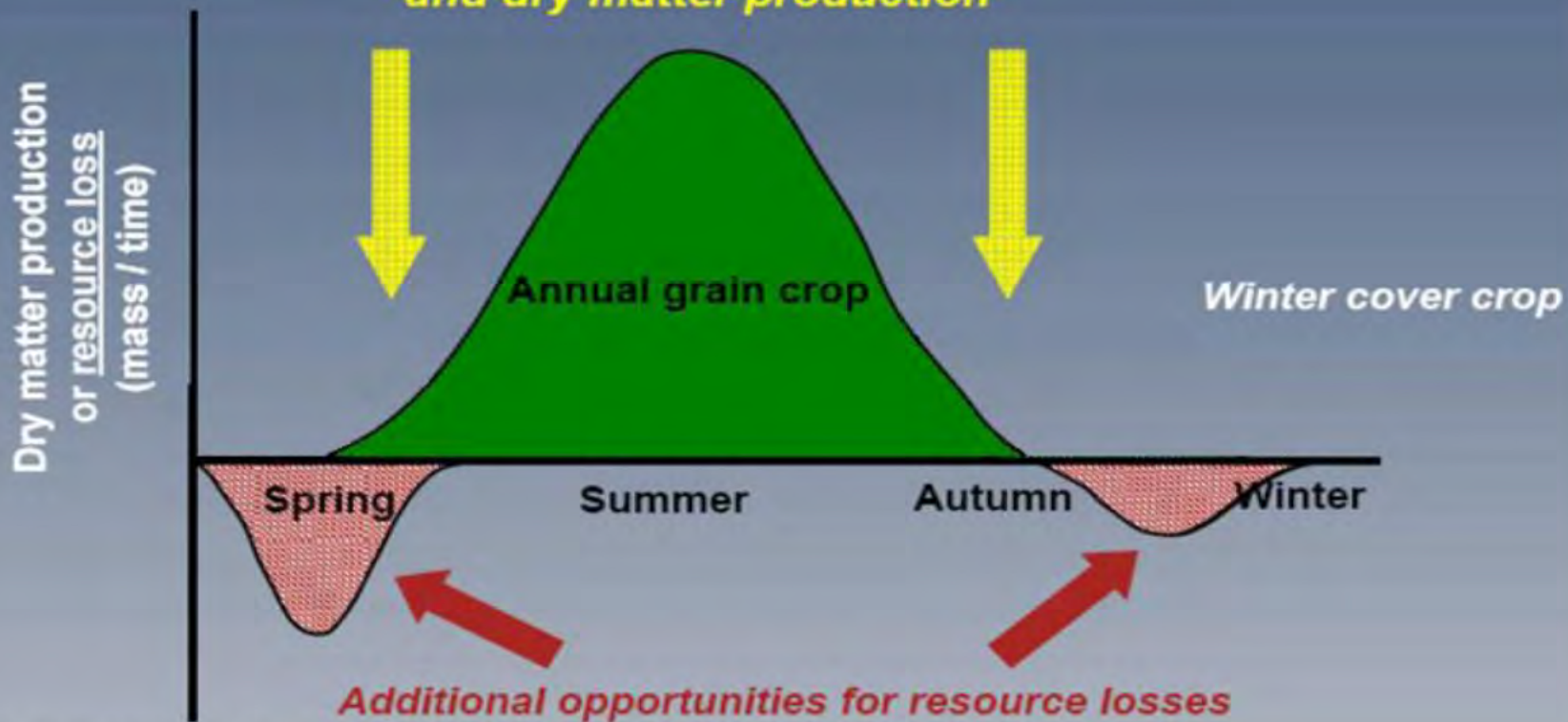




# Biomass Production Annual Cropping Systems



*Missed opportunities for resource assimilation  
and dry matter production*



after A.H. Heggenstaller

The Science of  
Conservation,  
We Deliver!

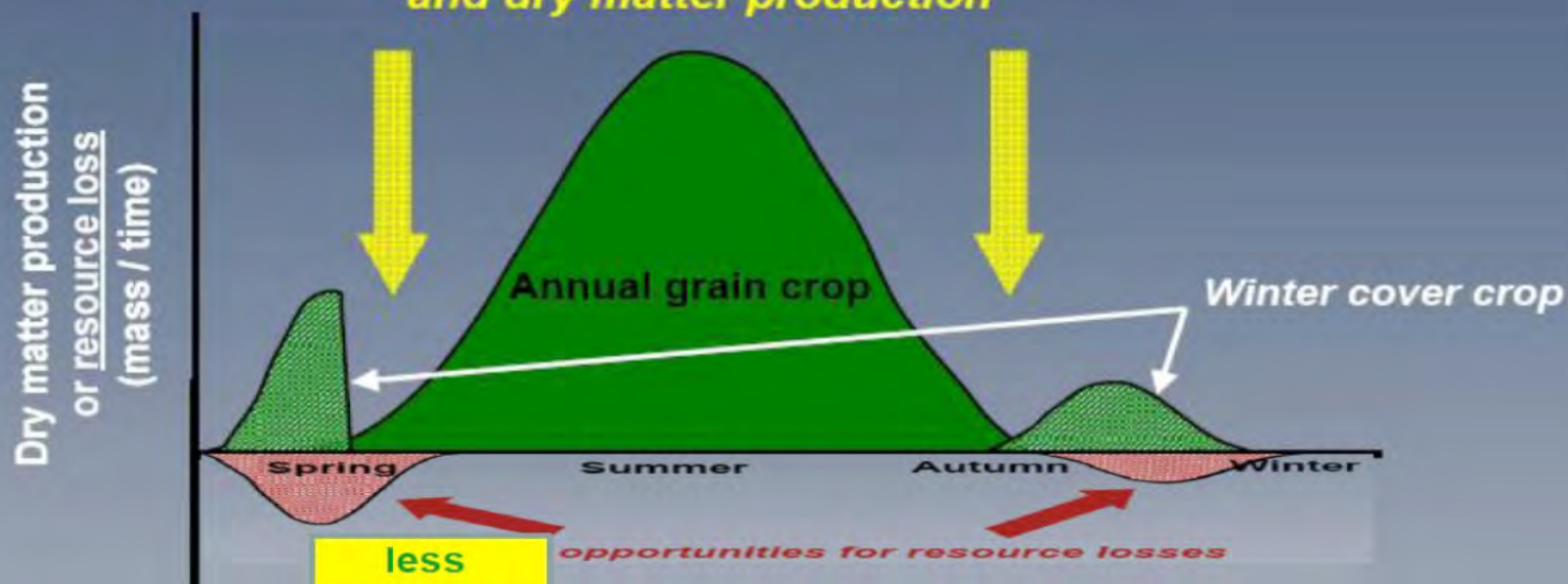
**NRCS**   
**East NTSC**

A. H. Heggenstaller, University of Alberta

# Biomass Production Annual Cropping Systems



**Cover crops** for resource assimilation  
and dry matter production



after A.H. Heggenstaller

The Science of  
Conservation,  
We Deliver!

**NRCS**  
East NTSC

A. H. Heggenstaller, University of Alberta



# Pacific Northwest: Air Quality

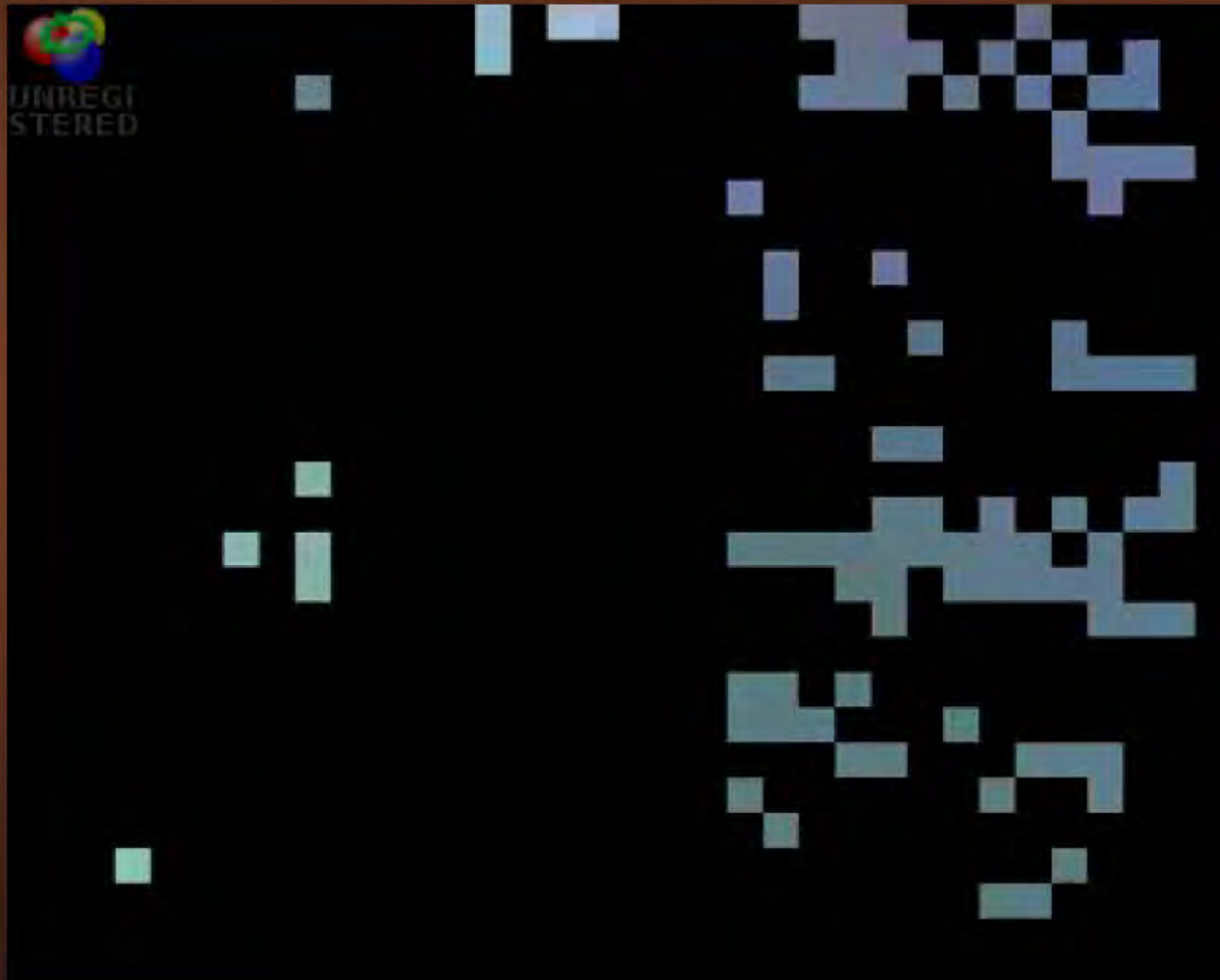


One major windstorm can generate enough airborne dust to exceed air quality standards for PM<sub>10</sub>," Sharratt says. "

Sept. 13 (60 days)



# *The root is a Leverage Point: Rhizoengineering*



## *Root Exudates:*

*Amino Acids*

*Organic Acids*

*Sugars*

*Vitamins*

*Purines/Nucleosides*

*Enzymes*

*Inorganic ions and Gaseous*

*Molecules*

West 1939, Fries and Forseman (1951),  
Gagnon and Ibrhaim (1998)

# Plants and Microbes Communicate

**TABLE 1.2**  
**Root Products: A Classification**

Product	Compound
Root exudates	
Diffusates	Sugars, organic acids/anions, amino acids, water, inorganic ions, oxygen, riboflavin etc.
Excretions	Carbon dioxide, bicarbonate ions, protons, electrons, ethylene, etc.
Secretions	Mucilage, protons, electrons, enzymes, siderophores, allelochemicals, etc.
Border cells	Root cap cells separated from the root apex
Root debris	Cell contents, lysates, etc.

*Source:* From Uren, N.C. and Reisenauer, H.M., *Adv. Plant Nutr.*, 3, 79, 1988. With permission.

# *Nature's residue managers*



# Giant Australian earthworm



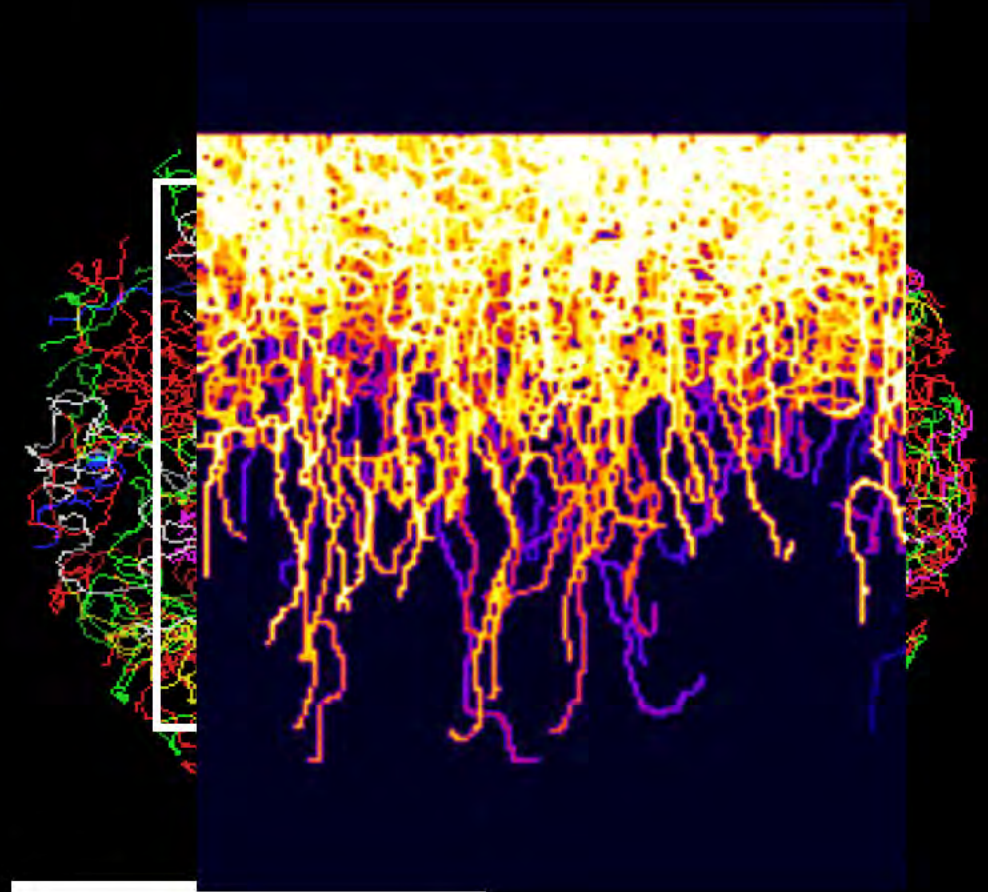
***Megascolides australis*** can get up to 11 feet !!

# Soil Engineers: Earthworms

## Subsoil macropores - Model of earthworm burrow systems



- 75 ind/m<sup>2</sup>
- 30% endogeic (Ø 2-3 mm)
  - 70% anecic (Ø 6 mm)
  - Ø core 212 cm





# Ohio 2012 Drought:

## Vertical Tillage



## No-till With Covers





# NM Desert Soil



What the heck did Archuleta get me into..  
Last time I am go to North Dakota with him...  
What am I going to do with all this material?







# John Pickler Planting Corn into cover crop Mix



# No-drill Plants into Residue

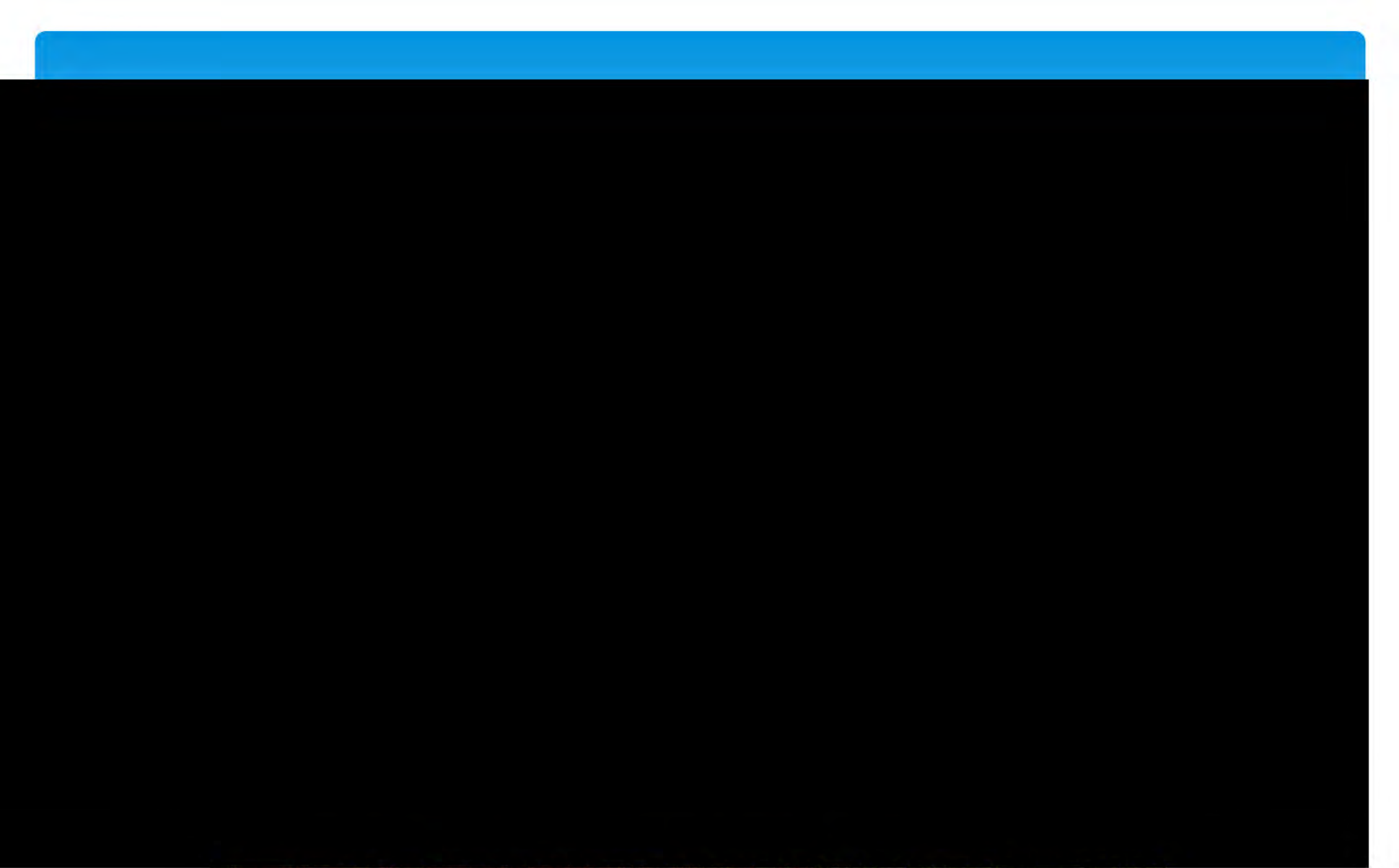






# The tale of two NC cotton Fields:







# The Answer is to Imitate Native Rangeland



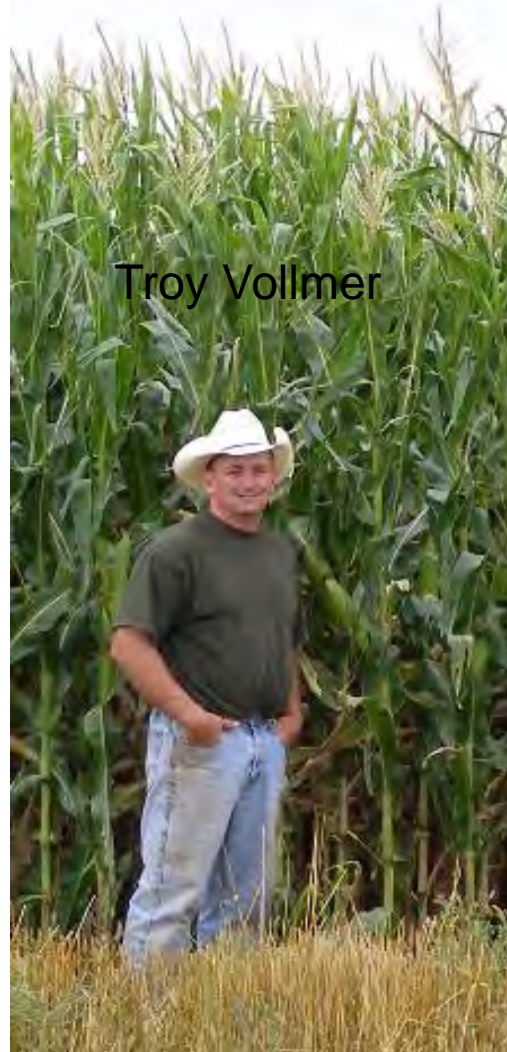
# Farmers Talking To Farmers About Soil Health



Marlyn Richter



Gabe Brown



Troy Vollmer



Linn Berg



Glenn Bauer

**Burleigh County  
Soil Conservation District**

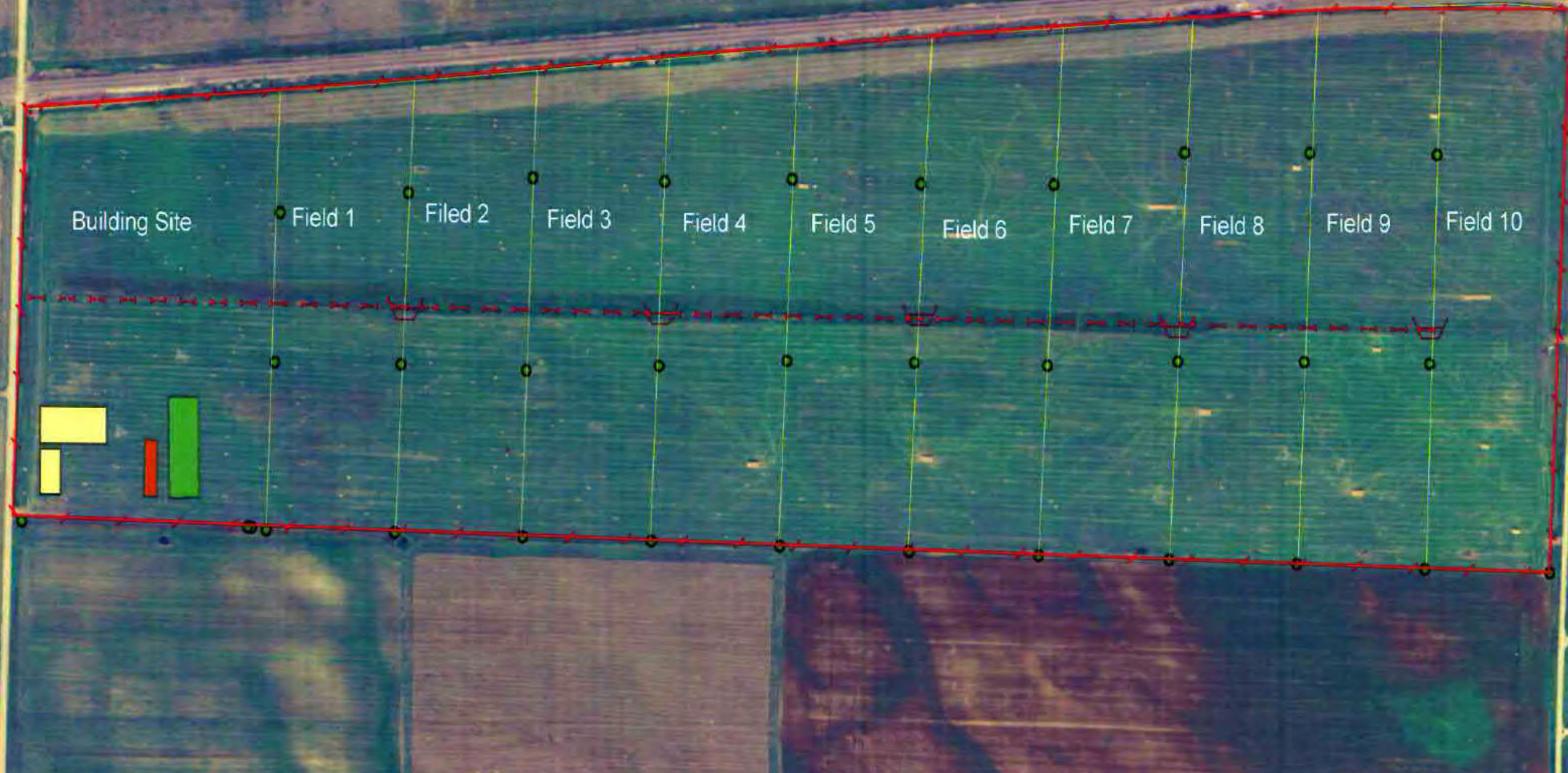
**ADVANCING SOIL HEALTH**

**—Menoken Farm—**

[www.bcscd.com](http://www.bcscd.com)

Established 2009

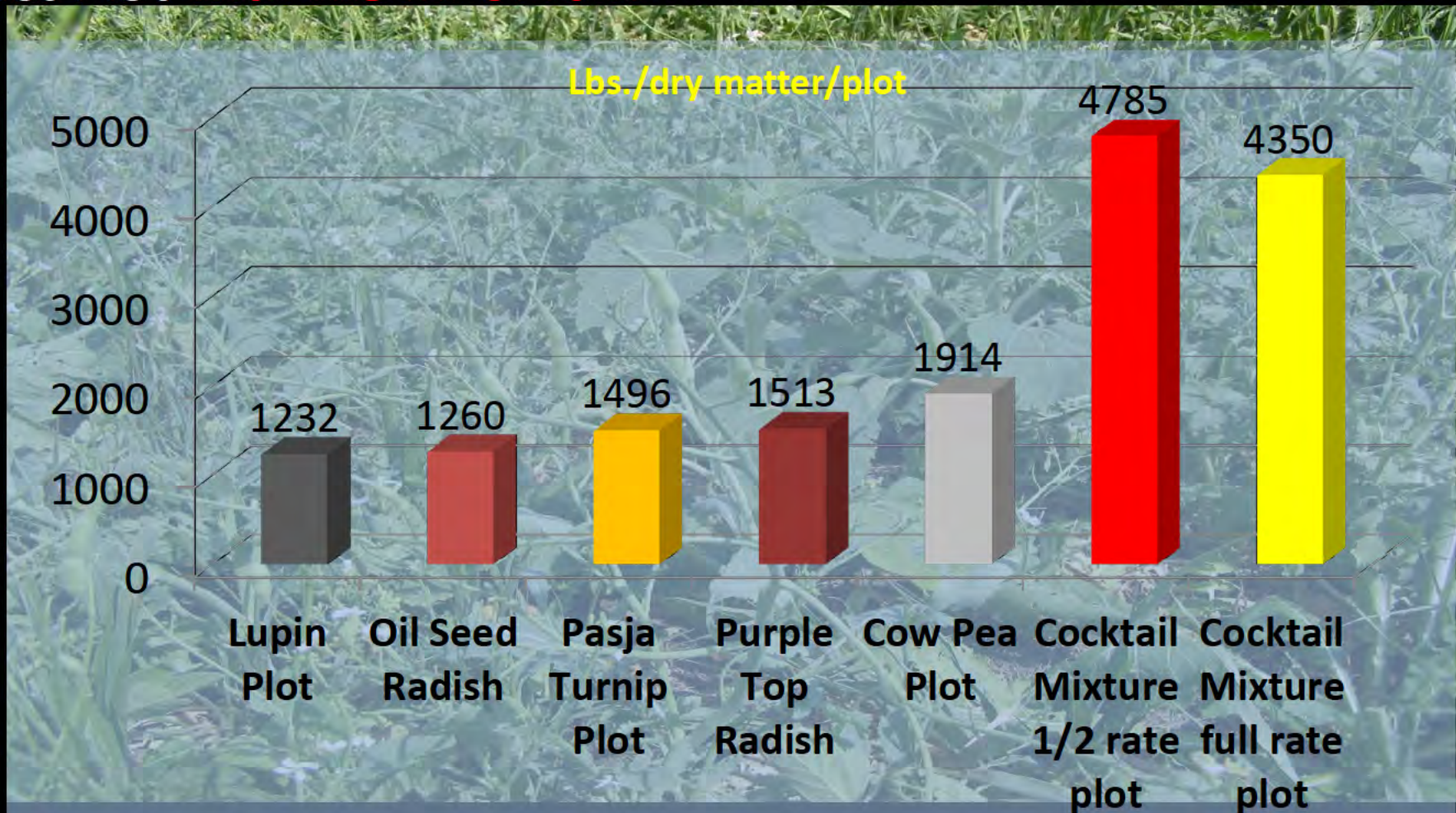
# Menoken Farm





Utilize energy efficiently- understand the power of diversity: Collaboration is more apparent than

Competition: ND case study: 2006 Production On Burleigh District Plot with 1.8 in. of rain



# Turnip July 31



# Oilseed Radish July 31



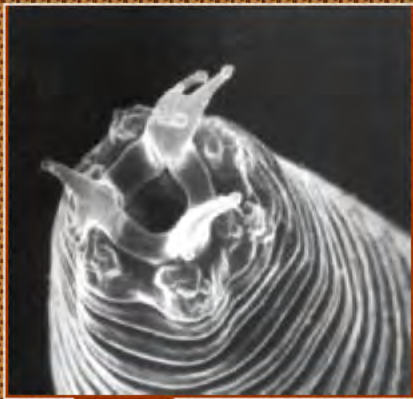
# Cocktail July 31



# *Diversity conduit for energy and nutrients.*



Soil Surface



# September 4, 2009

## No Commercial Fertilizer



- Sunflower 1 lb
- Soybean 15 lbs
- Cowpea 10 lbs
- Turnip 1 lb
- Radish 2 lbs
- Proso Millet 4 lbs
- Pearl Millet 4 lbs
- Sweet Clover 1 lb

# Planting Corn Into Last Year's Cover Crop Residue

May 20, 2010



## **West Side**

No Commercial Fertilizer

No Compost

No Compost Tea

122.3 Bushels per Acre

## **East Side**

No Commercial Fertilizer

1-2 Ton of Compost

2 Compost Tea Applications

128.8 Bushels per Acre

# **The Menoken Farm**

**Power of Crop Diversity**

**Both Sides were Planted into Last Year's Cover Crop Residue**

2006 – 2010 Burleigh County FSA Committee Reasonable  
Yield Established by Year = 100 Bushels per Acre



Tundra?



# Hail



Brown's Ranch  
Home of Sustainable Ranching  
[www.sustainable ranching.com](http://www.sustainable ranching.com)



# Cool Season Cocktail



# Cowpea/Proso Millet/Buckwheat





**Phacelia and Native Pollinator**

Mob Grazing 2010  
Before



# Eggmobile





# Layers enjoying the cover crop



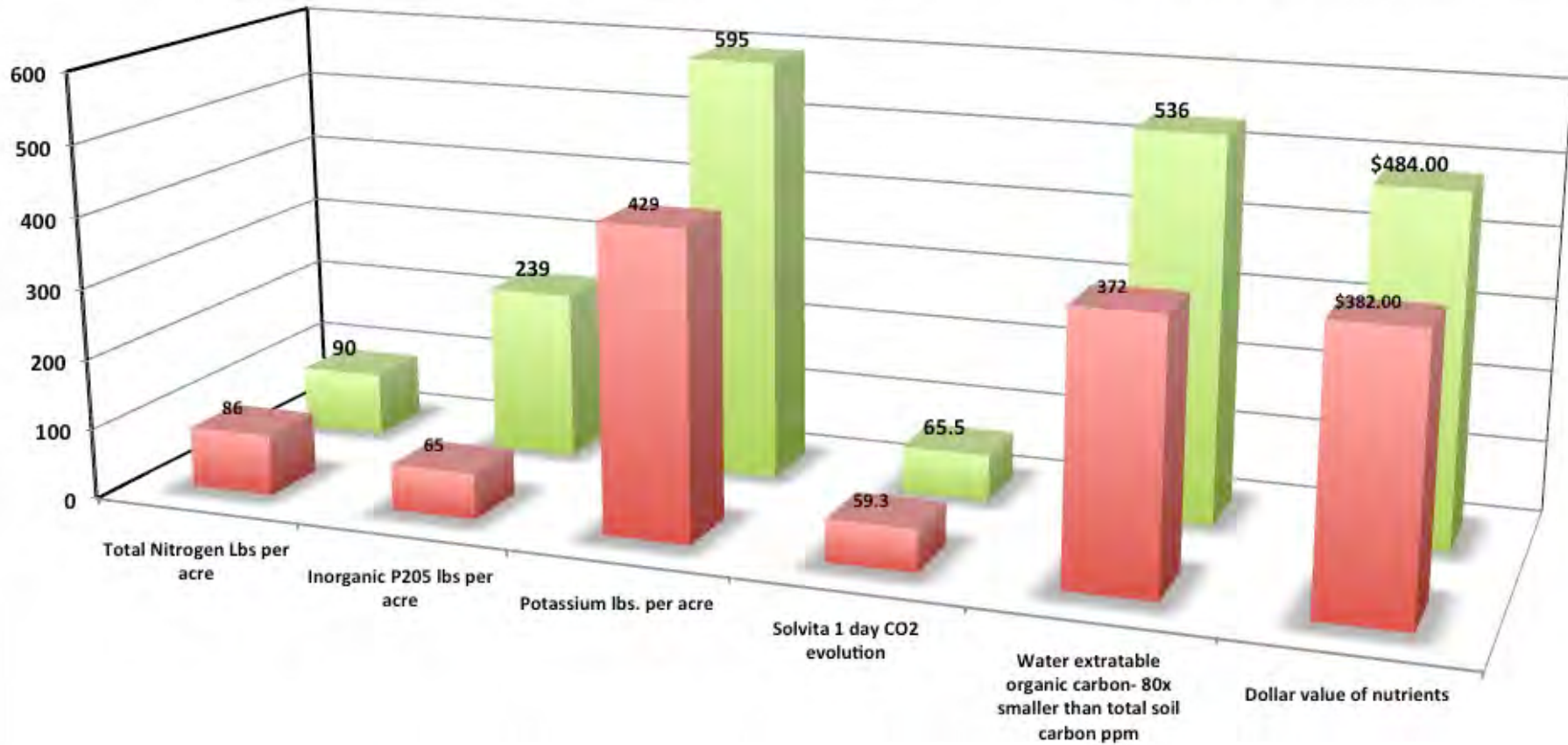
# Sheep



# Tale of Two Fields



## Gabe Brown's Soil Samples: Zero-till versus Holistic Soil Healthy System (Zero-till)



■ Zero-till East Field- ( Since 1983) First 10 years Monoculture Alfalfa/ withsome diversity

■ Zero-till West Field- (Since 1993)- Diverse Rotations/Multi-Species covers With Mob Grazing

Dr. Rick Haney ARS, USDA

# 2011 Corn

Yield 159 bushels per acre

Price \$6.48

- \* Gross Income \$1030.32 per acre
  
- \* Expenses:
  - \* Seed \$64.05
  - \* Herbicide 12.50
  - \* Crop ins. 17.94
  - \* Planting 18.00
  - \* Combining 22.00
  - \* Trucking 24.40
  - \* Storage 15.90
  
- \* Total \$174.79 (excluding land cost)
  
- \* Return to labor, management and land cost \$855.53 per acre
  
- \* (This does not include income  
\* from Direct payments, CSP and  
\* winter grazing.)
  
- \* Cost per bushel of corn **\$1.10** (excluding land cost)
  
- \* Return to labor, management and land per bushel \$5.38



## Diversity attracts Diversity

Ringneck Pheasant, Sharptail Grouse, Hungarian Partridge,  
Canada Geese,  
Duck, Whitetail Deer, Song Bird, Raptors, Mink, Weasel,  
Raccoons, Coyote, Fox and more

# 4 years of applied grazing system



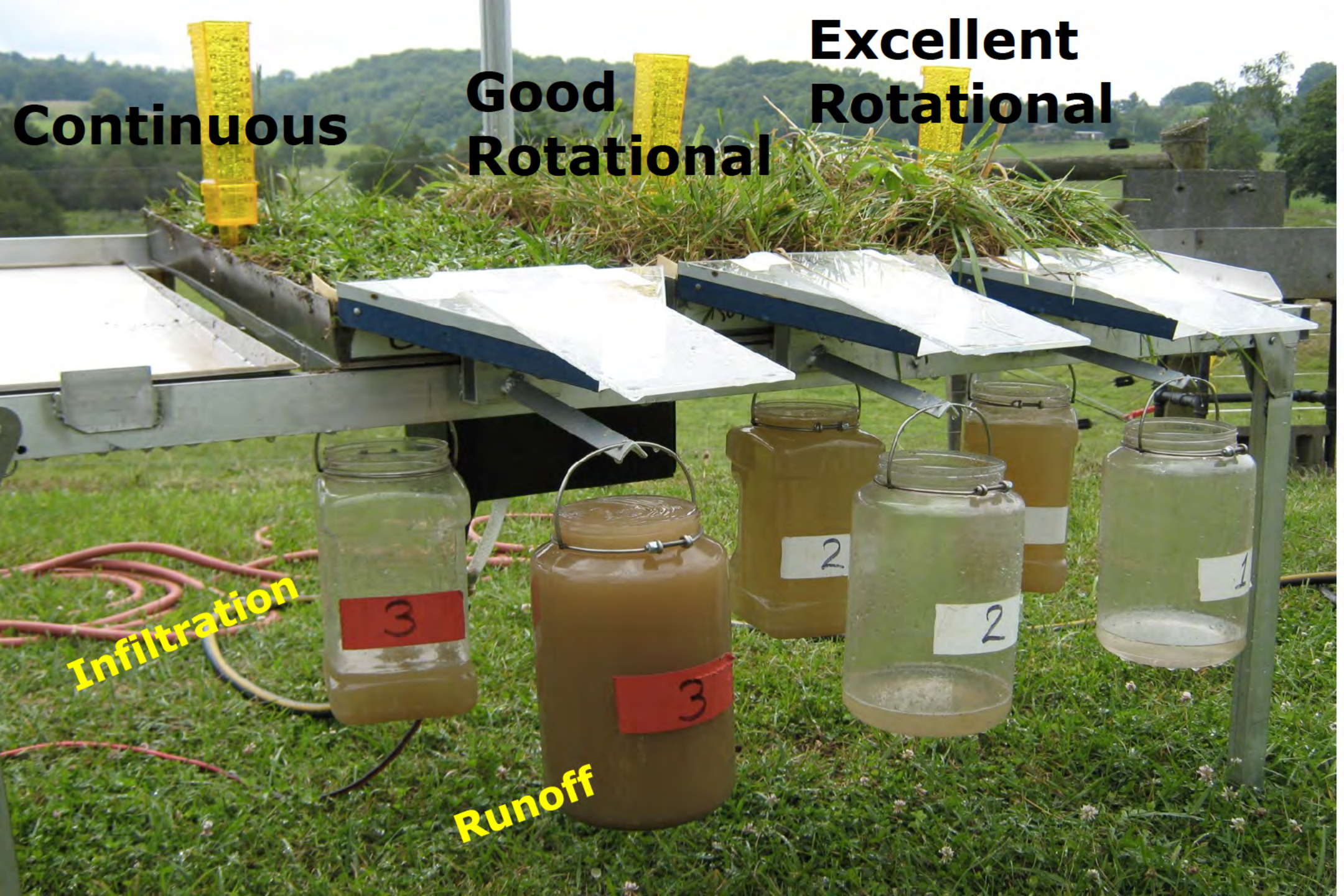
**Continuous**

**Good  
Rotational**

**Excellent  
Rotational**

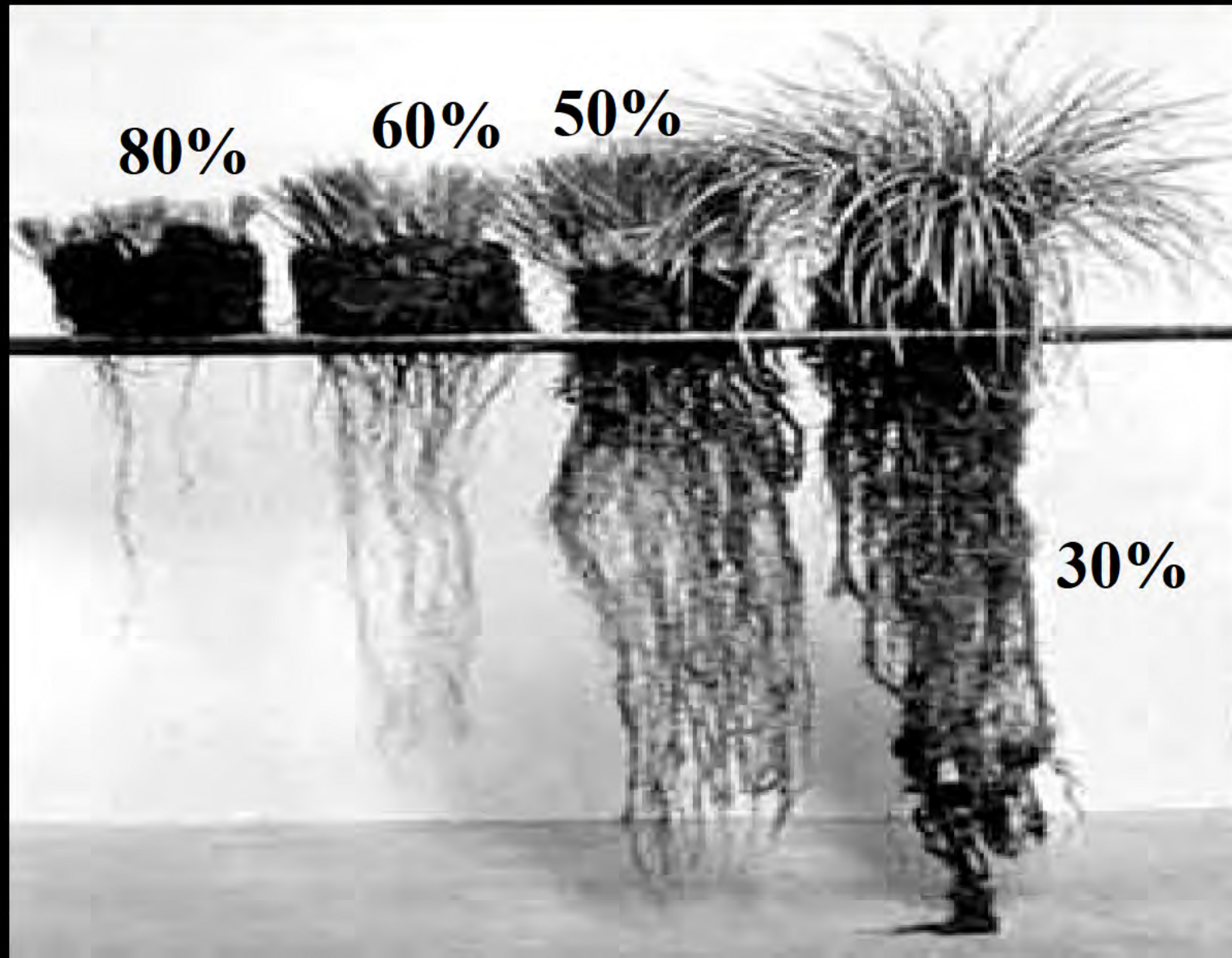
**Infiltration**

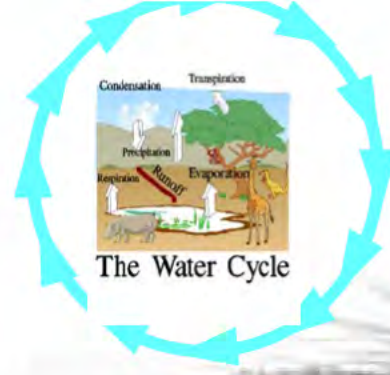
**Runoff**





# ***Overgrazing: another source of disturbance***

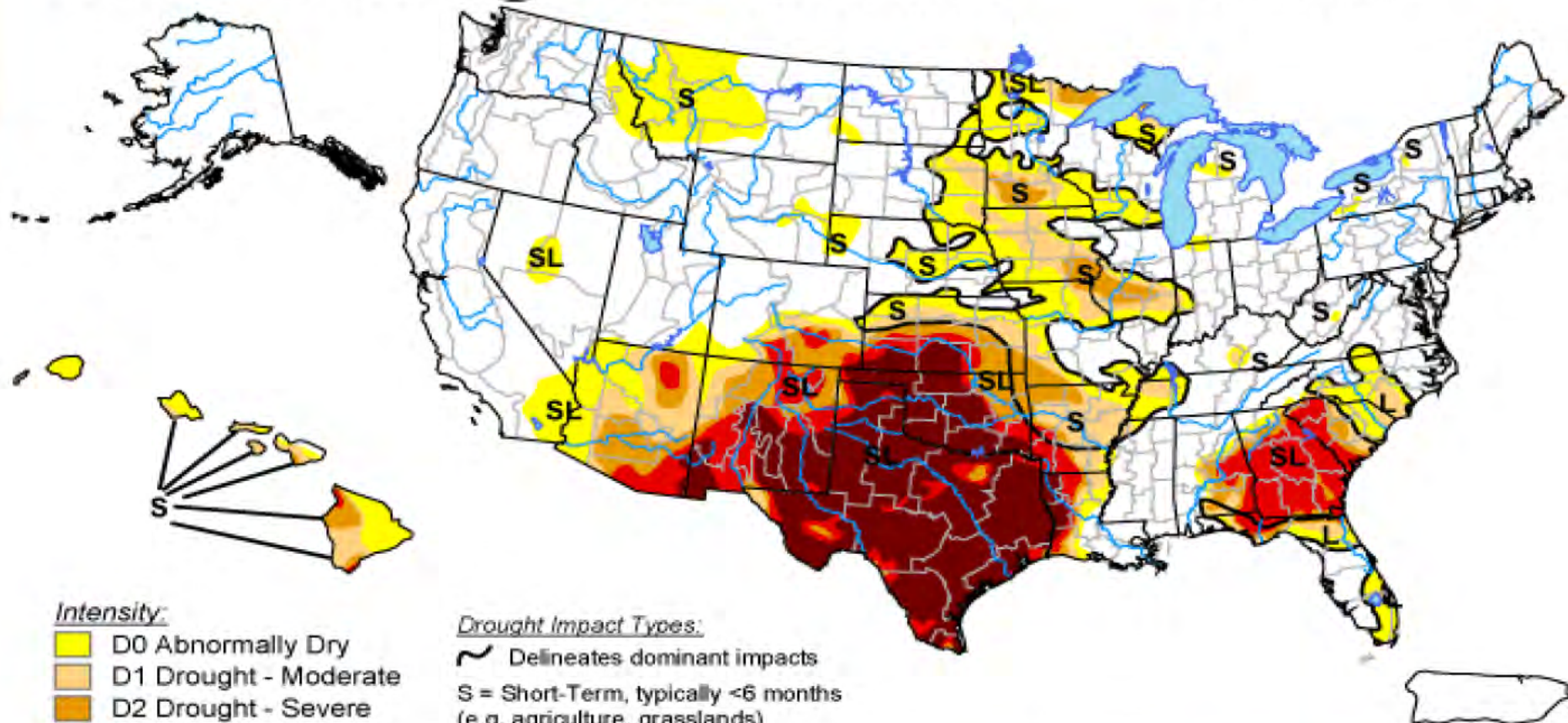









# U.S. Drought Monitor

October 4, 2011


Valid 8 a.m. EDT



## Intensity:

-  D0 Abnormally Dry
-  D1 Drought - Moderate
-  D2 Drought - Severe
-  D3 Drought - Extreme
-  D4 Drought - Exceptional

## Drought Impact Types:

-  Delineates dominant impacts
- S = Short-Term, typically <6 months  
(e.g. agriculture, grasslands)
- L = Long-Term, typically >6 months  
(e.g. hydrology, ecology)

*The Drought Monitor focuses on broad-scale conditions.  
Local conditions may vary. See accompanying text summary  
for forecast statements.*

<http://droughtmonitor.unl.edu/>



**Released Thursday, October 6, 2011**

**Author: Rich Tinker, CPC/NCEP/NWS/NOAA**



# Weed and Brush Control

Smooth Sumac in St. Clair County





Neighbor's Pastures

2011 Drought

Mark Brownlee's Pastures



# 2012 Drought: St. Clair County





# Results





## Wal-Mart to Buy More Local Produce

As Wal-Mart is doing with consumer products, it will begin asking agricultural producers questions about water, fertilizer and chemical use. The eventual goal is to include that information in a sustainability index.

Customers would see sustainability ratings, so they could decide whether to choose one avocado over another based on how efficiently it was grown and shipped. Wal-Mart could use index information when it decided from whom to buy.

# Soil Health Conference: Farming like Nature: "The Supreme Farmer"!



# In The African Sahel: Trees Stop Sahara Desert



Bruce Wight NRCS National Forester ( E&E News July 2012)

# Healthy Profits From Healthy Soils

