NRCS Natural Resources Conservation Service

NRCS-ENTSC National Soil Quality team

- Ray Archuleta

Conservation Agronomist

NRCS-ENTSC

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Greensboro NC 27313

336-370-3360

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Keys to the kingdom of improving soil health

- **Understand your context**

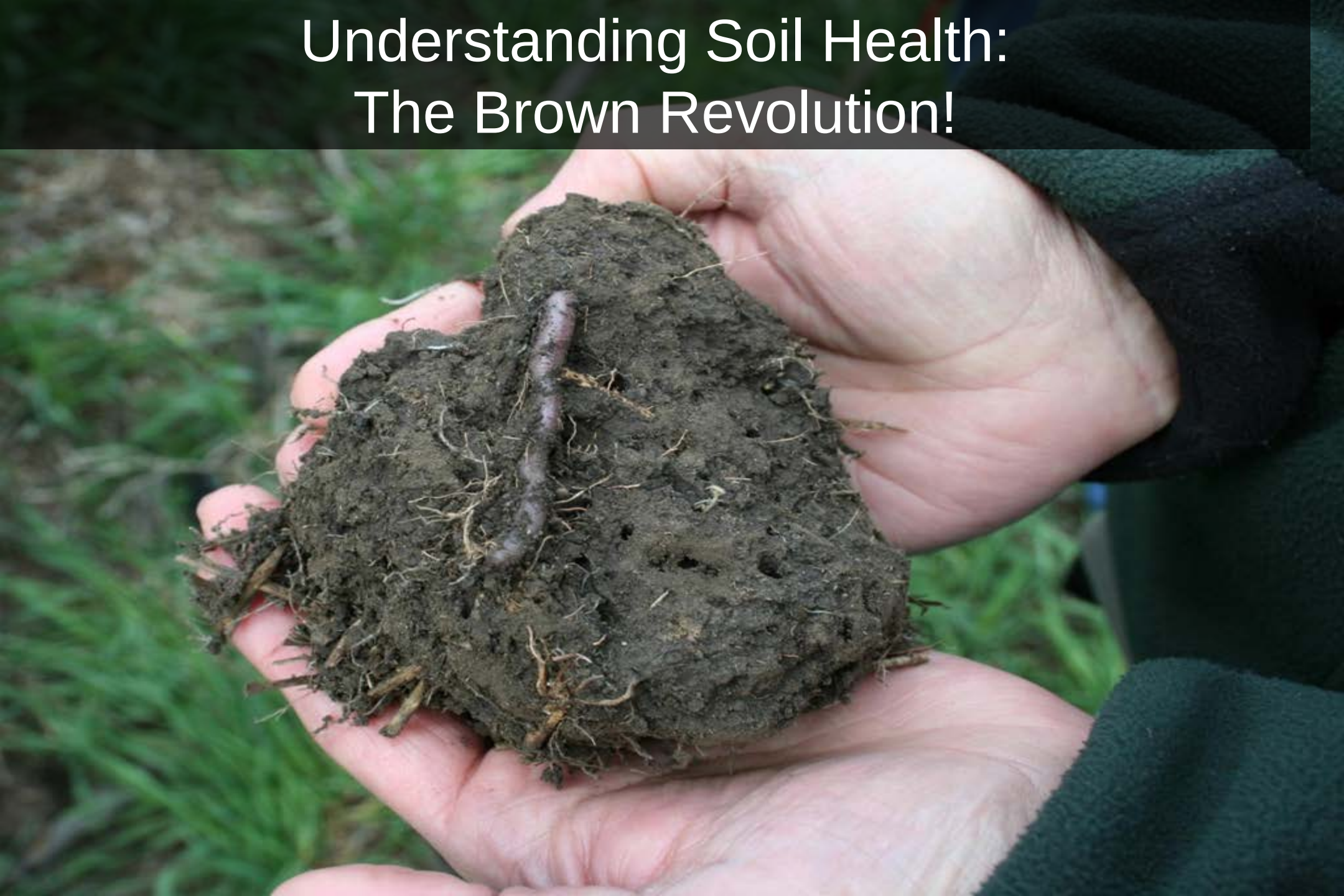
- **Protect the Soil Habitat**

  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

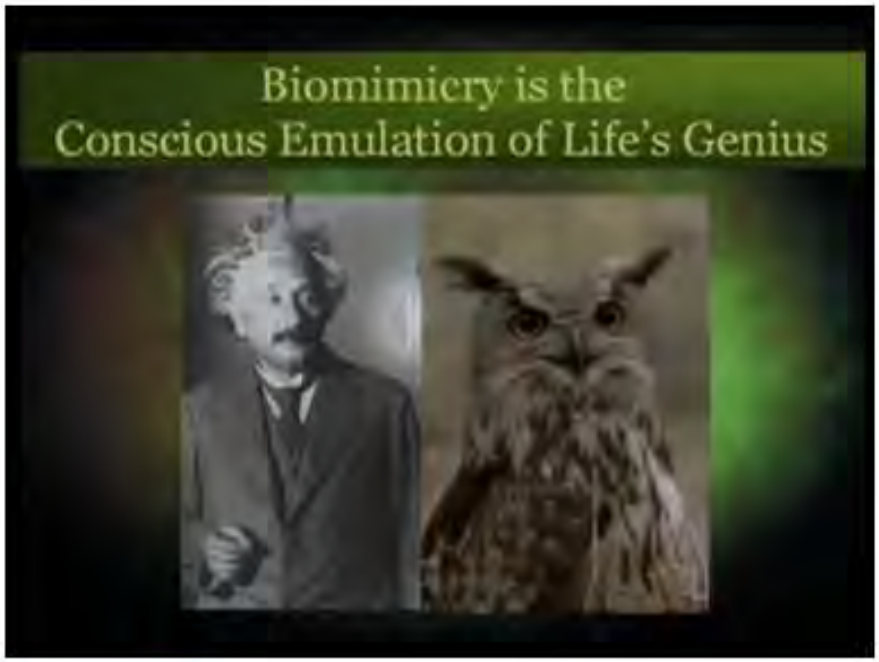
Janine Benyus shares nature's designs

TED2005, **Filmed** Feb 2005; **Posted** Apr 2007

TALKS

Janine Benyus shares nature's designs

TED2005, **Filmed** Feb 2005; **Posted** Apr 2007



06:57 | 23:16 Share Rate

Subtitles Available in: 21 languages [Off]

Interactive transcript

TALKS

Janine Benyus shares nature's designs

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10:13 | 23:16 Share Rate

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TALKS

Janine Benyus shares nature's designs

TED2005, Filmed Feb 2005; Posted Apr 2007

14:44 | 23:16 Share Rate

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TALKS

Janine Benyus shares nature's designs

TED2005, **Filmed** Feb 2005; **Posted** Apr 2007

16:00 | 23:16 Share Rate

Subtitles Available in: 21 languages [Off]

Interactive transcript

TALKS

Janine Benyus shares nature's designs

TED2005, **Filmed** Feb 2005; **Posted** Apr 2007

21:56 | 23:16 Share Rate

Subtitles Available in: 21 languages [Off] Interactive transcript

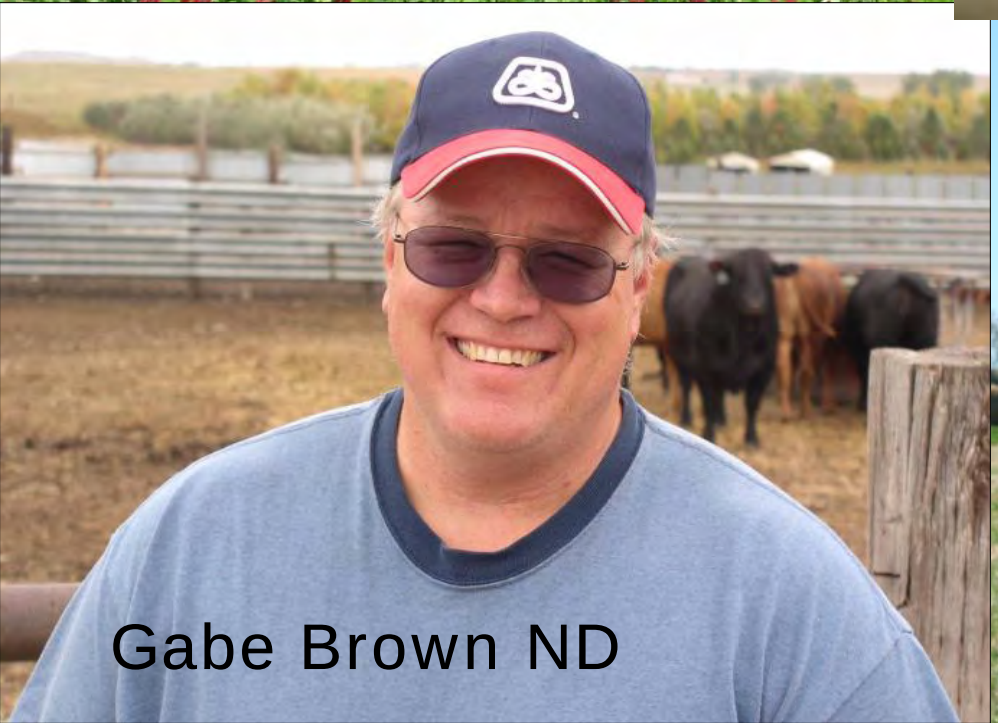
SOIL QUALITY/HEALTH is

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

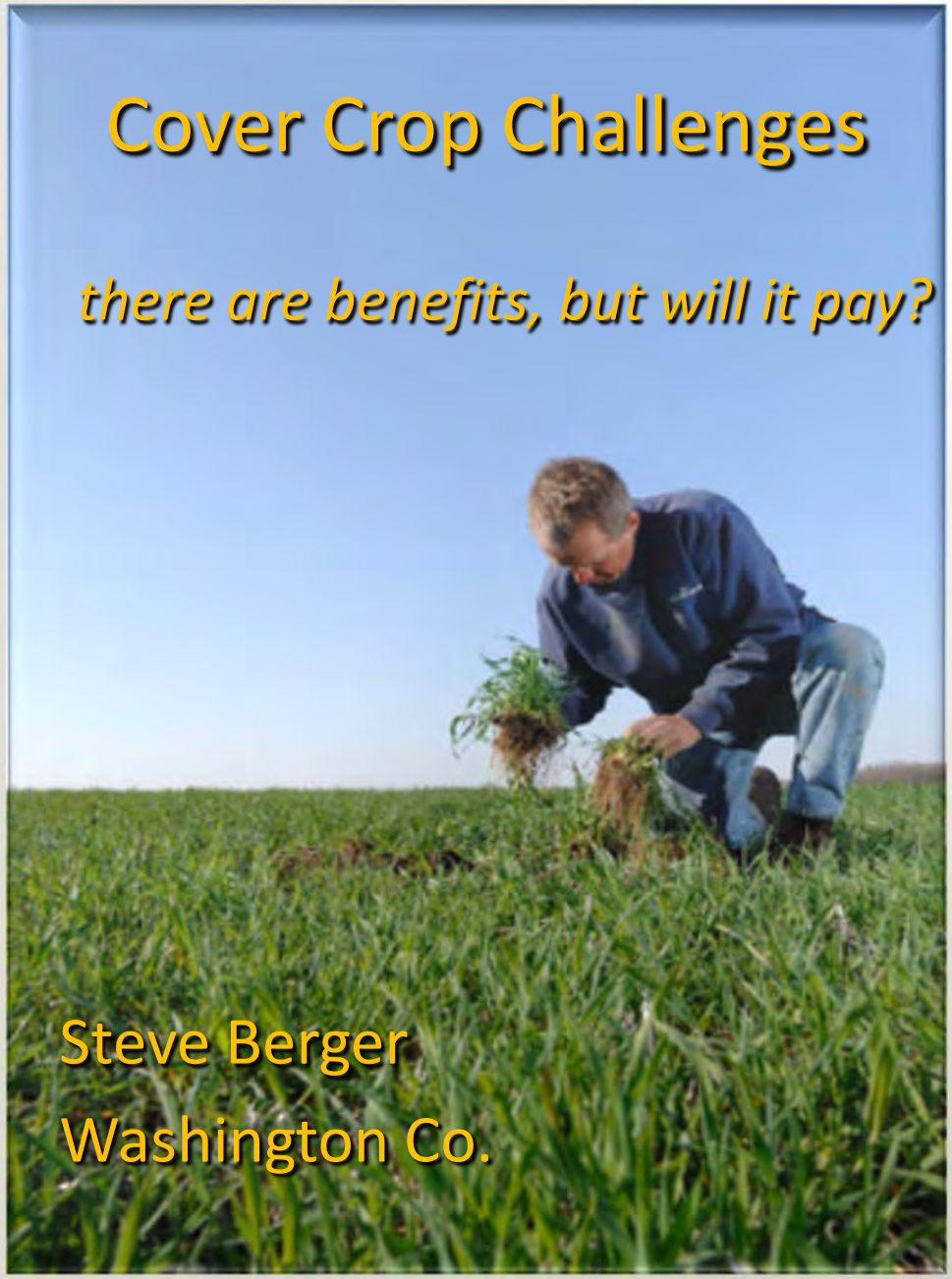

ROCKEY FARMS
SPECIALTY POTATOES
Est. 1938
Rocky
Brandon CO


Gabe Brown ND


Ray McCormick IN

Cover Crop Challenges

there are benefits, but will it pay?



Steve Berger

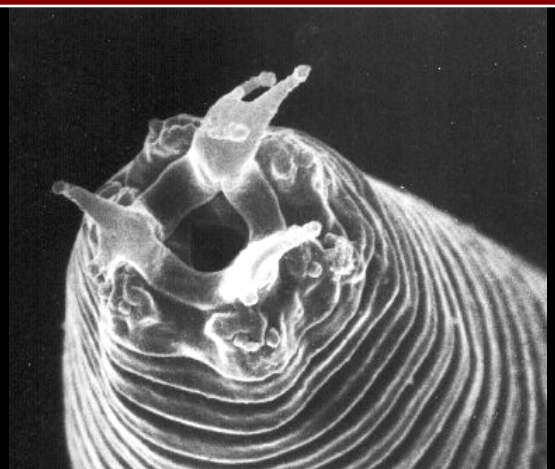
Washington Co.

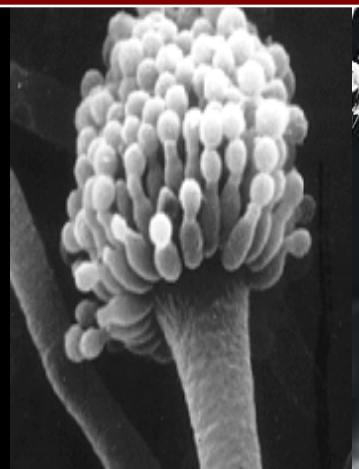
Ecology:

the study of relationships between people, animals, and plants, and their environment.

Interconnectedness

Soil Surface

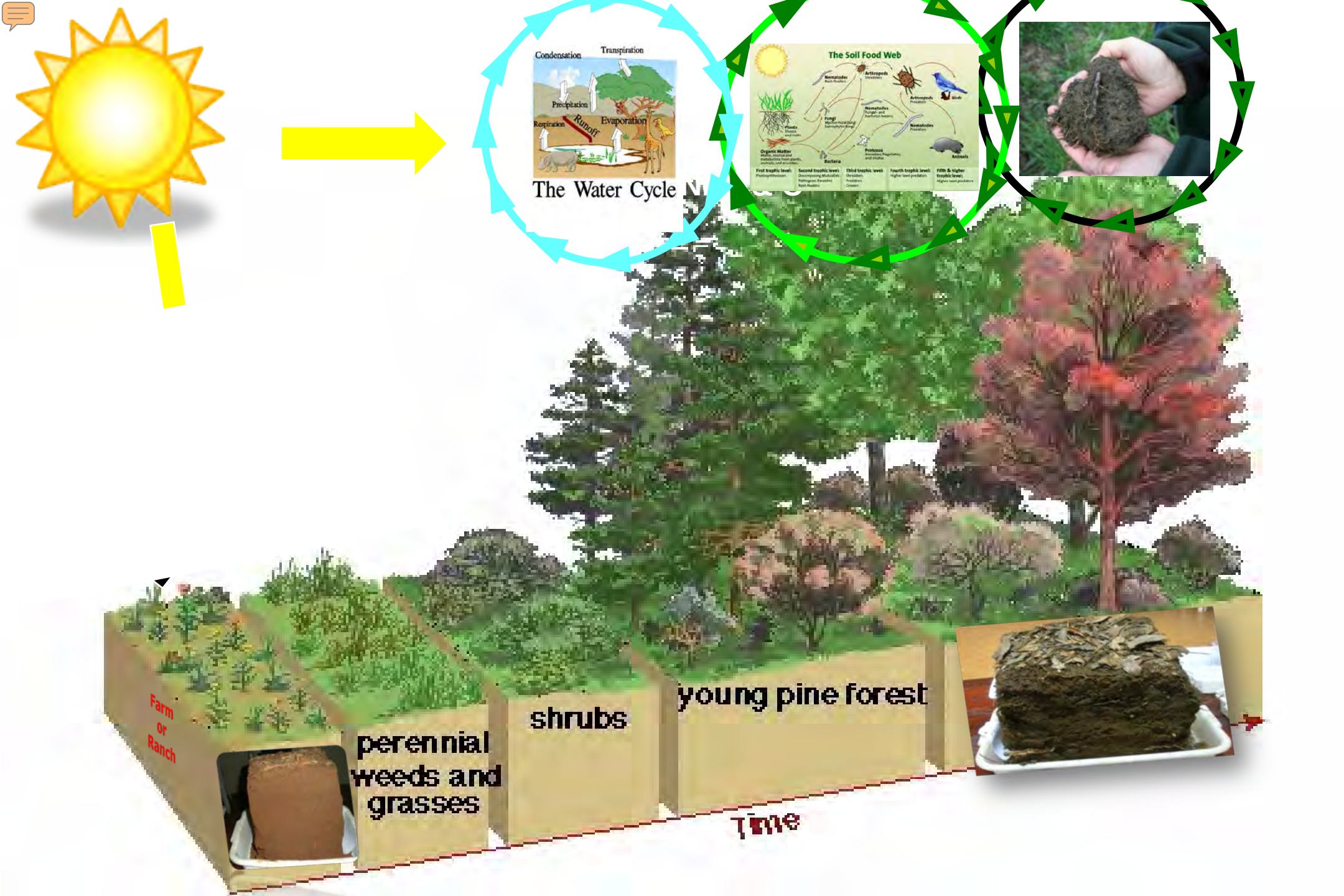




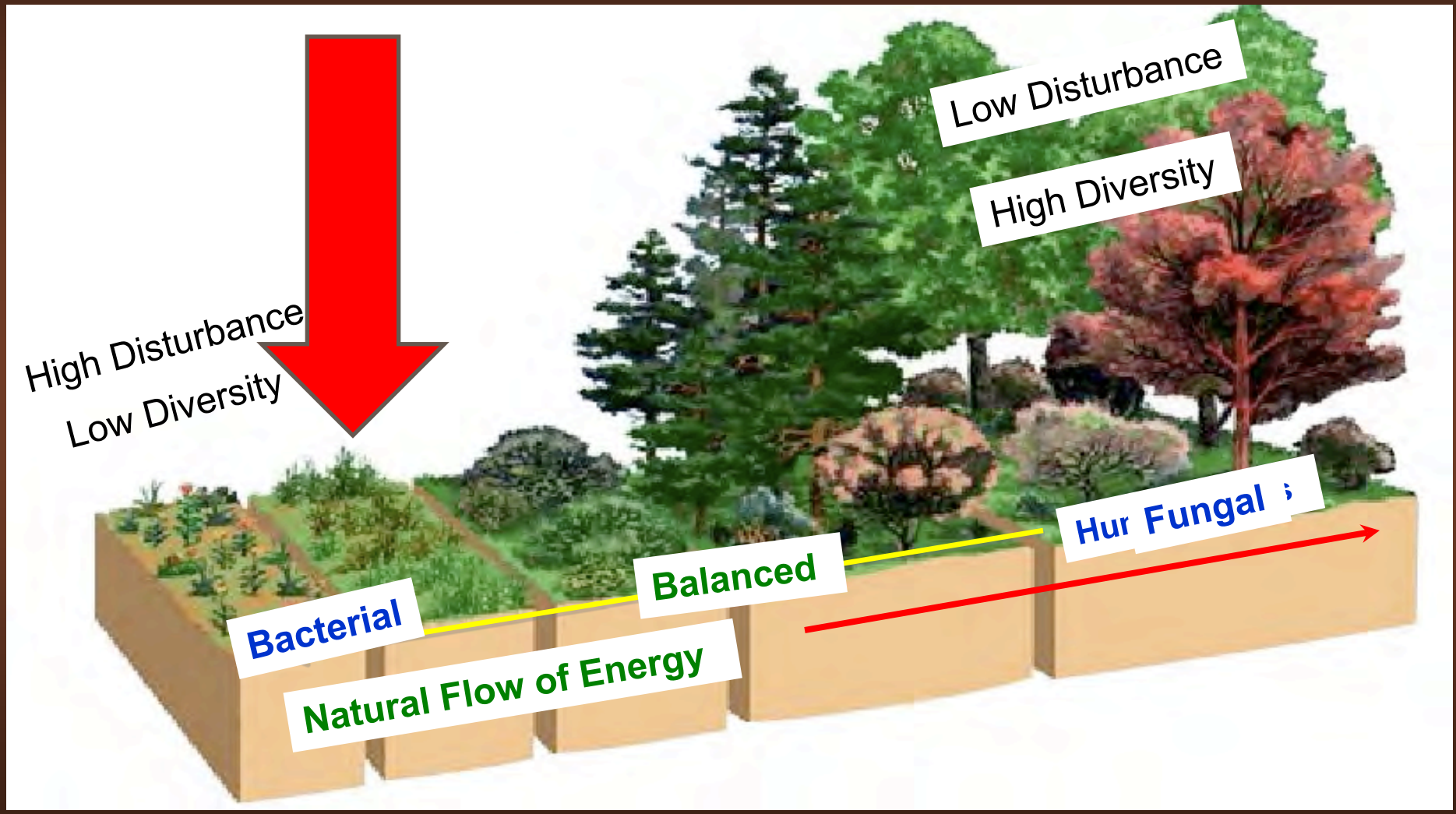
Focus On Nature's Similarities then Dissimilarities

Africa →

← Virginia


Condensation
Transpiration
Precipitation
Respiration
Runoff
Evaporation
The Water Cycle
The Soil Food Web
Farm or Ranch
perennial weeds and grasses
shrubs
young pine forest
Time

Natural Succession of Plants & Soil




Disrupted Soil Ecosystem
This soil is naked, hungry, thirsty and running a fever!
Ray Archuleta 2007

North towards New Jersey: 2008

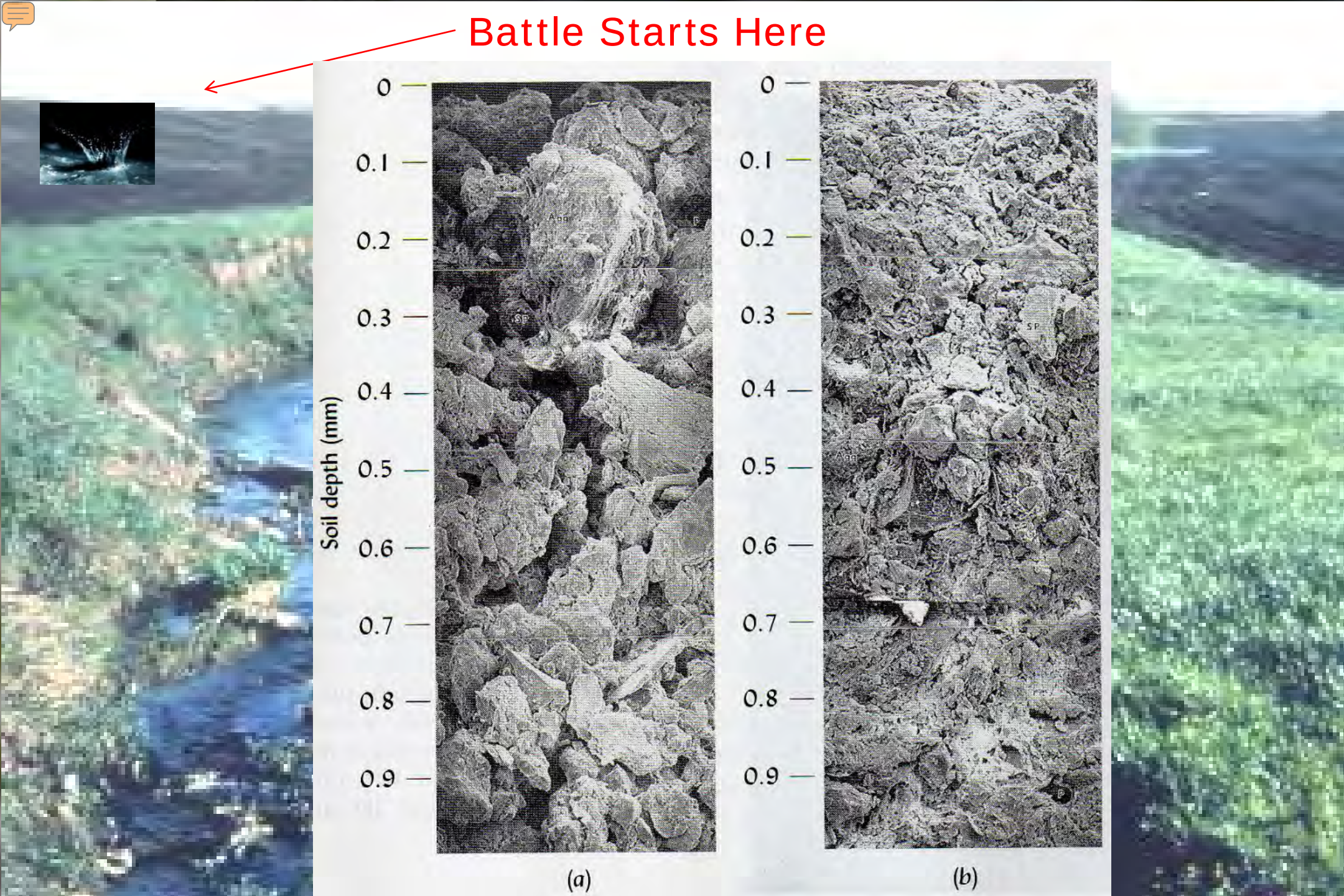

Erosion from bare fields
5/2007


Australia


Is the Buffer working? 6
/2007

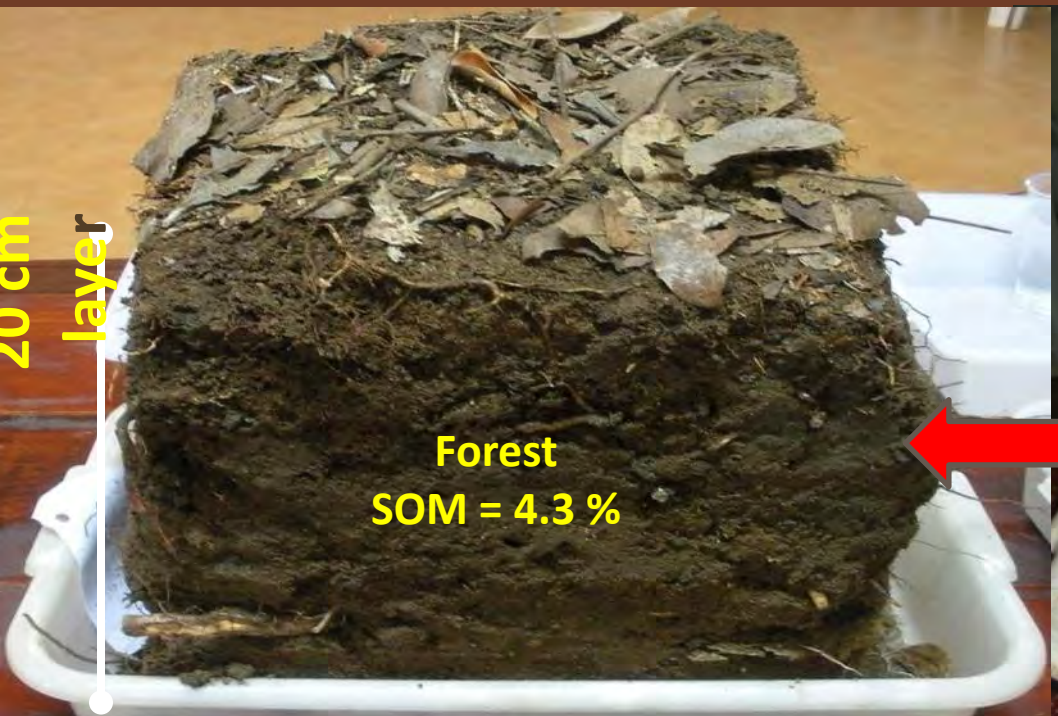

Lubbock Texas Oct.
17,2011

Battle Starts Here

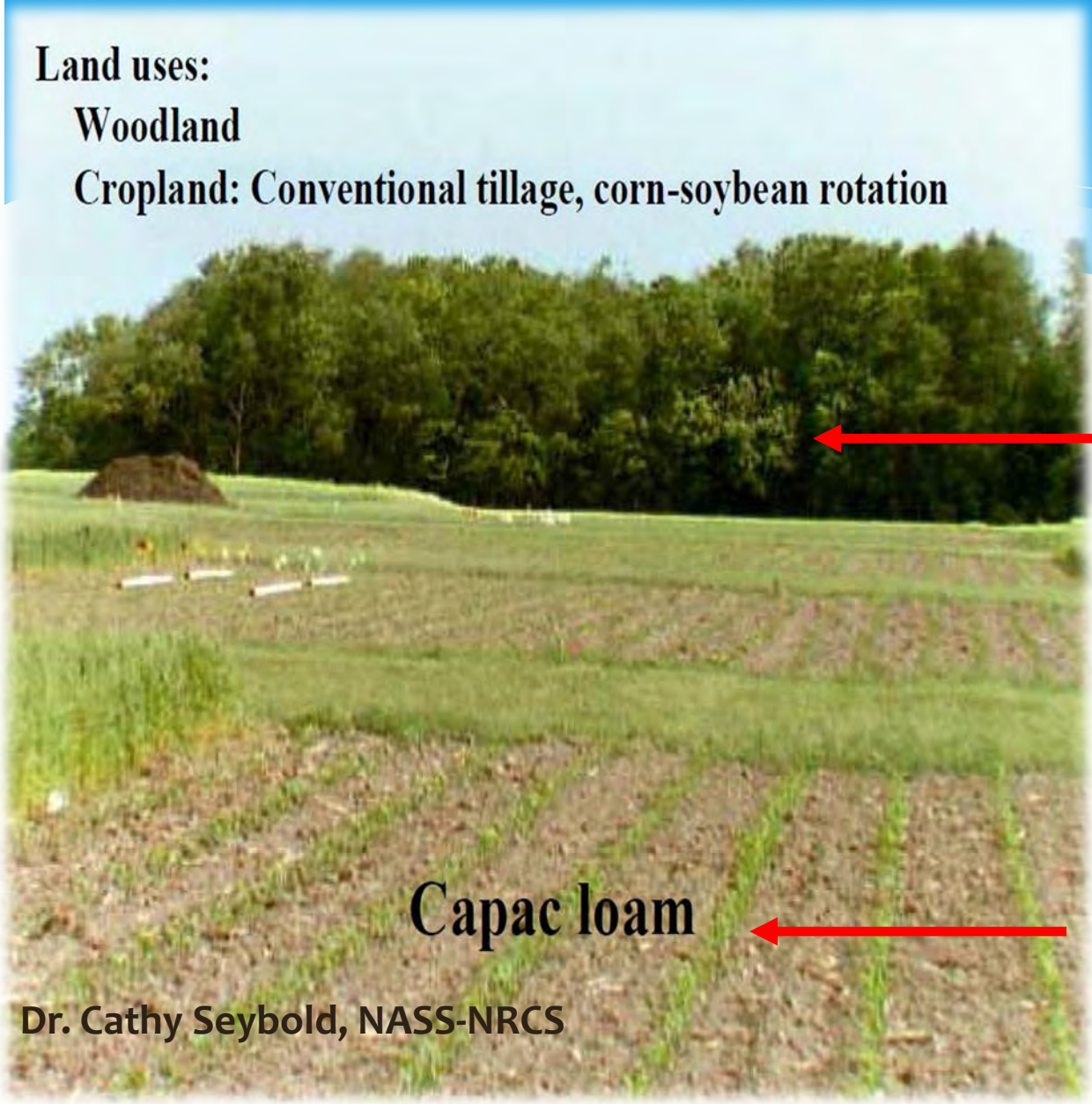


Same Soils: Dynamic Soil Properties Changed!

62.8% loss of SOM after 17 yr intensive tillage



Study: Use-dependent Soil Properties



Wooded Soil: Bulk Density- 1.01 g/cm^3

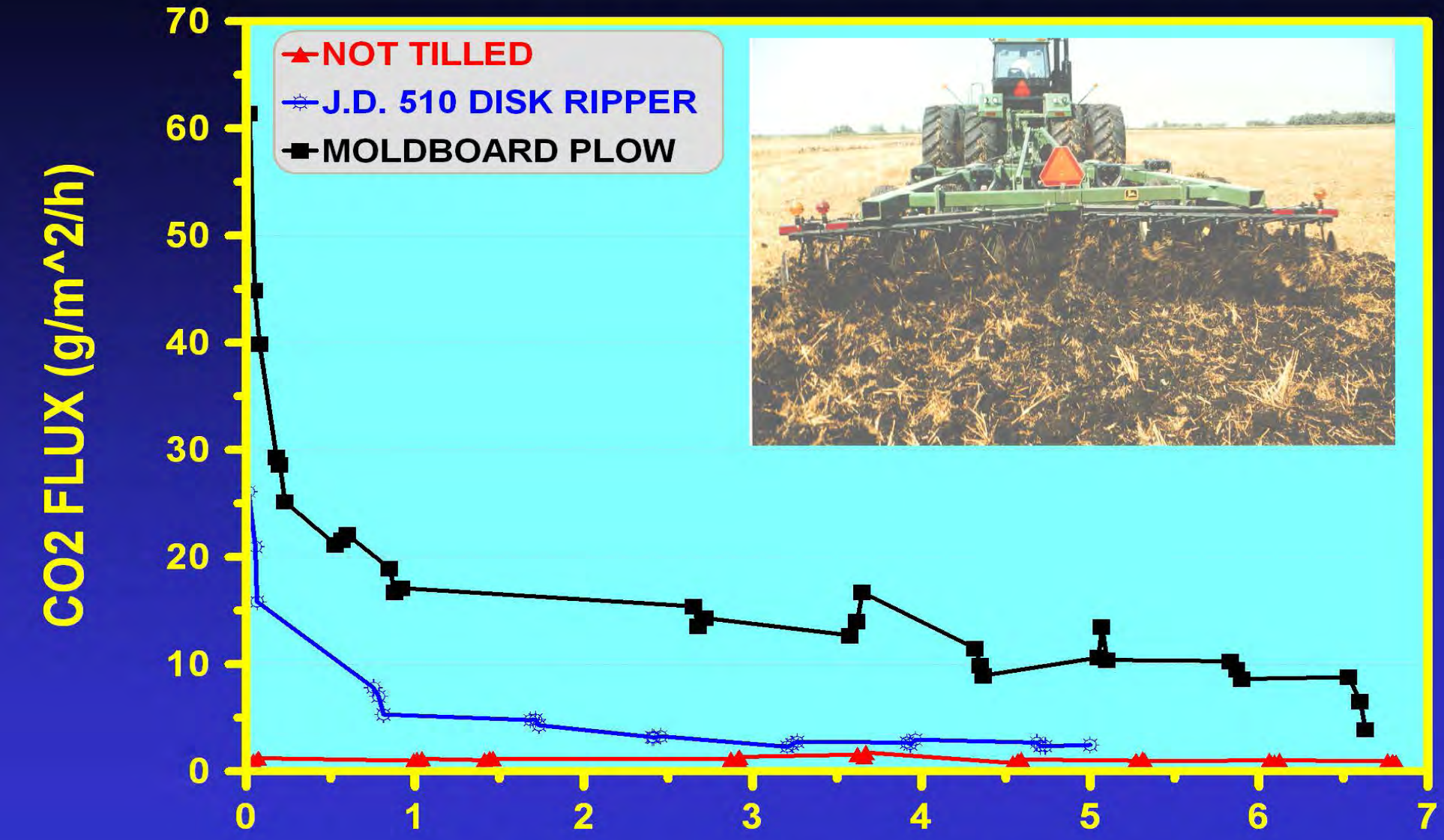
Infiltration rate	Soil Nitrate loss
50 in./hr	1.8 lbs. N/ac.

Conventional Tillage- Corn-Soybean:
Bulk Density- 1.40 g/cm^3

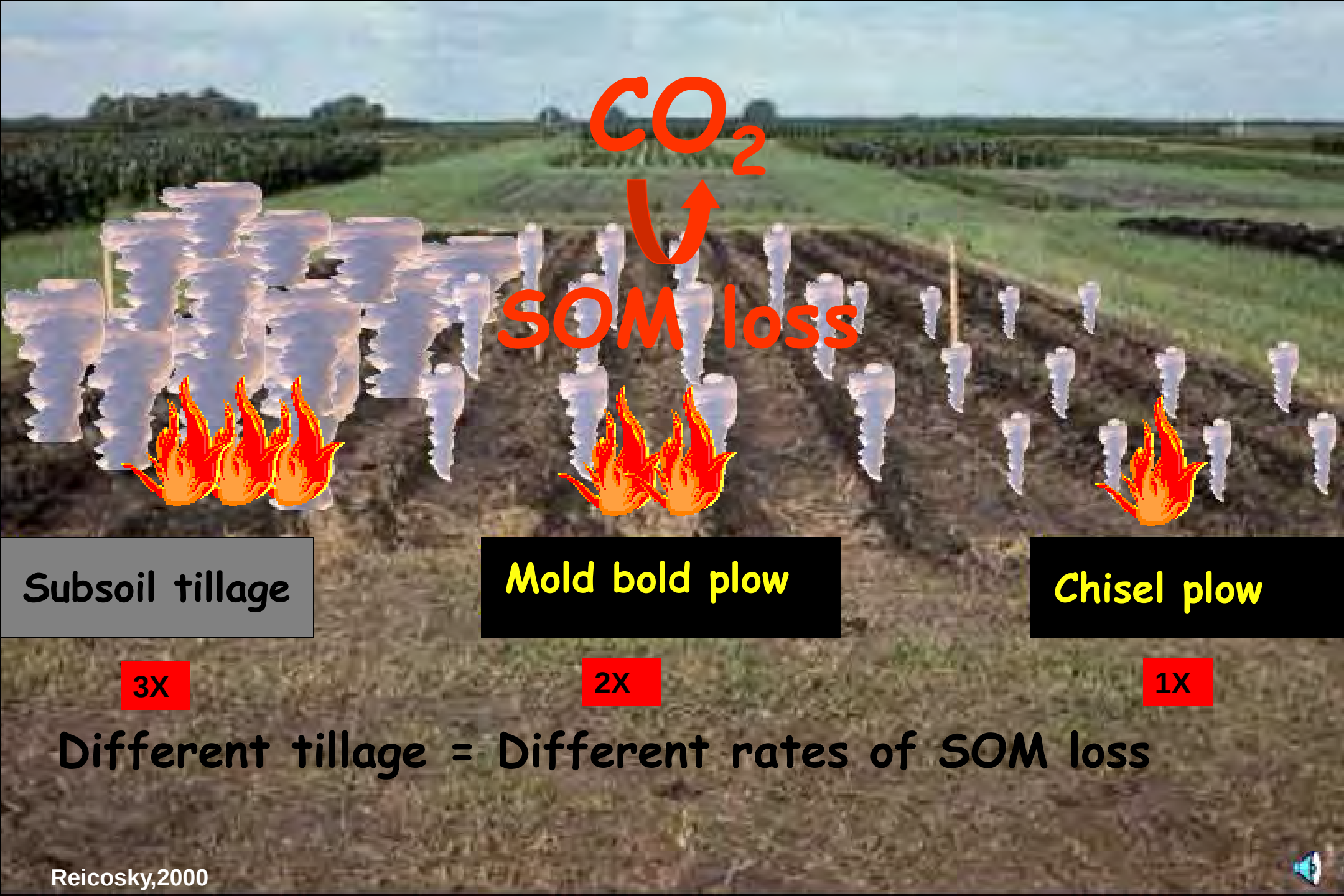
Infiltration rate	Soil Nitrate loss
.50 in./hr	15 lbs. N/ac.

JOHN DEERE 510 DISK RIPPER CO2 FLUX DATA

SWAN LAKE TILLAGE DEMONSTRATION AUGUST 24,1994



Reicosky et al., 1995

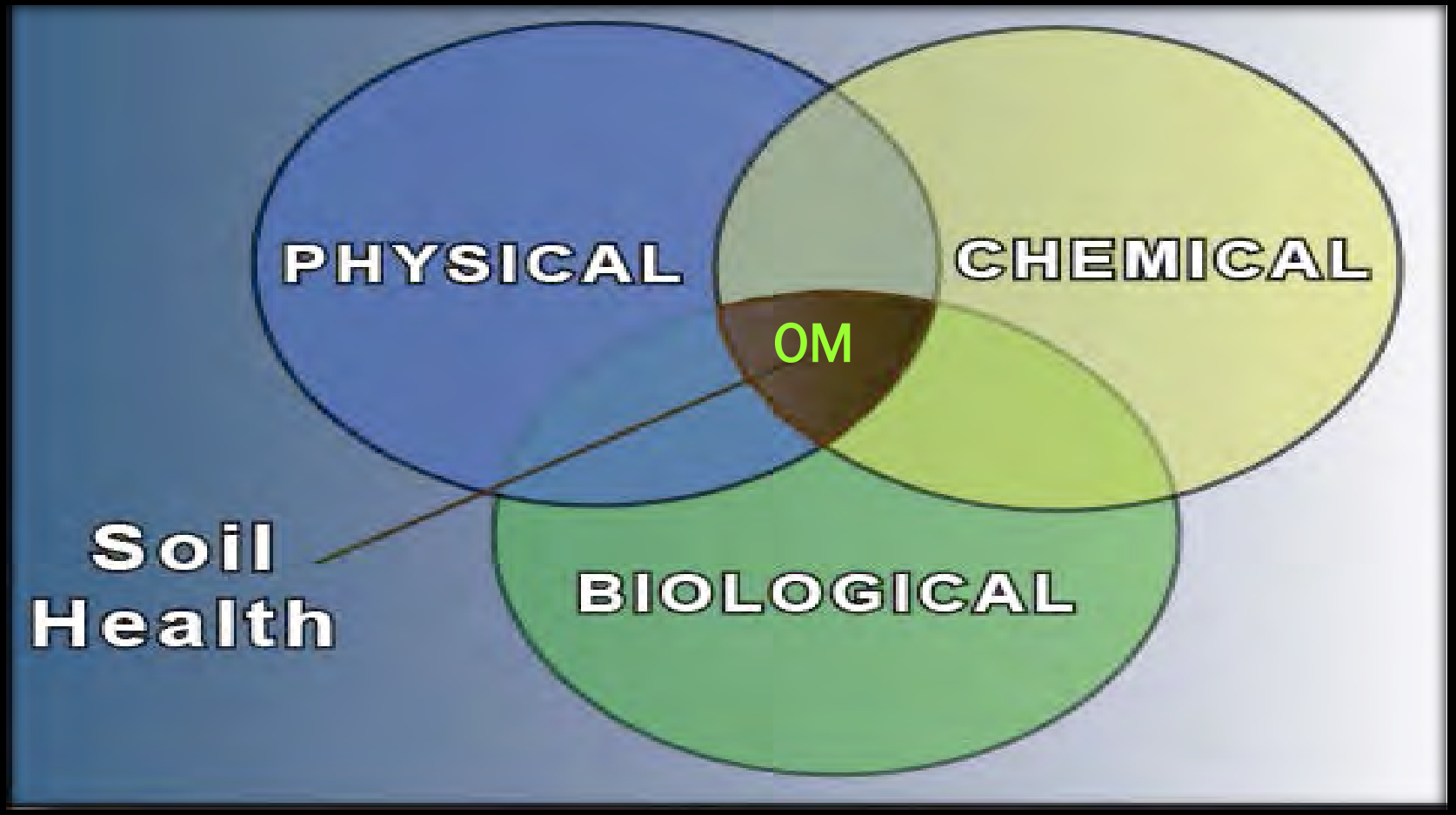

CO_2
SOM loss
Subsoil tillage
Mold bold plow
Chisel plow
3X
2X
1X
Different tillage = Different rates of SOM loss
Reicosky,2000

Tillage stimulates: R-Strategist (Opportunists bacteria) Copitrophic

Page 503 14th Edition Nature and Properties of Soils

Evaluate How Your Soil System is Functioning

- All parameters are important ; typically we focus on physical and chemical- but Biology is King!



Soil Health

"Every chemical-based pesticide, fumigant, herbicide and fertilizer tested, harms or outright kills some part of the beneficial life that exists in the soil, (or on the leaf surfaces) even when applied at rates recommended by their manufacturers... Less than half of the existing active ingredients used as pesticides have been tested for their effects on soil organisms."

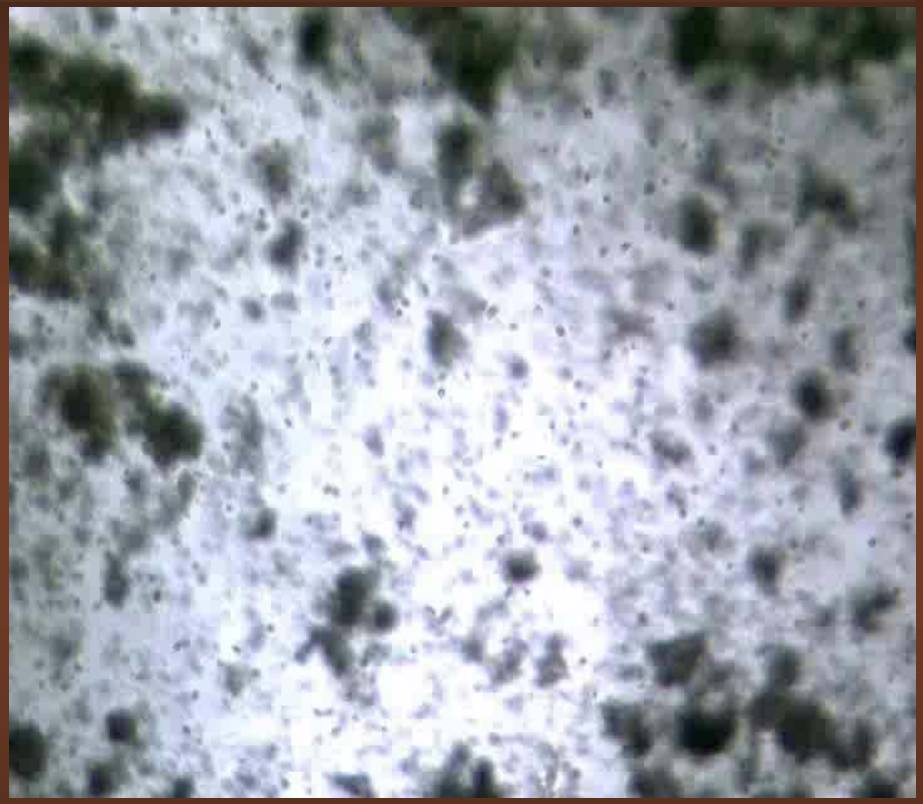
Dr. E. Ingham, 2002, Soil Food Web, Oregon State University

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

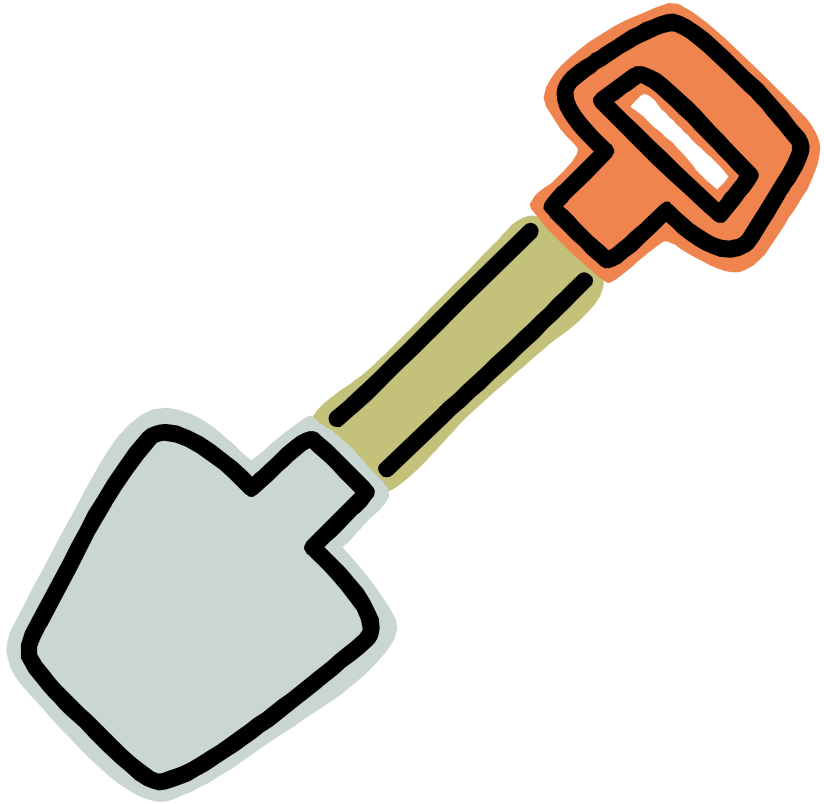
Ecologically Based



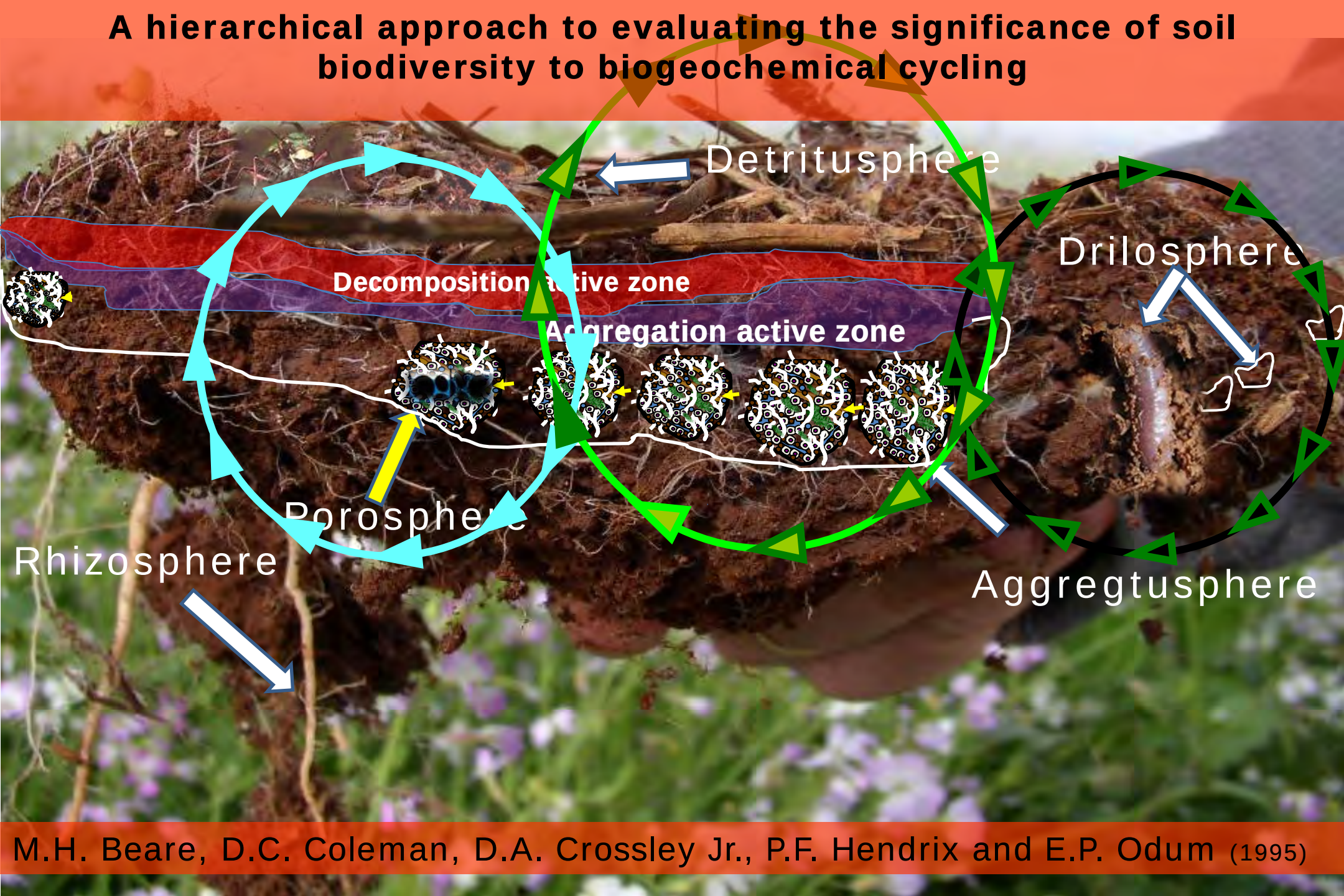
- Organic-mineral pools
- Microbially plant mediated process
- Strategic use of variable nutrients sources


The Soil Livestock is a complex and diverse mix of species and represents the greatest concentration of biomass of anywhere on the planet.

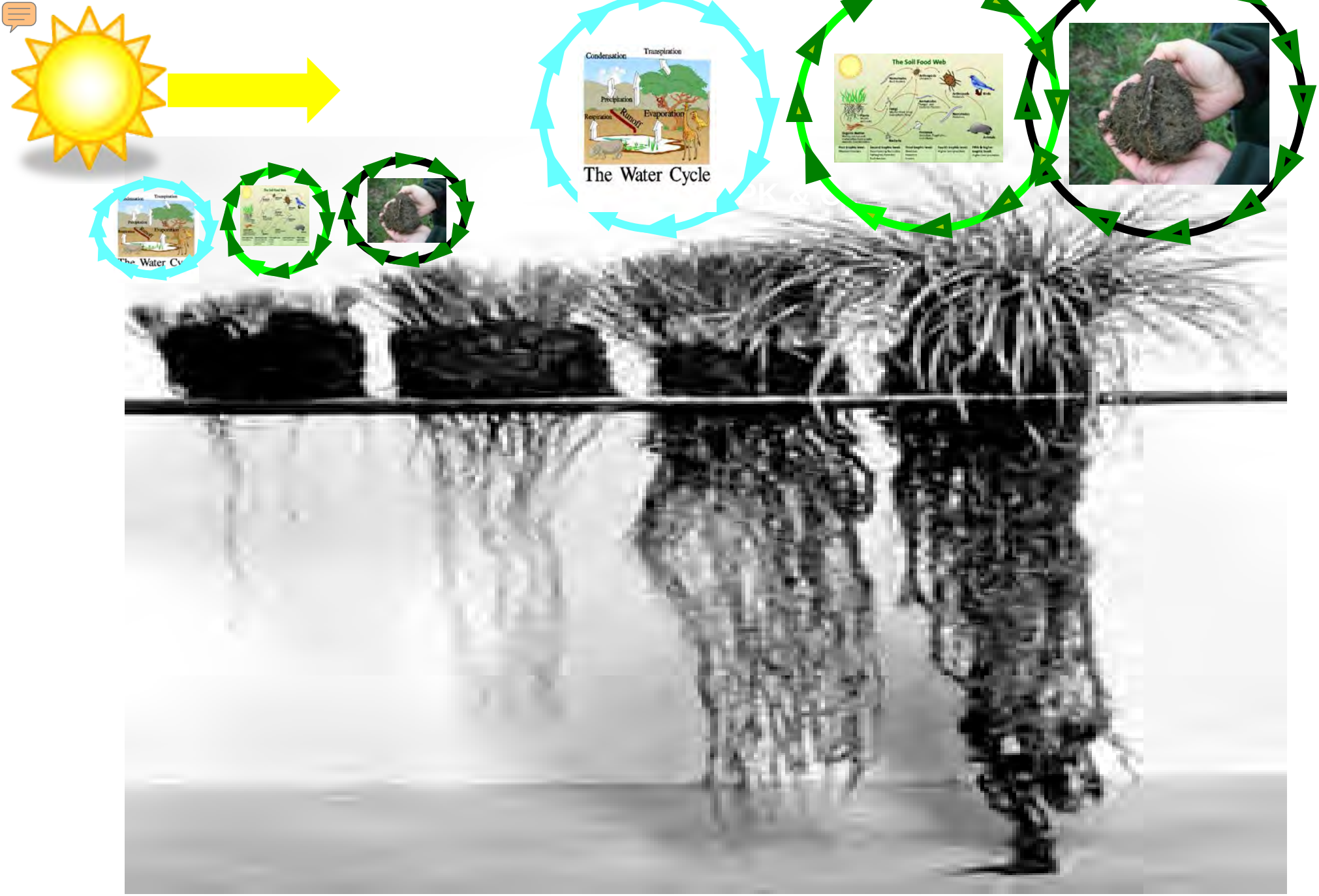
Shovel: A Tool to determine soil health



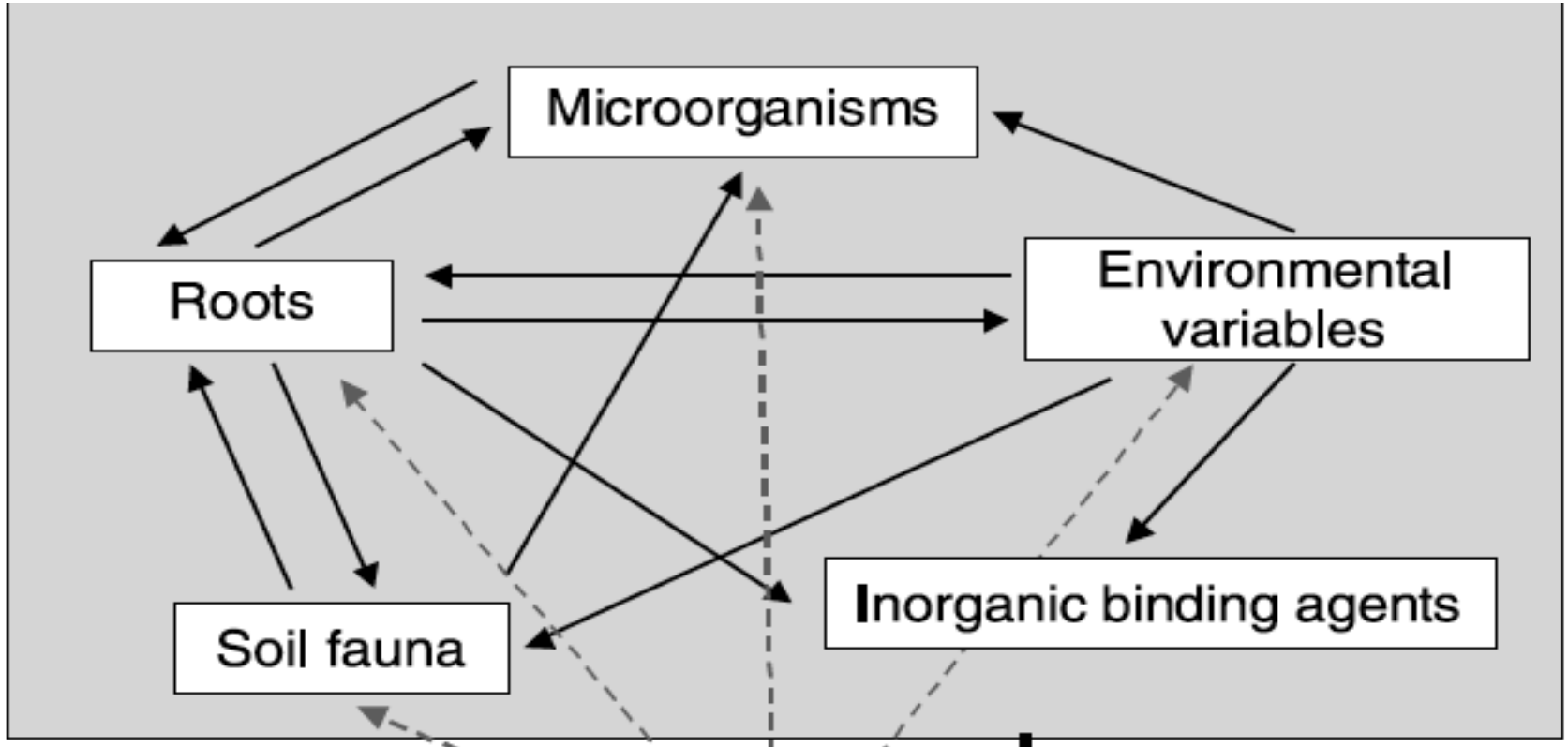
A hierarchical approach to evaluating the significance of soil biodiversity to biogeochemical cycling



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


Condensation
Transpiration
Precipitation
Respiration
Runoff
Evaporation
The Water Cycle
The Soil Food Web

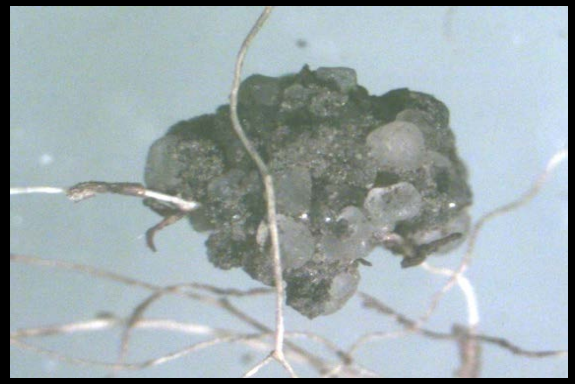
All Major Factors Playing a Role on Formation and Stabilization of Aggregates



J. Six a,b,*, H. Bossuyt c, S. Degryze d, K. Denef b 2004

Cottage Cheese

Soil Structure



Aggregation best under least disturbance.

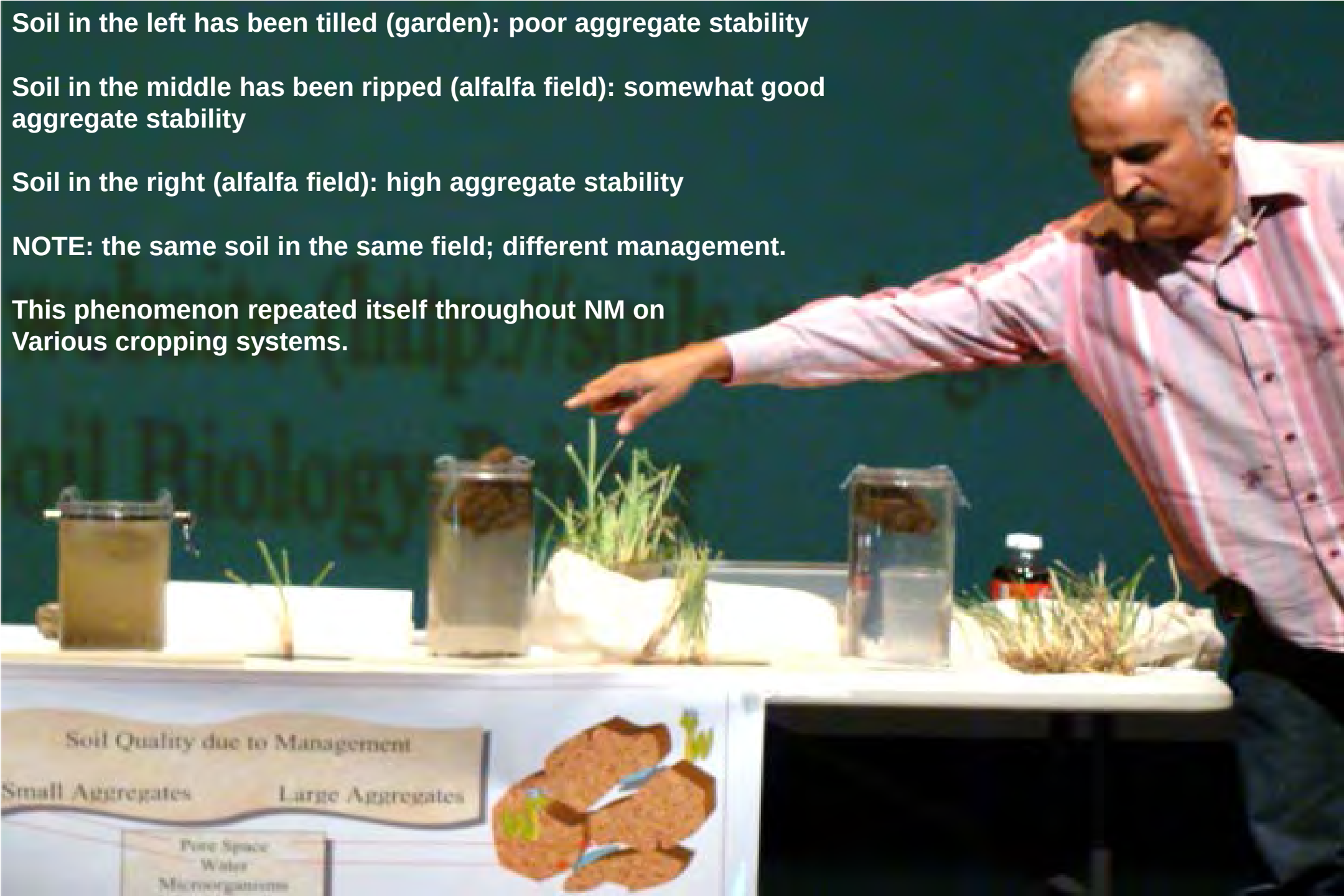
Tillage can only destroy soil aggregates… it cannot build them…

Tillage results in poor habitat for the soil foodweb.

These Processes have profound effects on SOM dynamics and nutrient cycling.

1. Physically protect soil organic matter (e.g. Tisdall and Oades, 1982)
2. Influence microbial community structure (e.g. Hattori, 1988),
3. Limit oxygen diffusion (e.g. Sexston et al., 1985),
4. Regulate water flow (e.g. Prove et al., 1990),
5. Determine nutrient adsorption and desorption (e.g. Linquist et al., 1997)
5) Reduce run-off and erosion (e.g. Barthes and Roose, 2002)

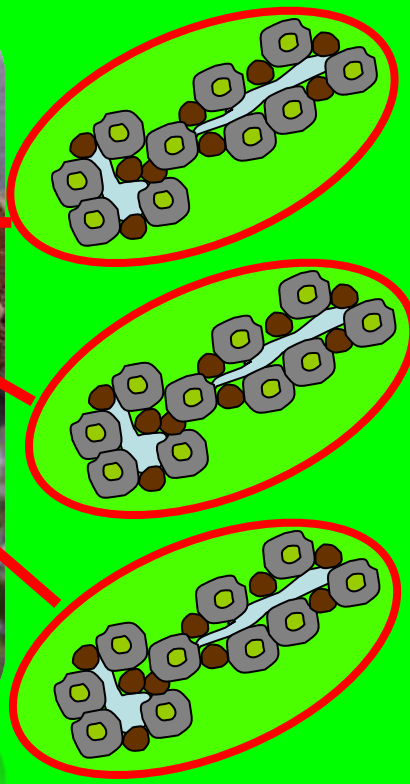
NM Desert Soil


Soil in the left has been tilled (garden): poor aggregate stability
Soil in the middle has been ripped (alfalfa field): somewhat good aggregate stability
Soil in the right (alfalfa field): high aggregate stability
NOTE: the same soil in the same field; different management.
This phenomenon repeated itself throughout NM on Various cropping systems.
Soil Quality due to Management
Small Aggregates
Large Aggregates
Pore Space
Water
Microorganisms


40Yr No-Till Soils - Styer


Conventional Till Soil

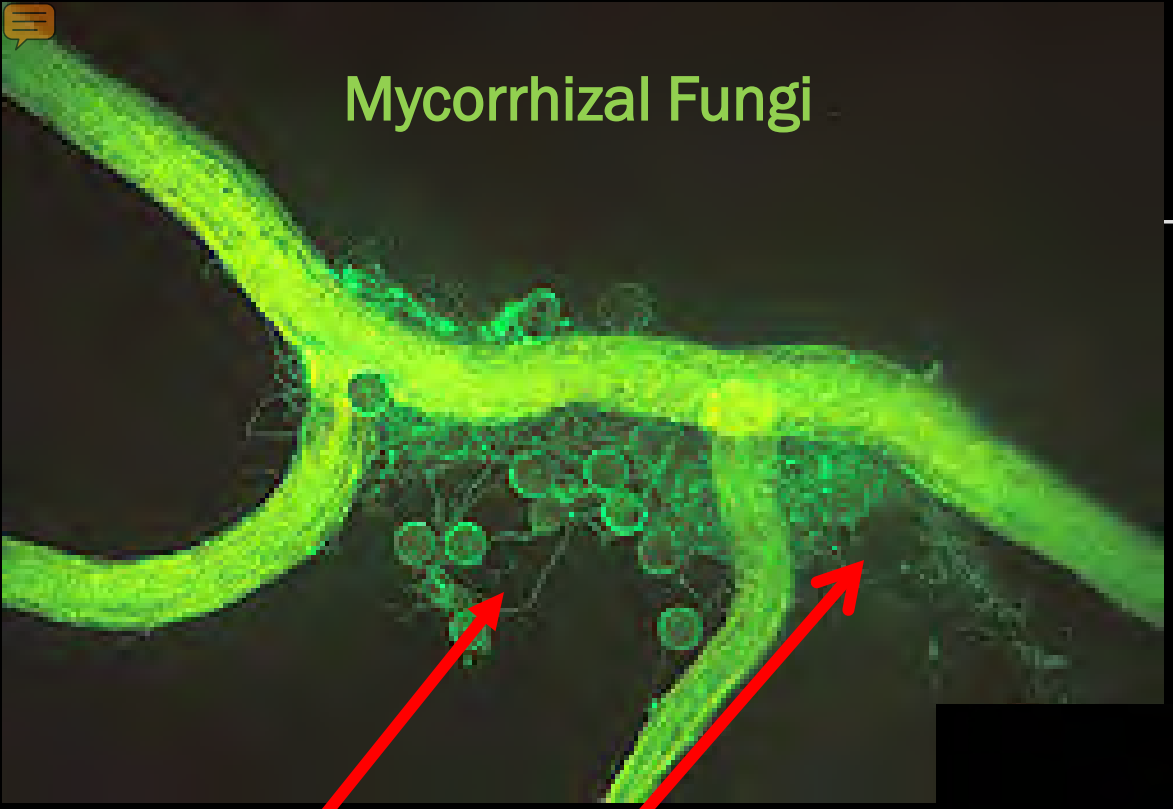
Aggregatusphere : Occluded Habitat of Micropores



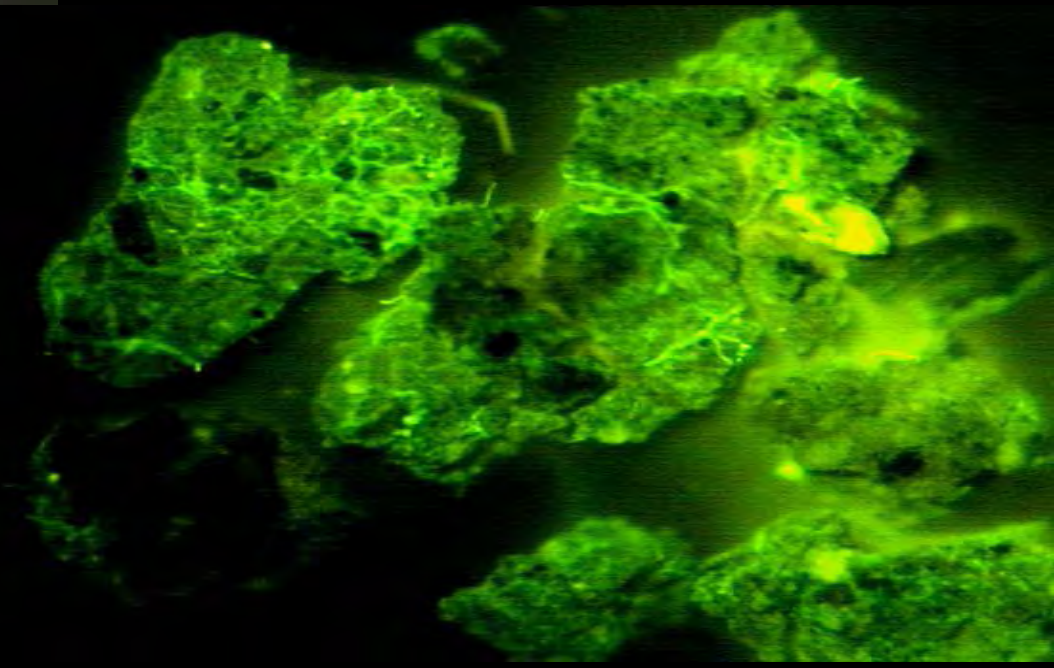
.Protects organic matter from decay
•Storage site for organic matter
• Habitat of Oligotrophic and Copiotrophic bacteria
•Protects and maintains the integrity of the porosphere

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

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

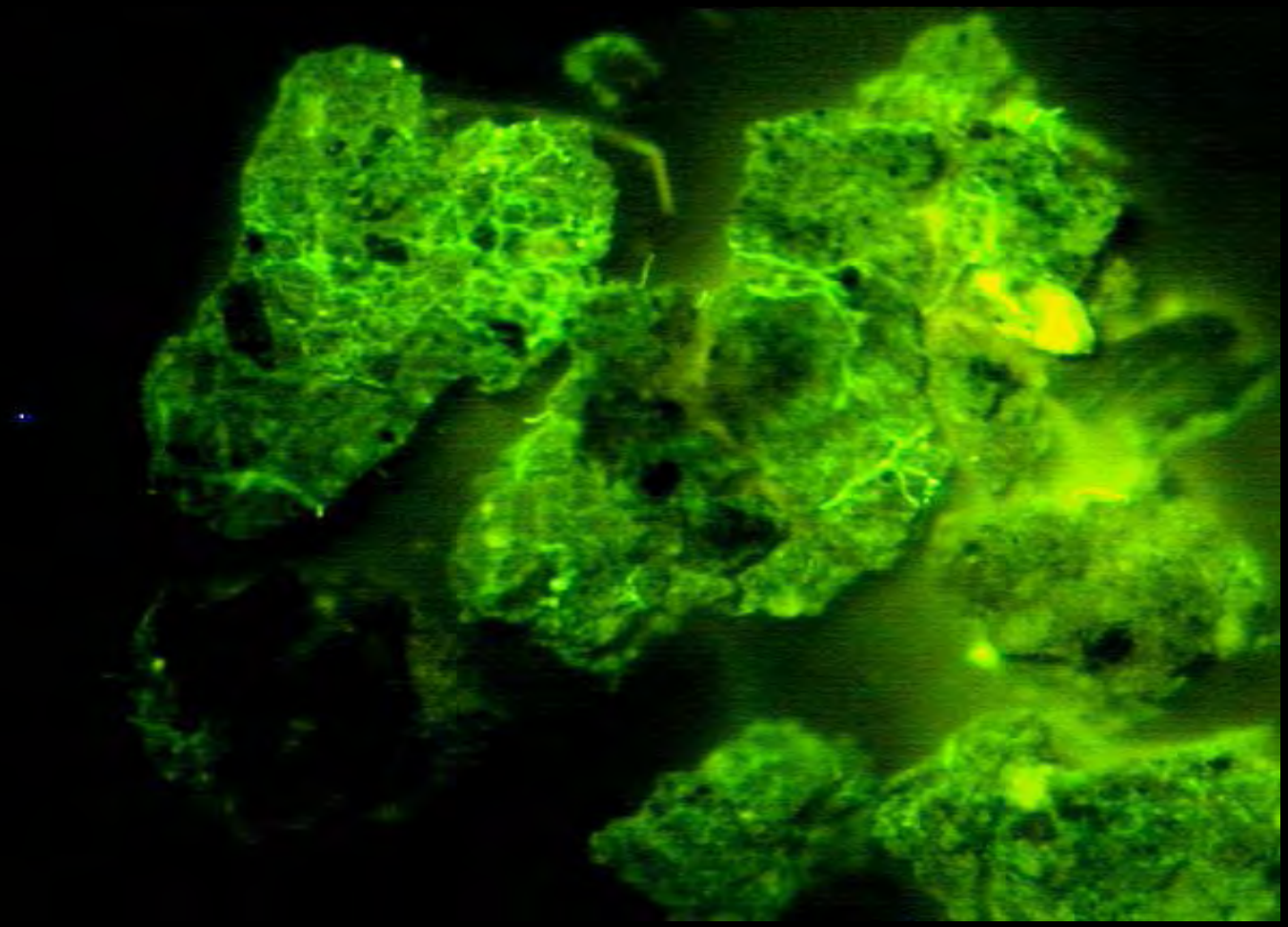


Glomalin is naturally brown. A laboratory procedure reveals glomalin on hypae and soil aggregates as the bright green material shown here.



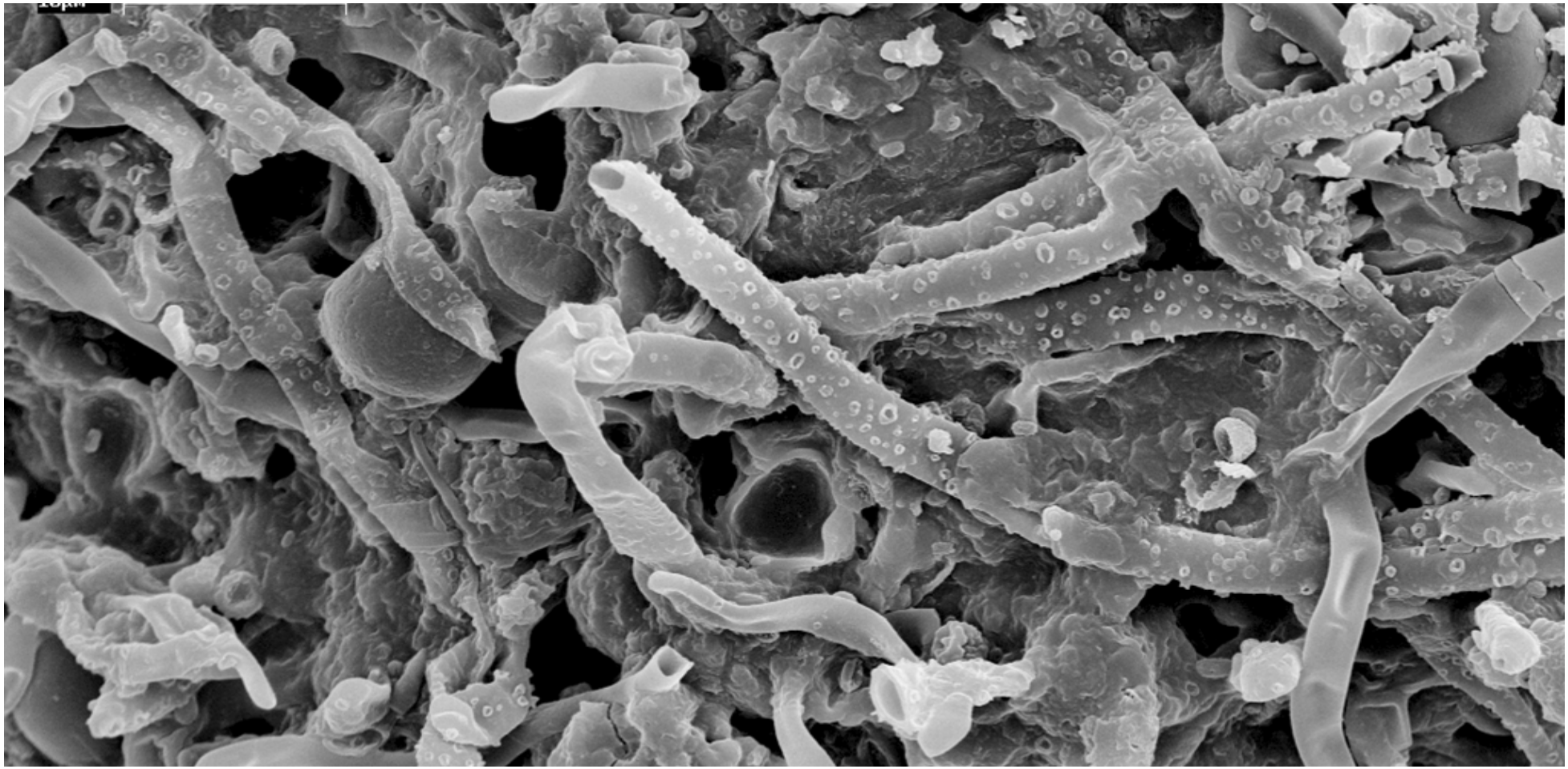
Dr. Kris Nichols – Microbiologist - USDA ARS

HOW DOES GLOMALIN WORK?

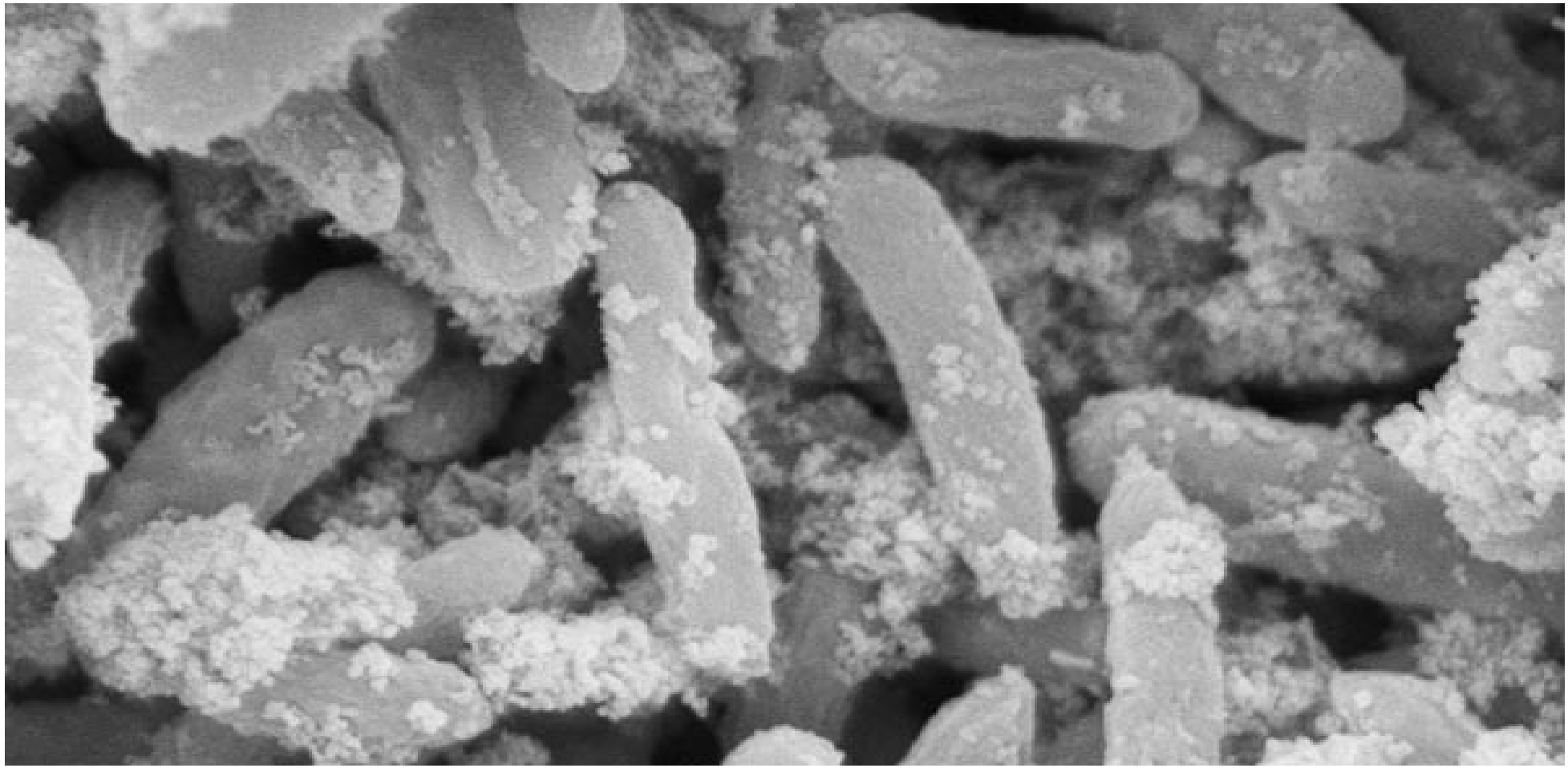



The so-called phyllosphere “the largest biological surface inhabited by microorganisms”
Julia Vorholt, a professor at the Institute of Microbiology

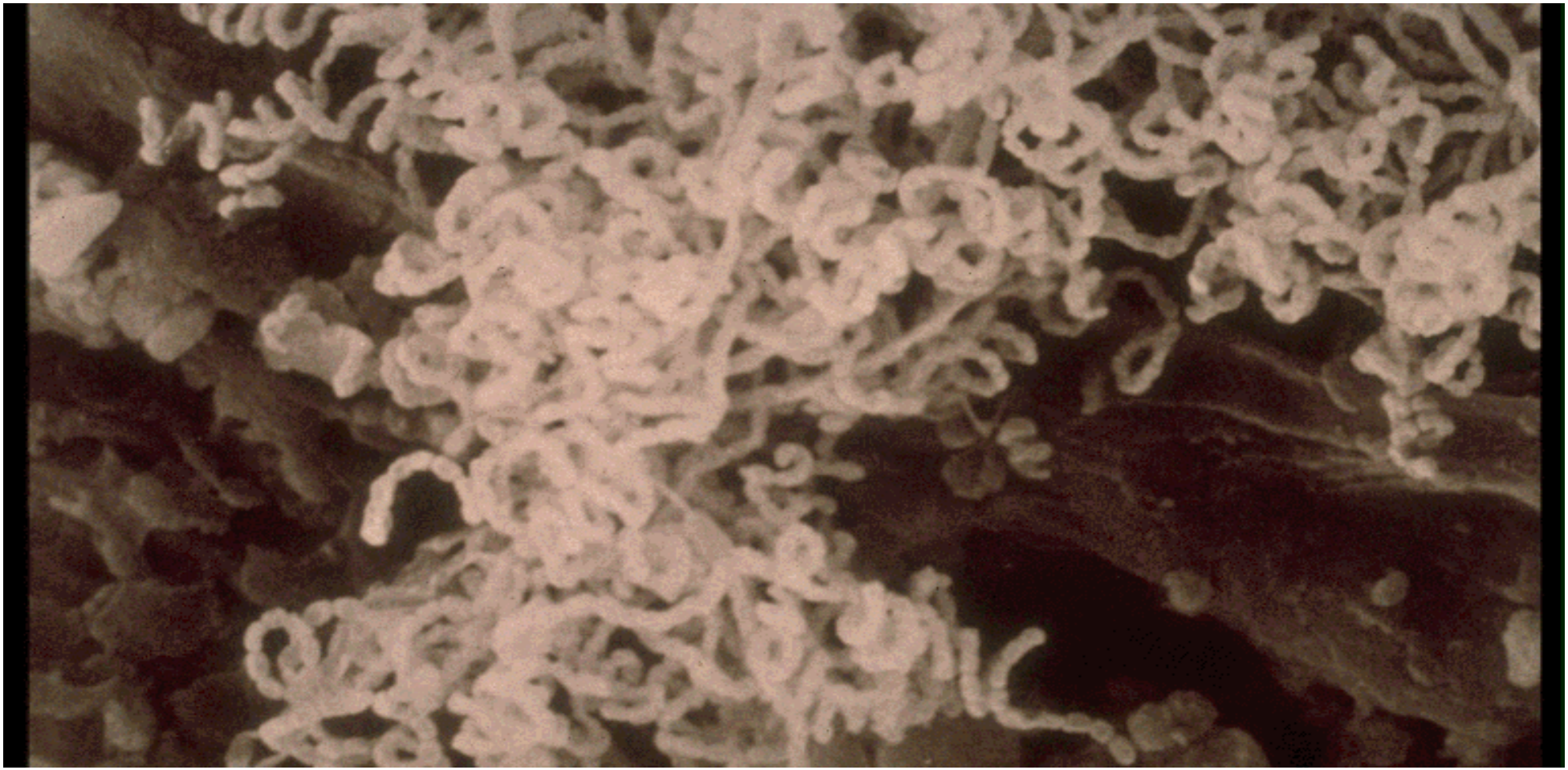
Fungi hold on to Calicum



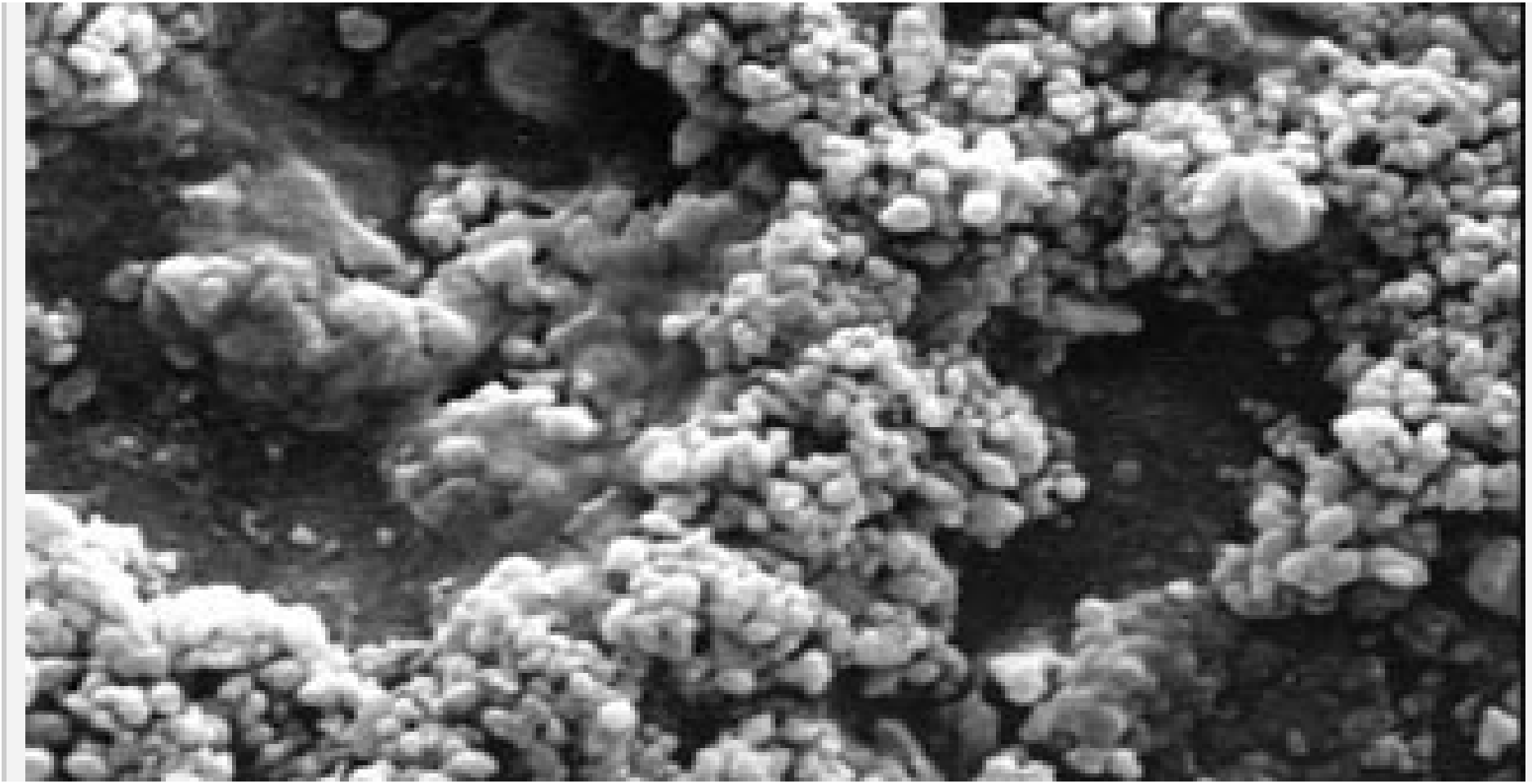
Bacteria Minerals to Create Grid: Transport Electrons



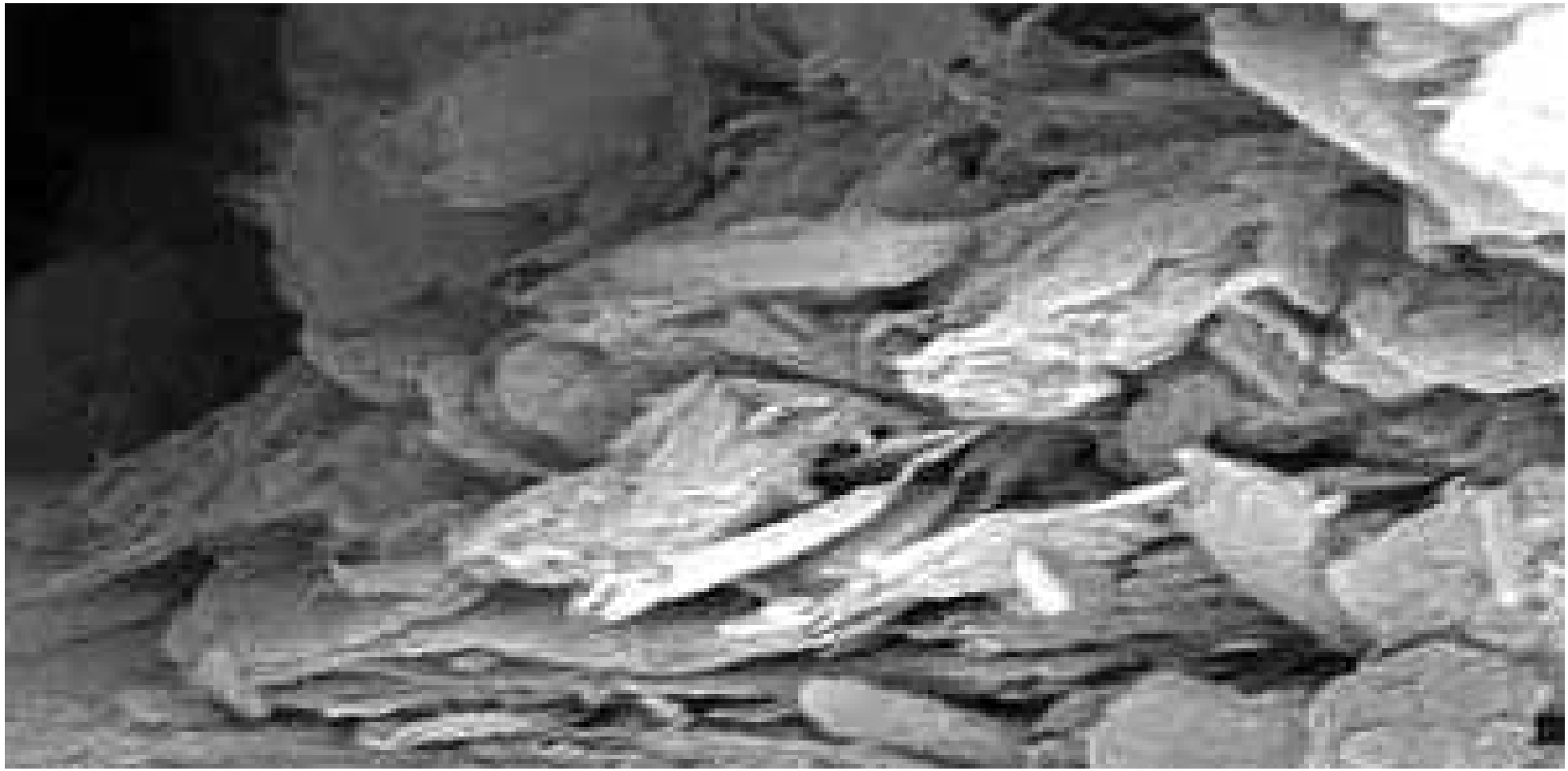
Actinobacteria



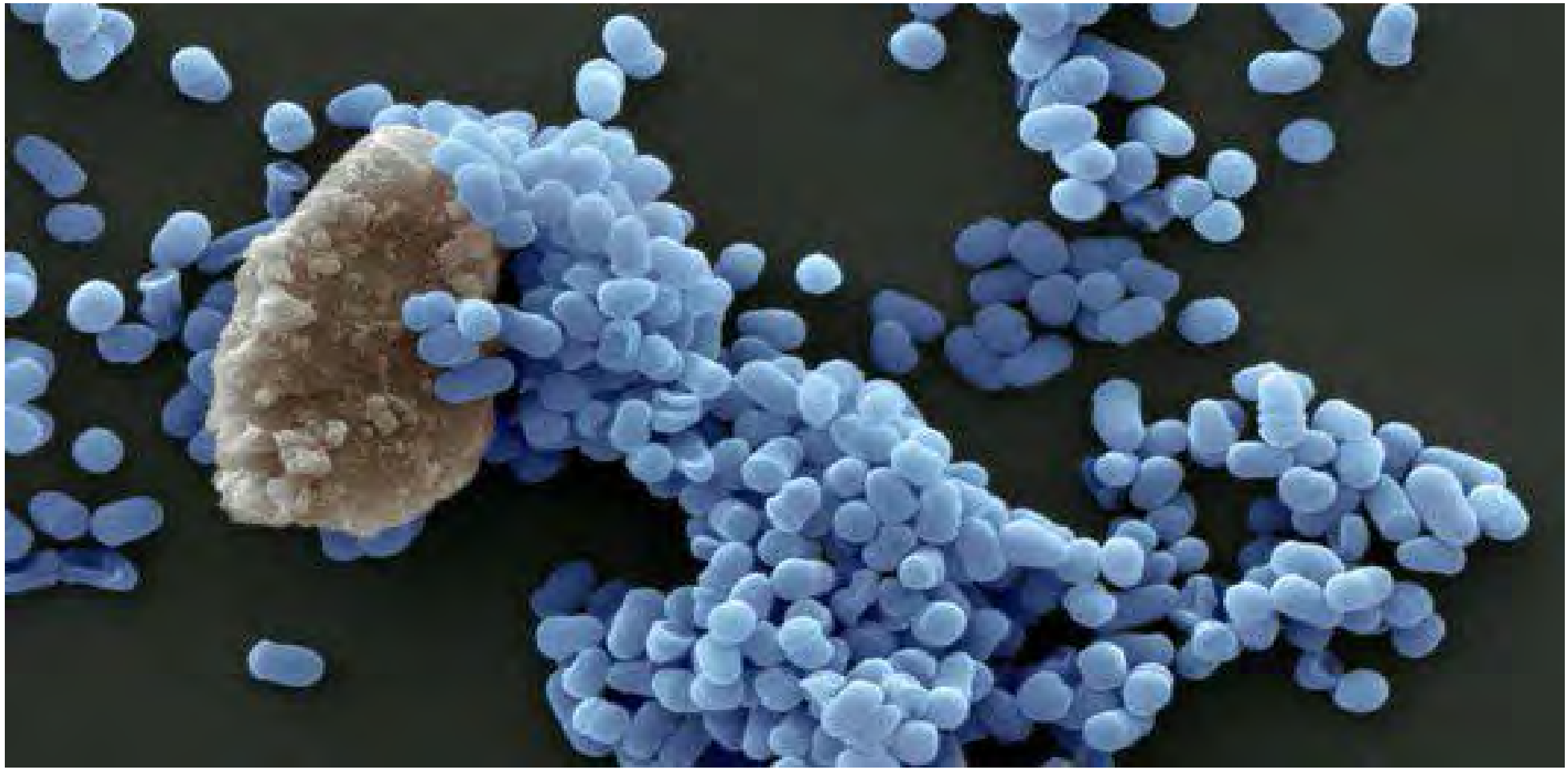
(HS) Humic Substances



Electron Image: Clay Particle



Arthrobacter



Liquid carbon pathway unrecognised

At cropping conferences when soil carbon is discussed, a conclusion usually drawn is that it is not possible to lift levels to a significant extent in a short timeframe. Most scientists contend carbon is a useful factor to consider for agronomy but not for sequestration. But Dr Christine Jones disagrees. She contends soil carbon can be increased quickly for both purposes and that most scientists are using a flawed model to measure carbon.

Christine Jones is rekindling awareness of a biological pathway for quickly increasing carbon in depleted cropping soil. Existing models she says don't account for the pathway and significantly underestimate the potential of cropping soils to sequester carbon.

A soil carbon improvement of only 0.5% in the top 30 centimetres of 2% of Australia's estimated 445 million hectares of agricultural land would safely and permanently sequester the entire nation's annual emissions of carbon dioxide. Sequestering atmospheric carbon in soil as humified organic carbon would also restore natural fertility, increase water-use efficiency, markedly improve farm productivity, provide resilience to climatic variation and inject much-needed cash into struggling rural economies.

The 'soil solution' to removing excess carbon dioxide (CO_2) from the earth's atmosphere is being overlooked because current mathematical models for soil carbon sequestration fail to include the primary pathway for natural soil building.

The process whereby gaseous CO_2 is converted to soil humus has been occurring for millions of years. Indeed, it is the only mechanism by which topsoil can form. When soils lose carbon, they also lose structure, water-holding capacity and nutrient availability.

Understanding soil building is thus fundamentally important to future viability of agriculture. Rebuilding carbon-rich topsoil is also the only practical and beneficial option for productively removing billions of tonnes of excess CO_2 from the atmosphere.

'Biological sequestration' begins with photosynthesis, a natural process during which green leaves turn sunlight energy, CO_2 and water into biochemical energy. For plants, animals and people, carbon is not a pollutant but the stuff of life. All living things are based on carbon.

Besides providing food for life, some of the carbon fixed during photosynthesis can be stored in a more permanent form, such as wood (in trees or shrubs) or humus (in soil). These processes have many similarities.

i) Turning air into wood: Formation of wood requires photosynthesis to capture CO_2 in green leaves, followed by lignification, a process within the plant whereby simple carbon compounds are joined together into more complex and stable molecules to form the structure of the tree.

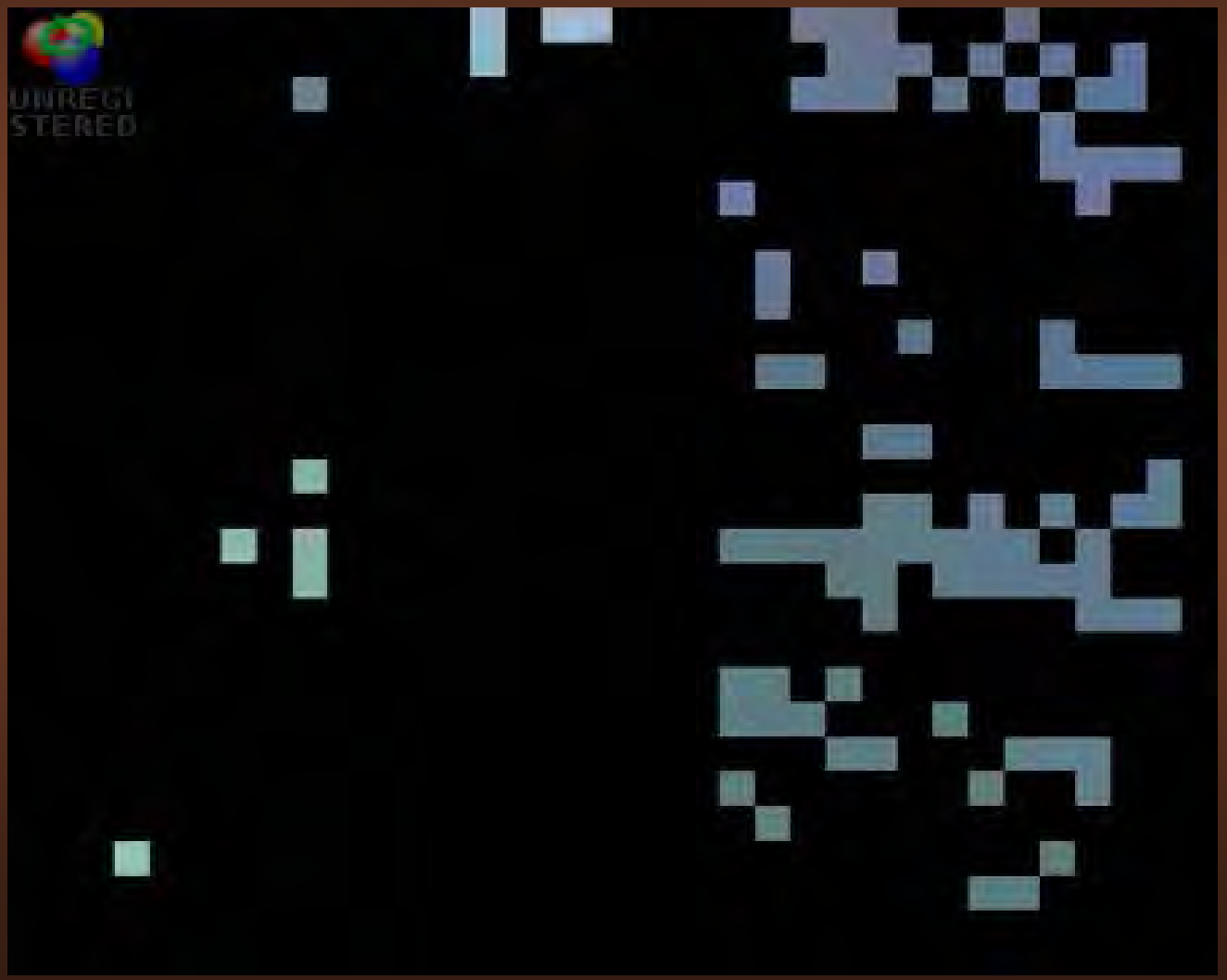
ii) Turning air into soil: The formation of topsoil requires photosynthesis to capture CO_2 in green leaves, followed by humification, a process within the soil whereby simple carbon compounds are joined together into more complex and stable molecules to form the structure of the soil.

How can it be that trees are still turning CO_2 into wood, but soils are no longer turning CO_2 into humus?

The answer is quite simple. In order for trees to produce new wood from soluble carbon, they must be living and covered with green leaves. In order for soil to produce new humus from soluble carbon, it must be living and covered with green leaves.

Building stable soil carbon is a four-step process that begins with photosynthesis and ends with humification. The humification part of the equation is absent from most broadacre agricultural produc-

The root is a Leverage Point: Engineering



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)

Scum Test

Switchgrass

Switchgrass – Immediately After Placing in Water

Switchgrass – After Submerging and Disruption

Switchgrass

Big Bluestem

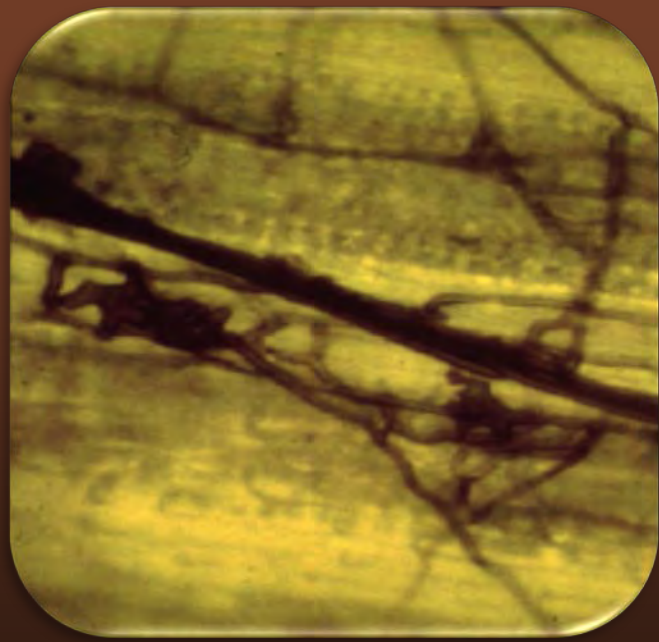
Alfalfa

growth

Spring 2008 Weed Suppression (ND)

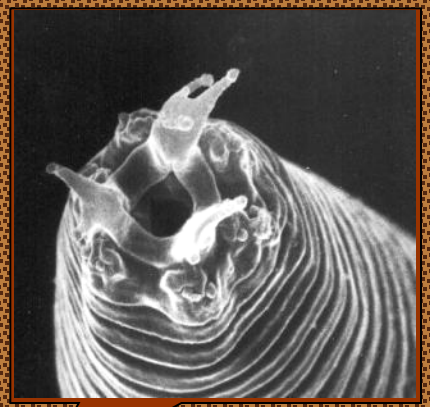
Fungi- Service they provide

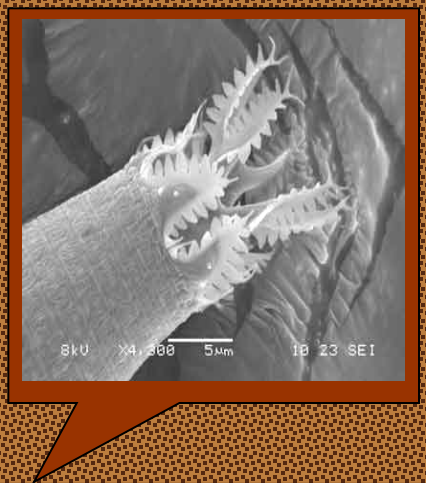
- Decompose Organic Matter
- Glomalin secretion develops soil structure
- Extract nutrients
- Hold nutrients

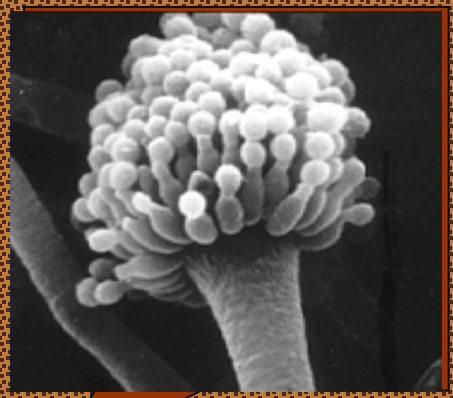


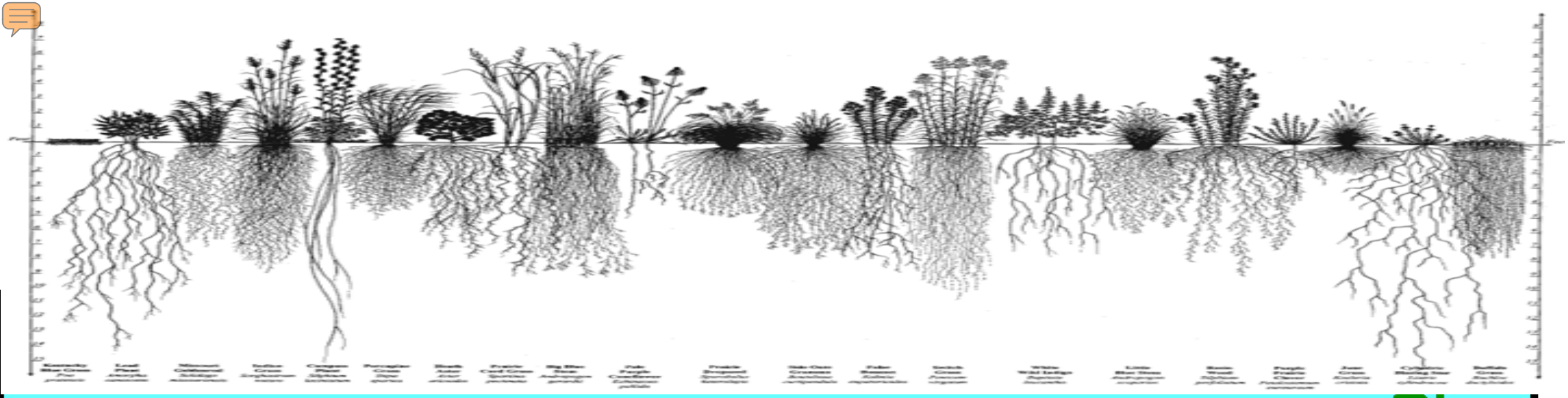
Diversity conduit for energy and nutrients

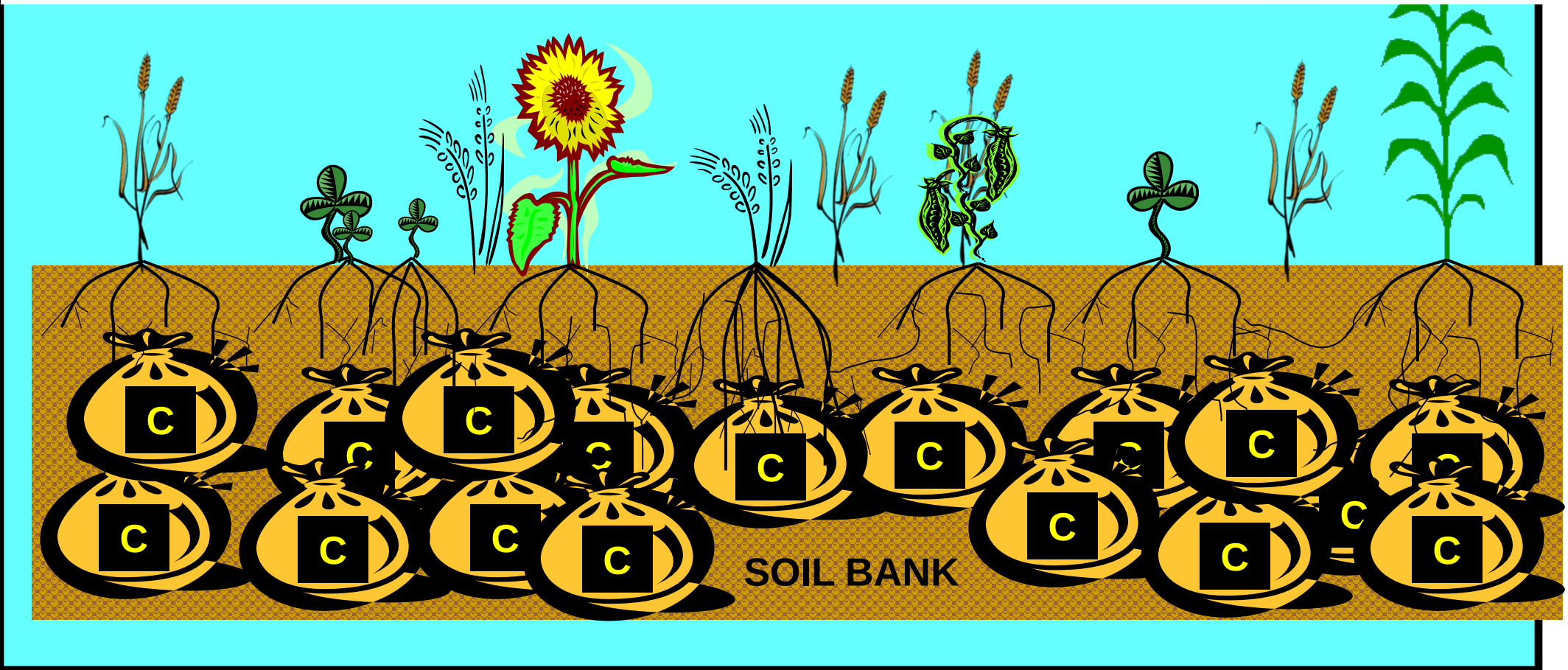
Soil Surface



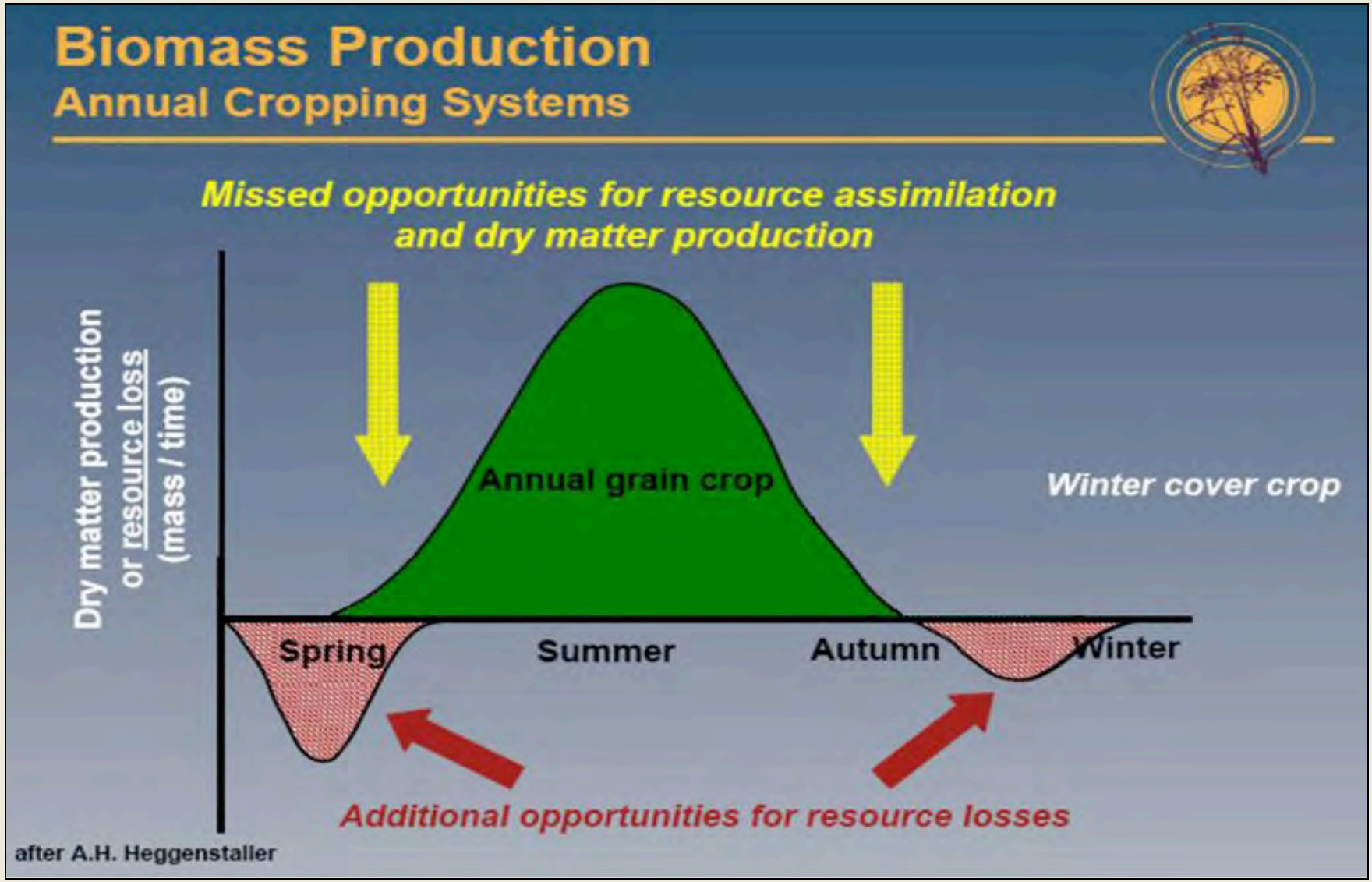







C
SOIL BANK

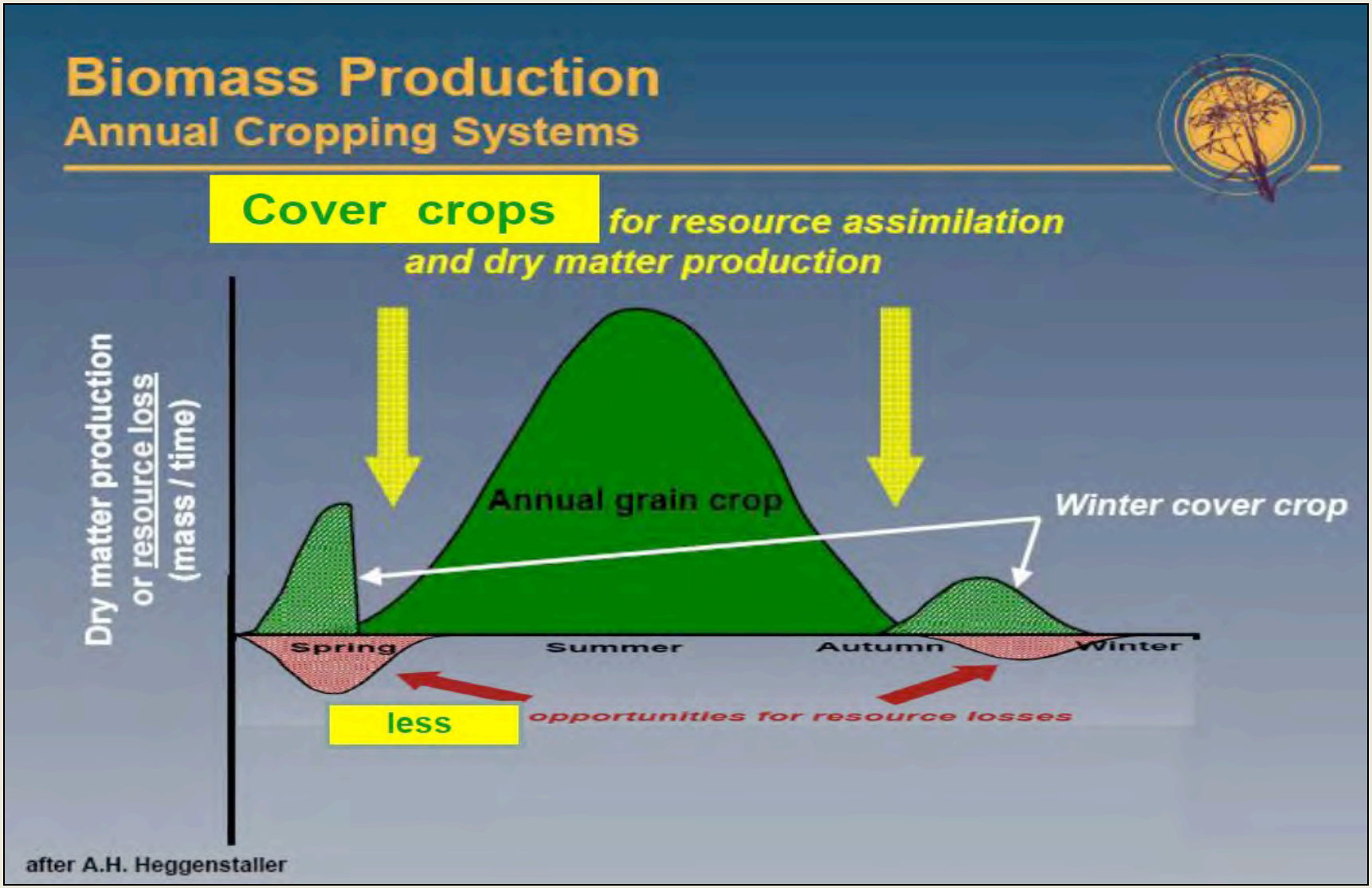
Mimic Nature



The Science of Conservation, We Deliver!

NRCS East NTSC

A. H. Heggenstaller, University of Alberta

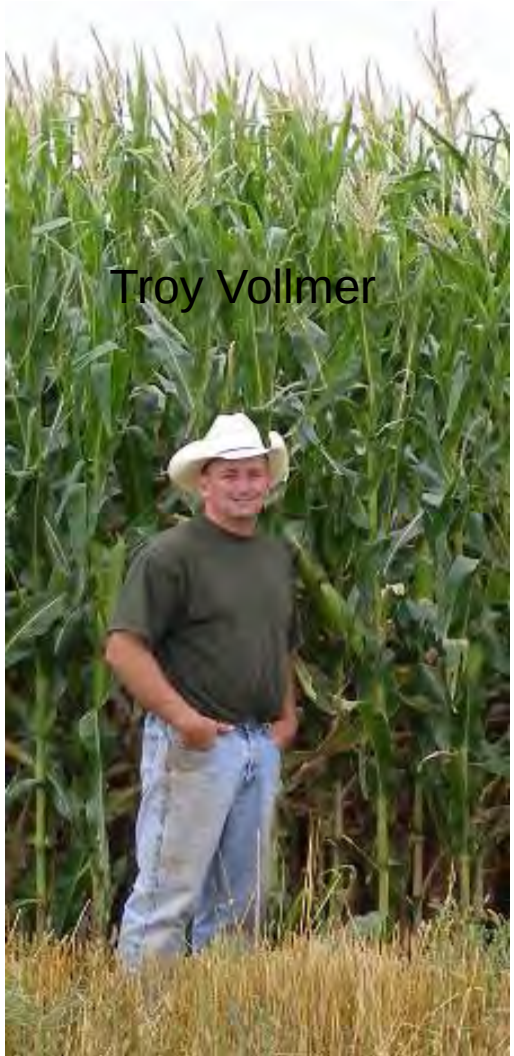


The Science of Conservation, We Deliver!

NRCS East NTSC

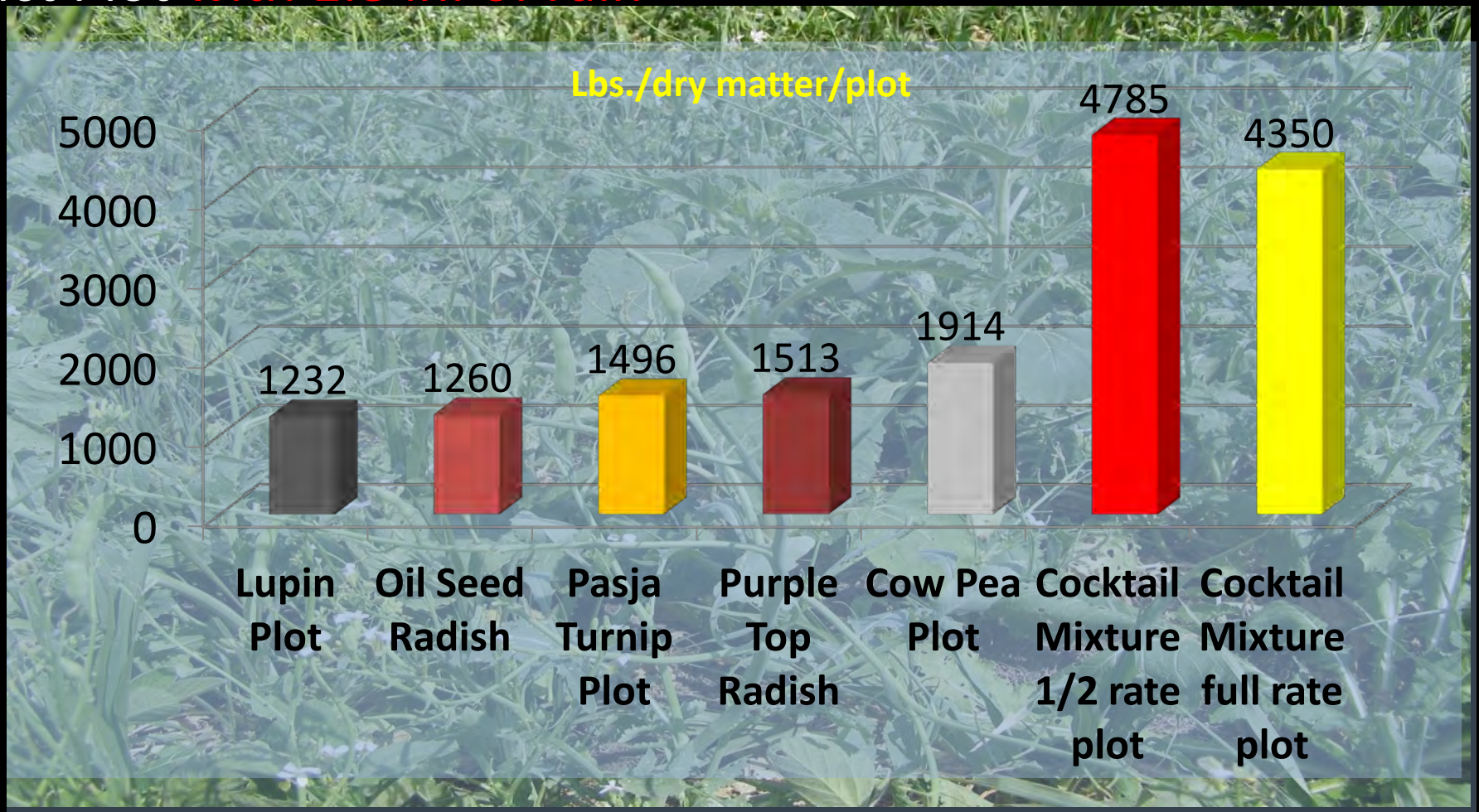
A. H. Heggenstaller, University of Alberta

Farmers Talking To Farmers About Soil Health



The Answer is to Imitate Native Rangeland

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

Sept. 13 (60 days)

Sept. 13 (60 days)

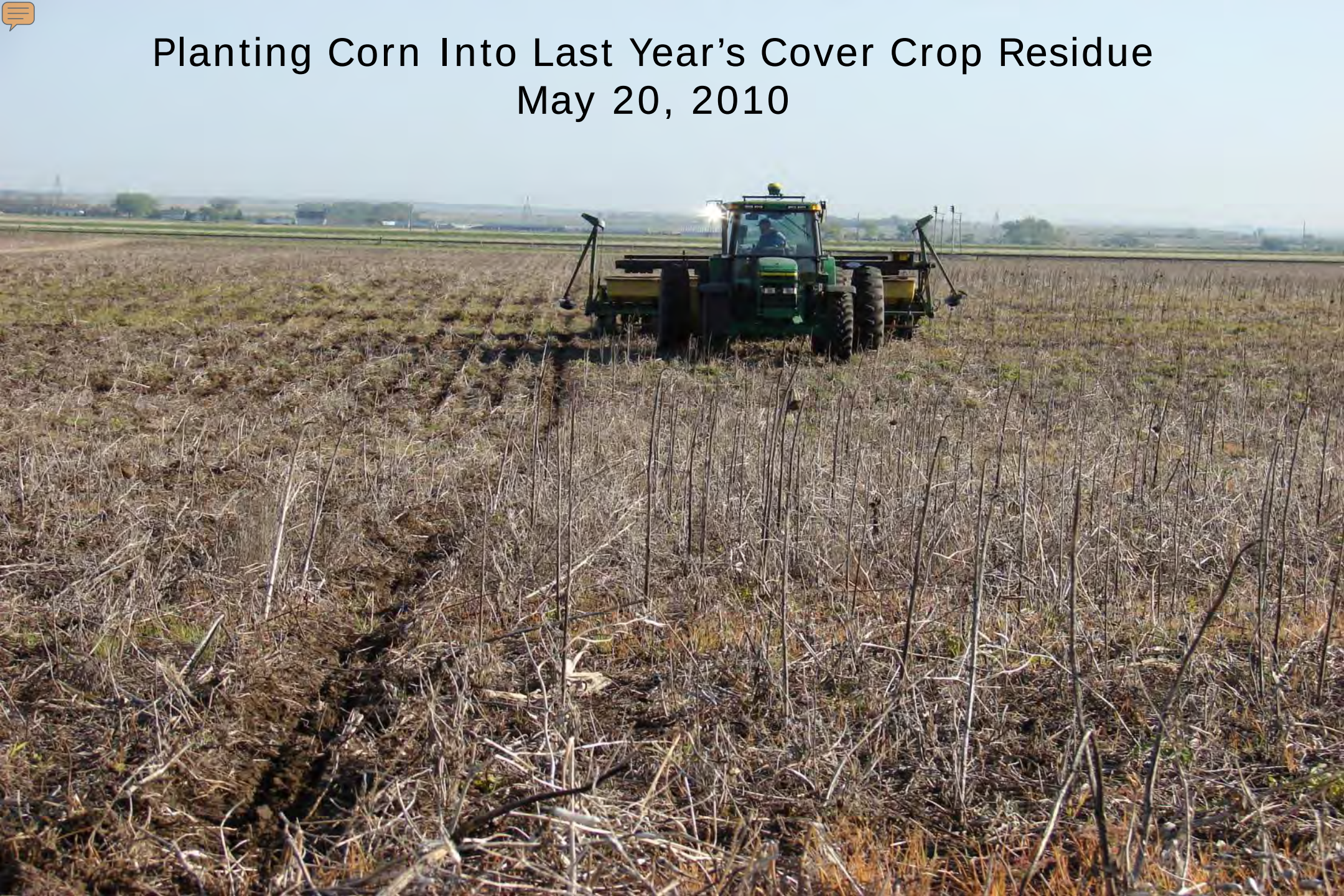

Burleigh County
Soil Conservation District
ADVANCING SOIL HEALTH
Menoken Farm
www.bcscd.com
Established 2009

Menoken Farm

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

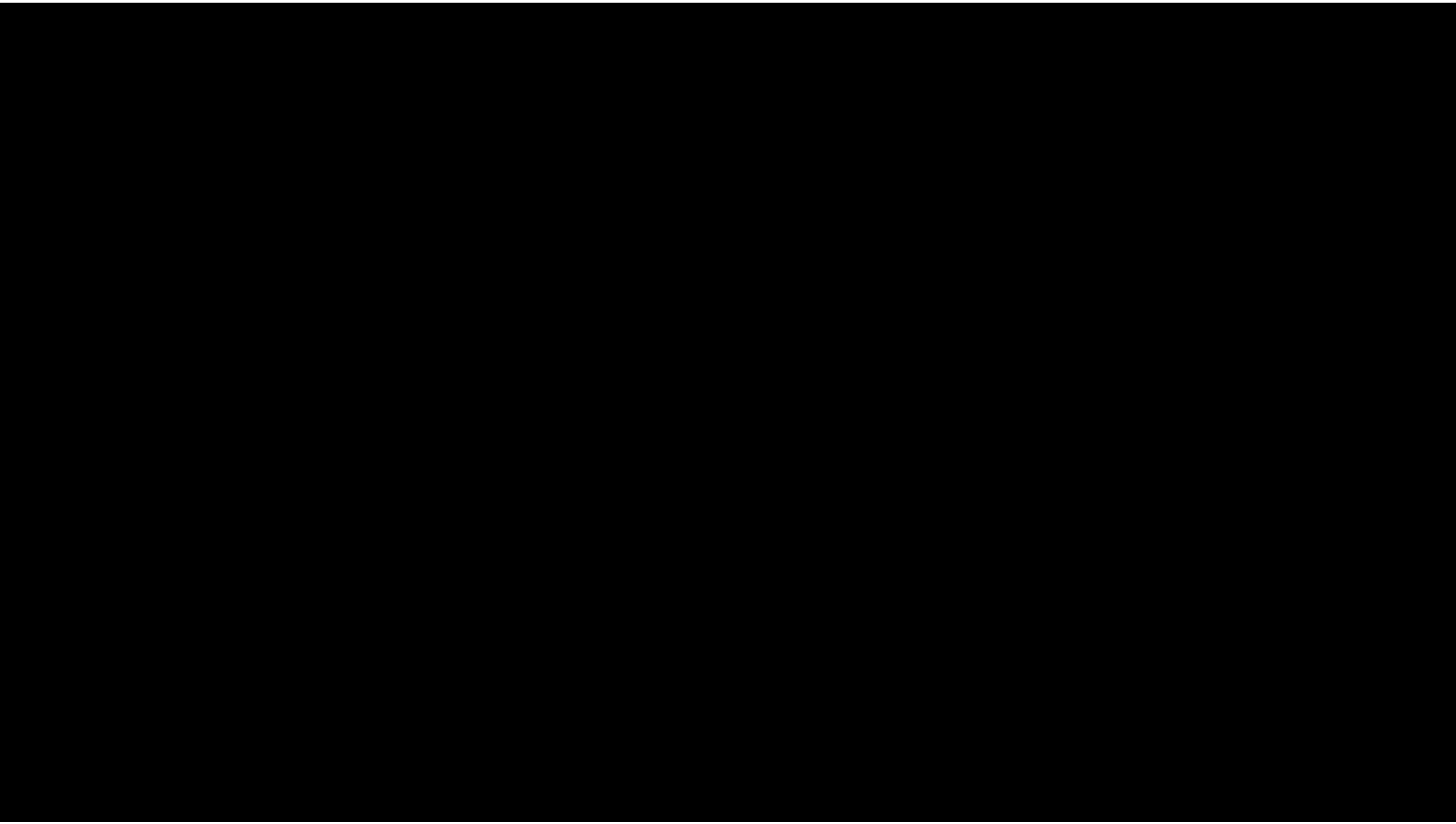
East Side
No Commercial Fertilizer
1-2 Ton of Compost
2 Compost Tea Applications
128.8 Bushels per Acre

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



Darrell Oswald Ranch: Cover crop Mix


12 species

All Plots Harvested October 18, 2011

Study 3

190 bu/ac corn grown with zero N input at planting

Cover Crop Economics

All Data is Per Acre Except Where Noted

Nitrogen input:
60/40 blend of Super U
and Ammonium Sulfate,
at $0.795 / lb

190.8 bu/ac
Zero Units / N

205.6 bu/ac
60 Units / N

198.1 bu/ac
90 Units / N

196.9 bu/ac
120 Units / N

RESEARCH SPONSORED BY

COVER CROP SOLUTIONS
Home of the Tillage Radish

Nature’s residue managers

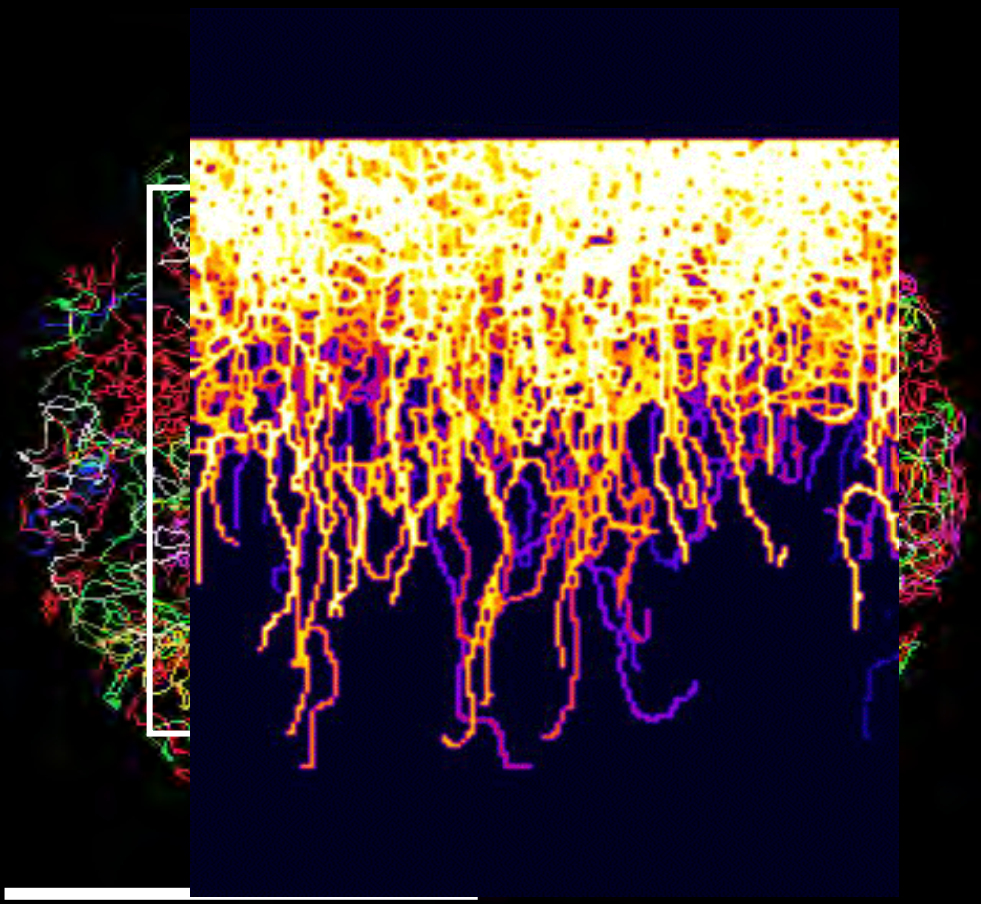
Giant Australian earthworm

Megascolides australis can get up to 11 feet !!

Soil Engineers: Earthworms
Subsoil macropores - Model of earthworm burrow systems

75 ind/m²

- 30% endogeic (∅ 2-3 mm)
- 70% anecic (∅ 6 mm)
- ∅ core 212 cm



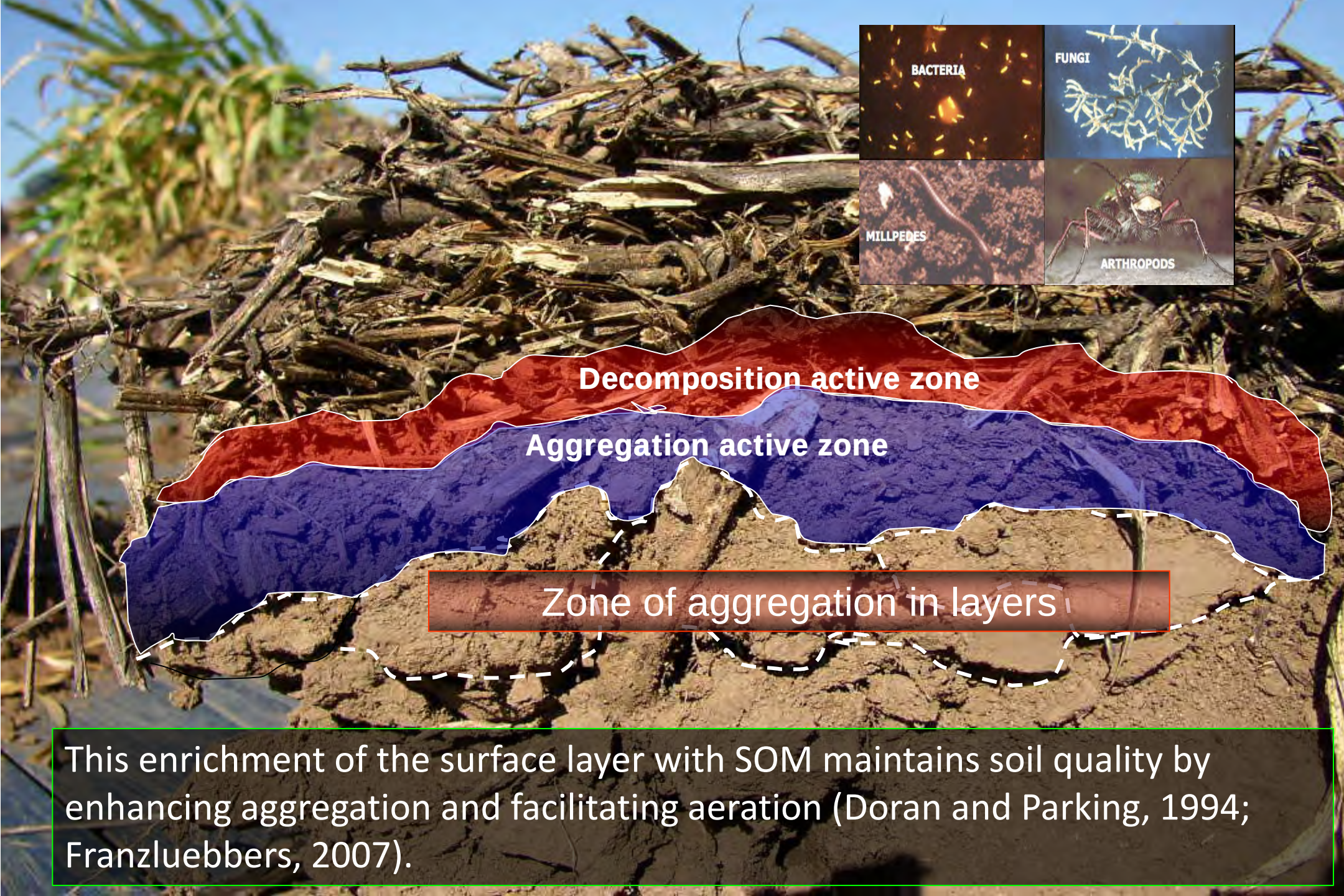
Bastardie, Capowiez *et al.* Biol Fertil Soils (2002) 36:161–169

Brown's Ranch

Same Field

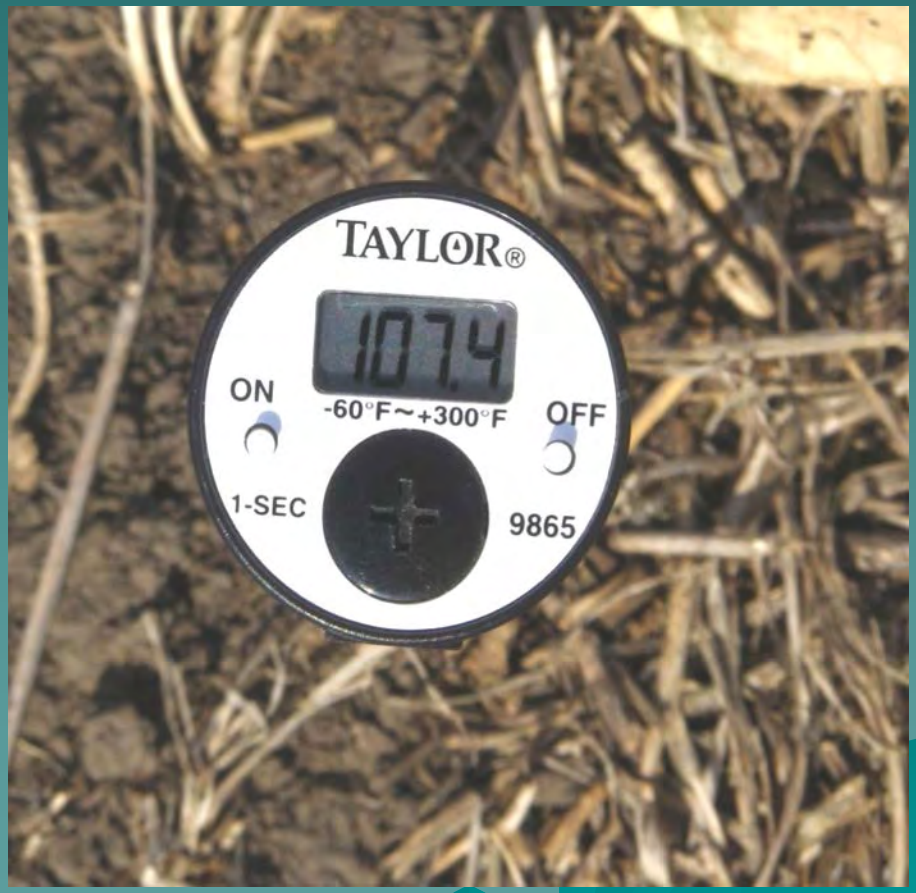
June 16, 2009
Corn planted into last years cover crop residue

July 1, 2009
Rapid residue decomposition



This enrichment of the surface layer with SOM maintains soil quality by enhancing aggregation and facilitating aeration (Doran and Parking, 1994; Franzluebbers, 2007).

Soil Temperatures



When soil temperature reaches...

140 F Soil bacteria die

130 F 100% moisture is lost through evaporation and transpiration

113 F

Some bacteria species start dying

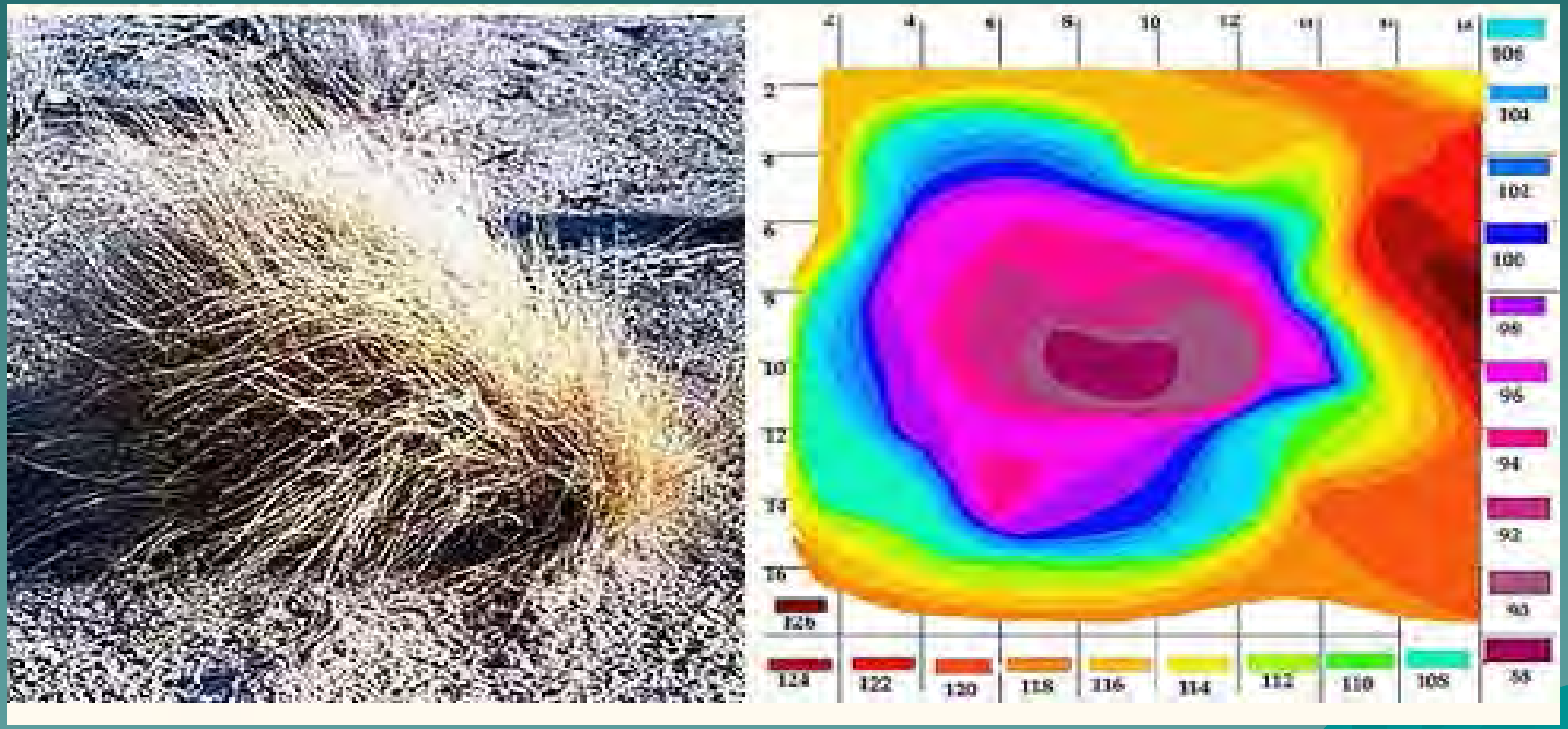
100 F 15% of moisture is used for growth
85% moisture lost through evaporation and transpiration

95 F

70 F 100% moisture is used for growth

J.J. McEntire, WUC, USDA SCS, Kernville TX, 3-58 4-R-12198. 1956

Plants Regulate Soil Temp and Moisture



http://www.ecoseeds.com/juicy.gossip.fourteen.html

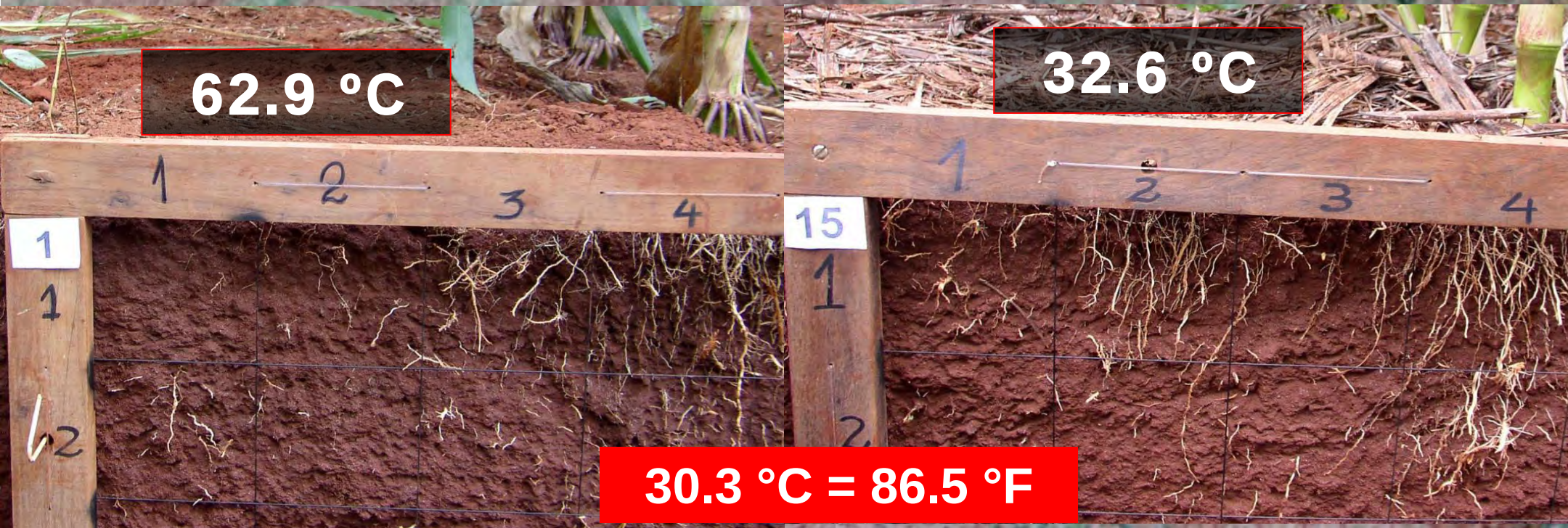
Soil temperature with 9.2 ton ha^{-1} (Brachiaria *Decumbens*) and without crop residues on the soil surface (NT - 10 years – GO, 16 ° SL)

(Two years average: 14/01/2003 and 13/01/2004 at 2pm)

No Crop Residues

9.2 ton ha^{-1}

Sá et al., 2004 and 2007




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

United States Department of Agriculture
Natural Resources Conservation Service

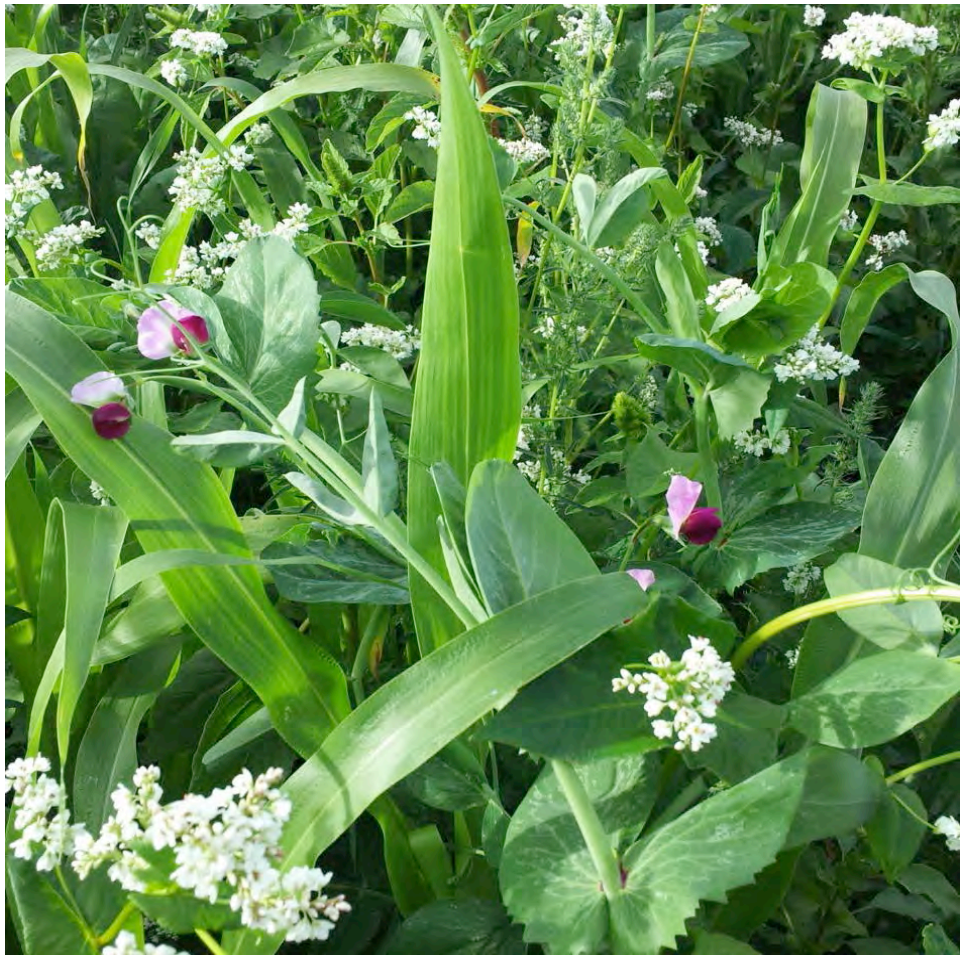
USDA NRCS

Curtis Furr Cotton planted into 8 Way Rye Cover Crop Mix

Brandon Rocky: Colorado

Cover Crop Mix:

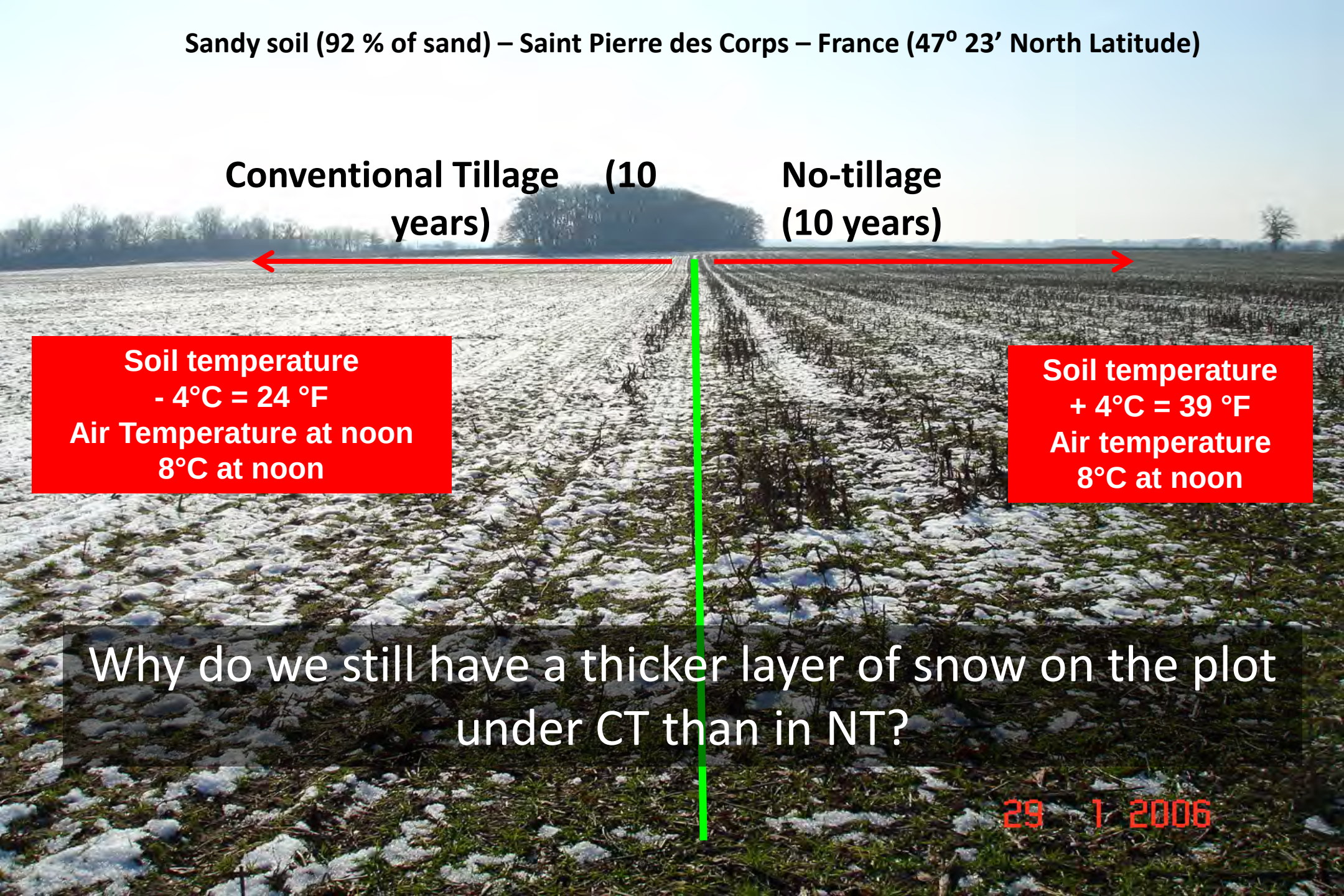
Cover Crop Mix



Winter Pea intercropped into Potato

20 years of similar tillage intensity and C inputs

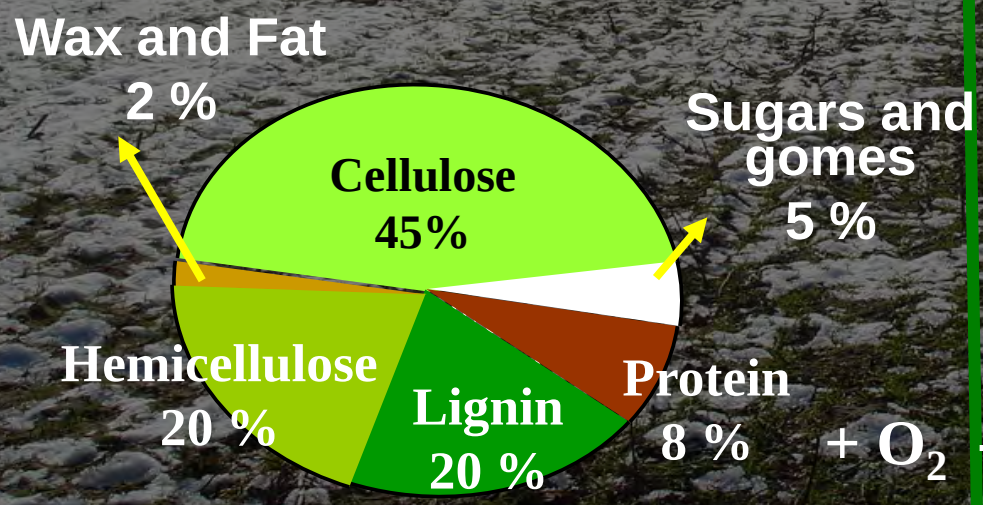
but contrasting types of organic inputs


Sandy soil (92 % of sand) – Saint Pierre des Corps – France (47° 23' North Latitude)
Conventional Tillage (10 years)
No-tillage (10 years)
Soil temperature - 4°C = 24 °F Air Temperature at noon 8°C at noon
Soil temperature + 4°C = 39 °F Air temperature 8°C at noon
Why do we still have a thicker layer of snow on the plot under CT than in NT?
29 1 2006

Sandy soil (92 % of sand) – Saint Pierre des Corps – France (47° 23' North Latitude)

Conventional Tillage (10 years) | **No-tillage (10 years)**

In sandy soils the silica is an excellent heat conductor and the freezing of water is higher, while the residues on the soil surface causing an insulating effect and the freezing is lower.

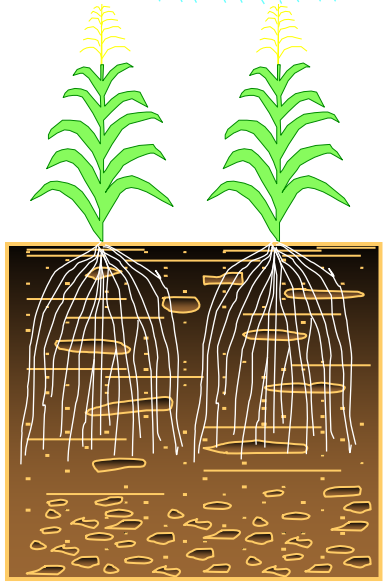


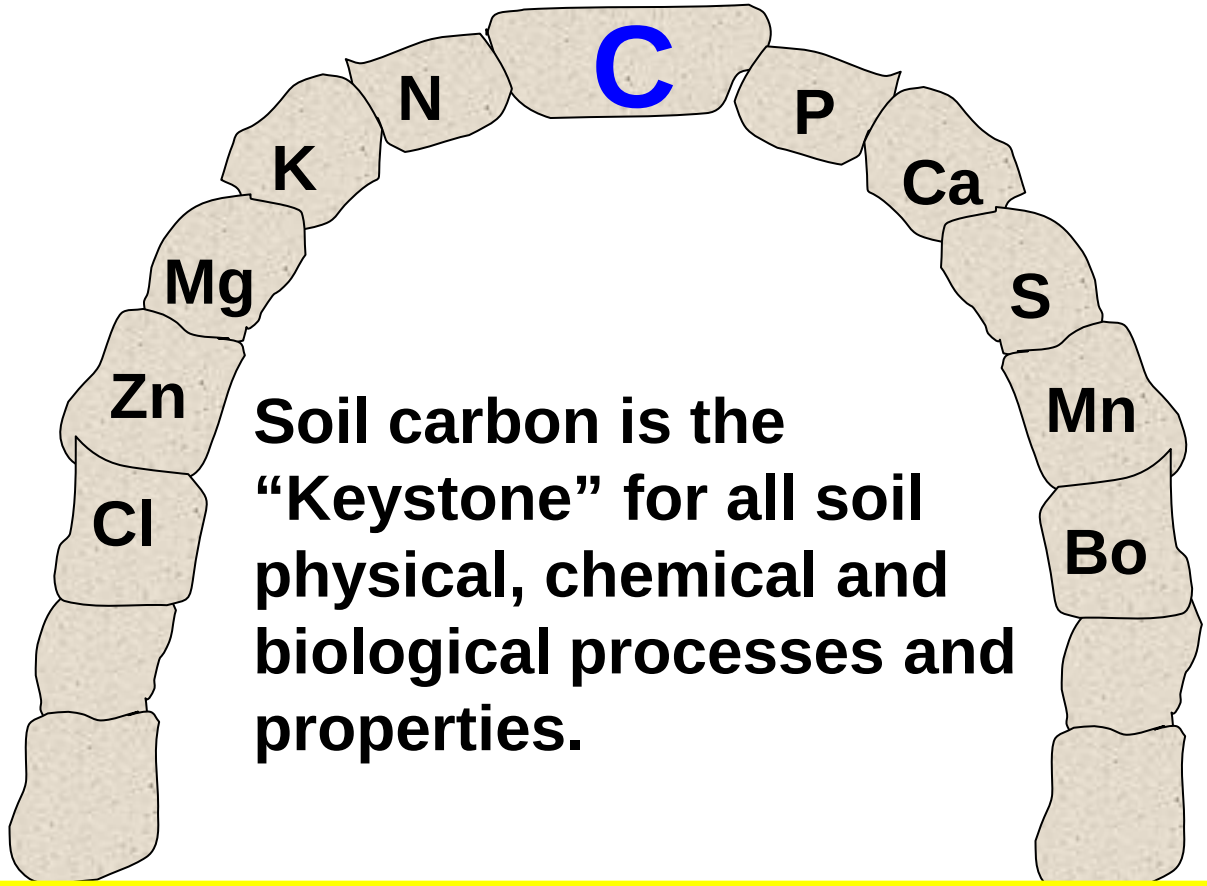
$+ O_2$ — Enzimatic oxidation → $CO_2 + H_2O$ + energy

CO_2

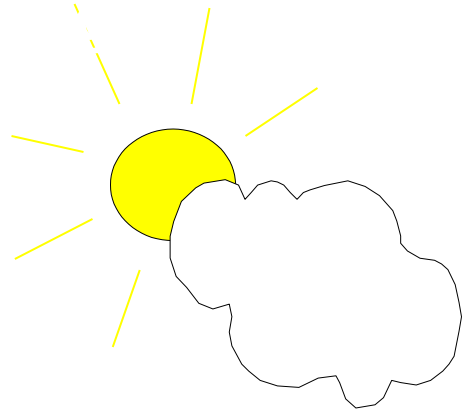
Heat

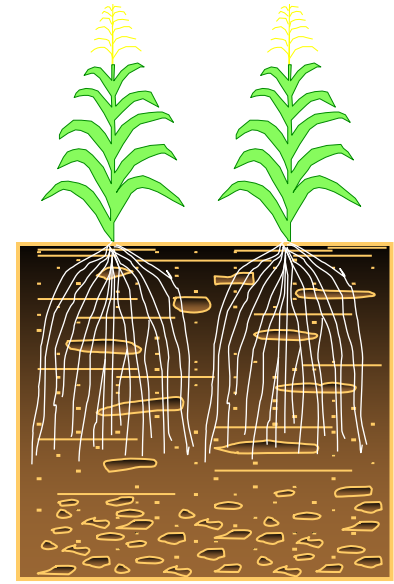
No-till has higher content of labile C and higher microbial population compared to conventional tillage. In this case, biological activity will be higher due to rising temperatures and therefore higher energy as heat is released.





Soil carbon is the "Keystone" for all soil physical, chemical and biological processes and properties.





Management platform

Dr. D.C. Reicosky, ARS, Morris, MN.

Ohio 2012 Drought:

Vertical Tillage

No-till With Covers

Building Soil

How did nature make all that soil in the first place?

Mimic Nature grazing template: Mob tall grazing (250k-500k lbs./ac.)

- Reduce individuality, it stimulates aggressive, less selective grazing habits.
- Aggressive grazing is primal instinct that herbivores must relearn

Mimic Nature grazing template:

- High numbers stomp, chip and shred unused grass onto the soil surface to increase biogeochemical nutrient cycling

High Density Grazing

Ultra High Density Grazing

Tundra?

Layers enjoying the cover crop

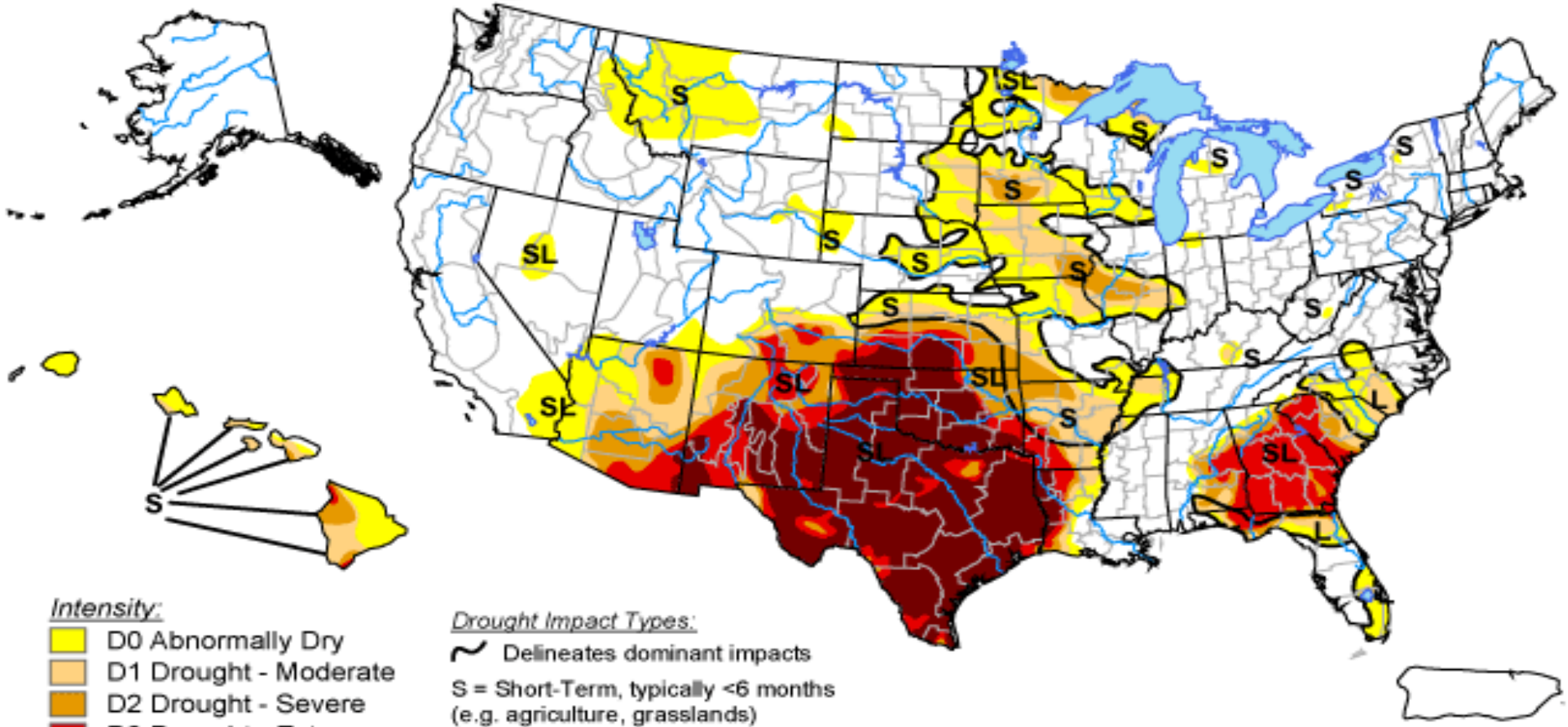
Next Move


09/17/2009

Noxious weeds: 20 years of no animal impact (Symptom)

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)

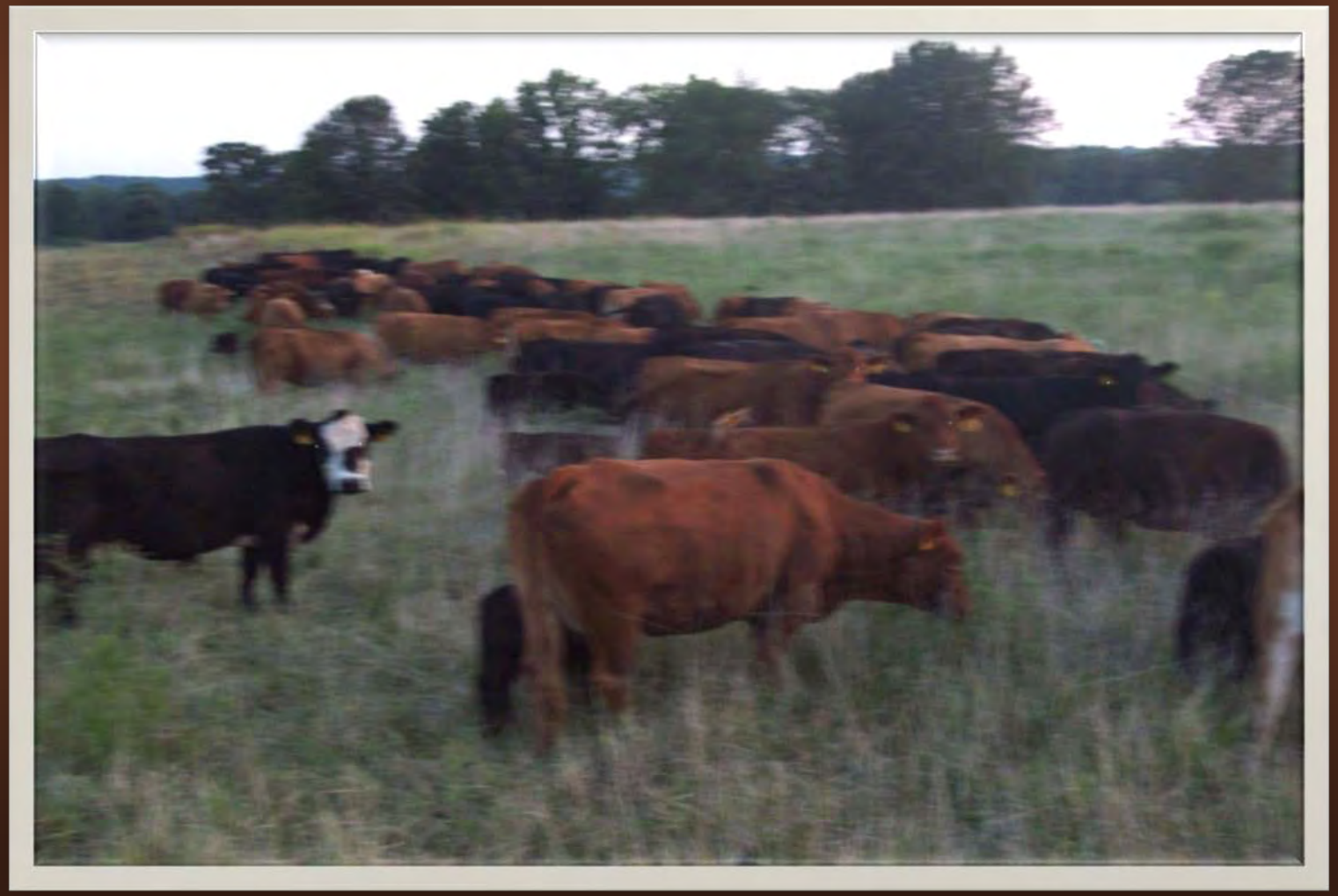
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/

USDA | National Drought Mitigation Center | NOAA

Released Thursday, October 6, 2011
Author: Rich Tinker, CPC/NCEP/NWS/NOAA

May 5, 2008- Started Moving cows 2 times per day



Weed and Brush Control

Smooth Sumac in St. Clair County

Neighbor's Pastures **2011 Drought** Mark Brownlee's Pastures

February 2010

Strip Grazed Hayfield – Fall Re-Growth

Tom Matoushek

Tom Matoushek

Gabe Brown 6000 acres:

A 4 Week Supply Based on 3% of Body Weight


May 2009

Bale Grazing Results **Tame** Pastures

Pasture With Bale Grazing

8573 lbs/ac
11.95% Crude Protein
59.43% TDN

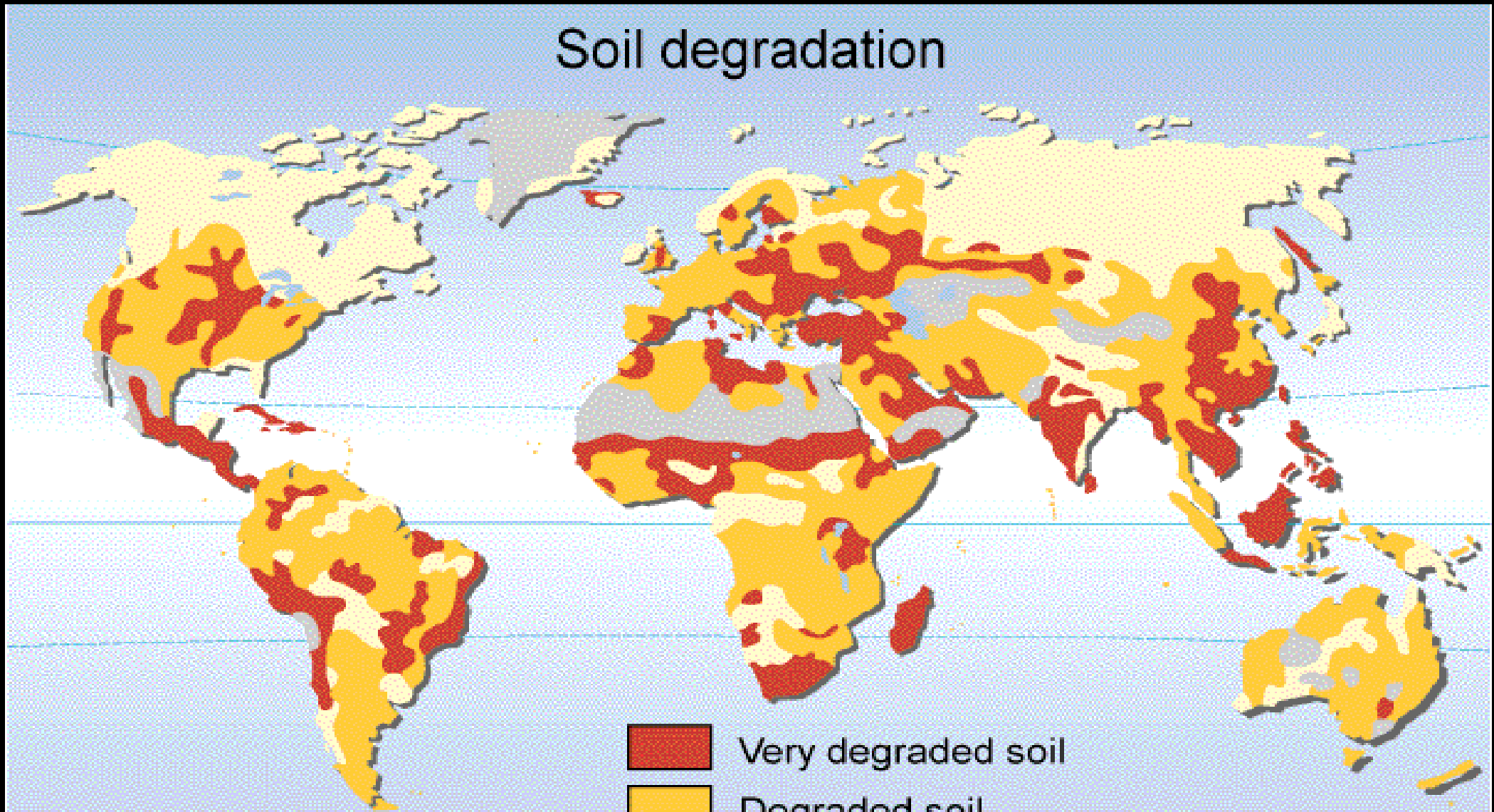
Pasture Without Bale Grazing

2559 lbs/ac
7.96% Crude Protein
60.70% TDN


DAY
HOUR
MIN
CLEAR
CLOCK
ENTER
BattyLatch
Automatic
GATEWAY
RELEASE
TIMER
Novel Ways
Ph:+64 7 856 6270
info@novel.co.nz
www.novel.co.nz
11.19.2010

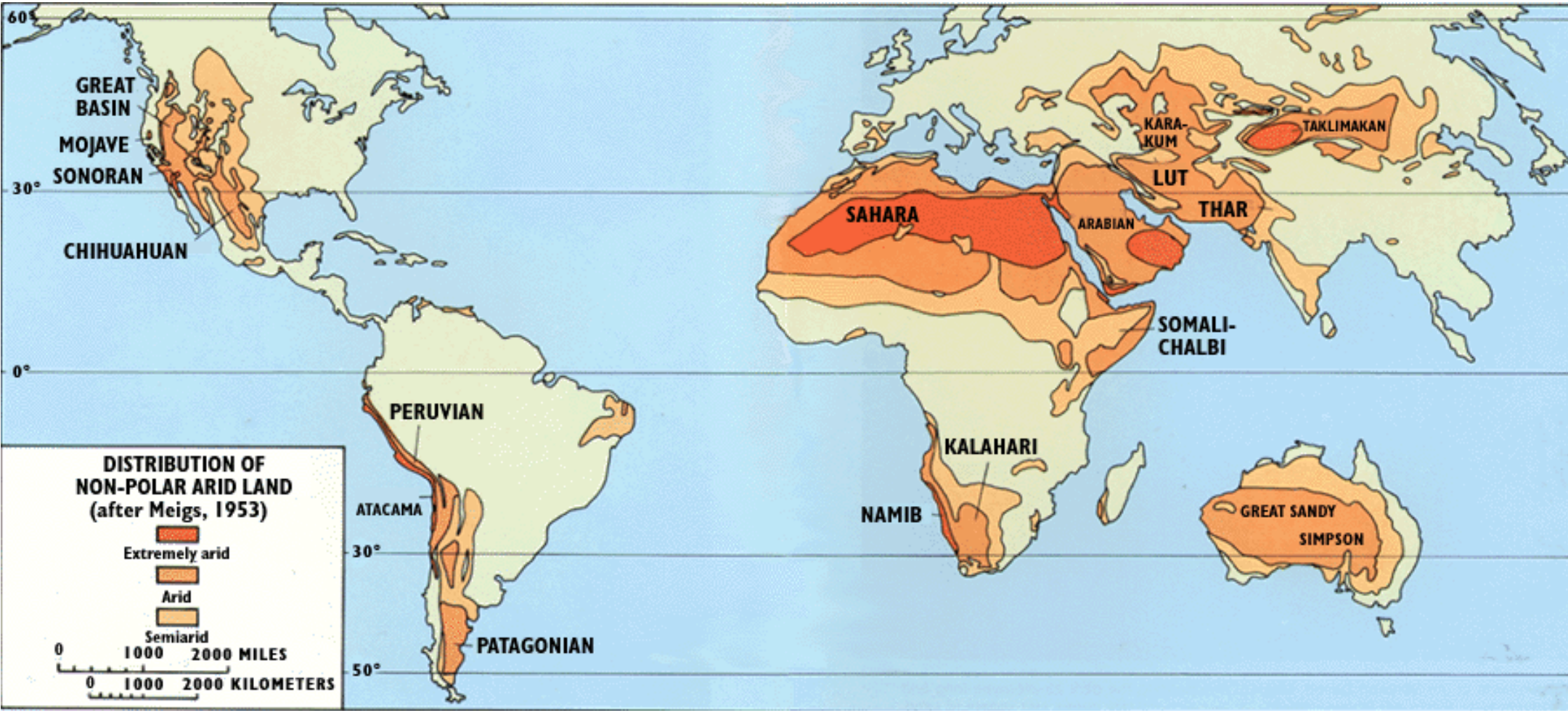
Why Should We Care? Future World Challenge!

Soil degradation



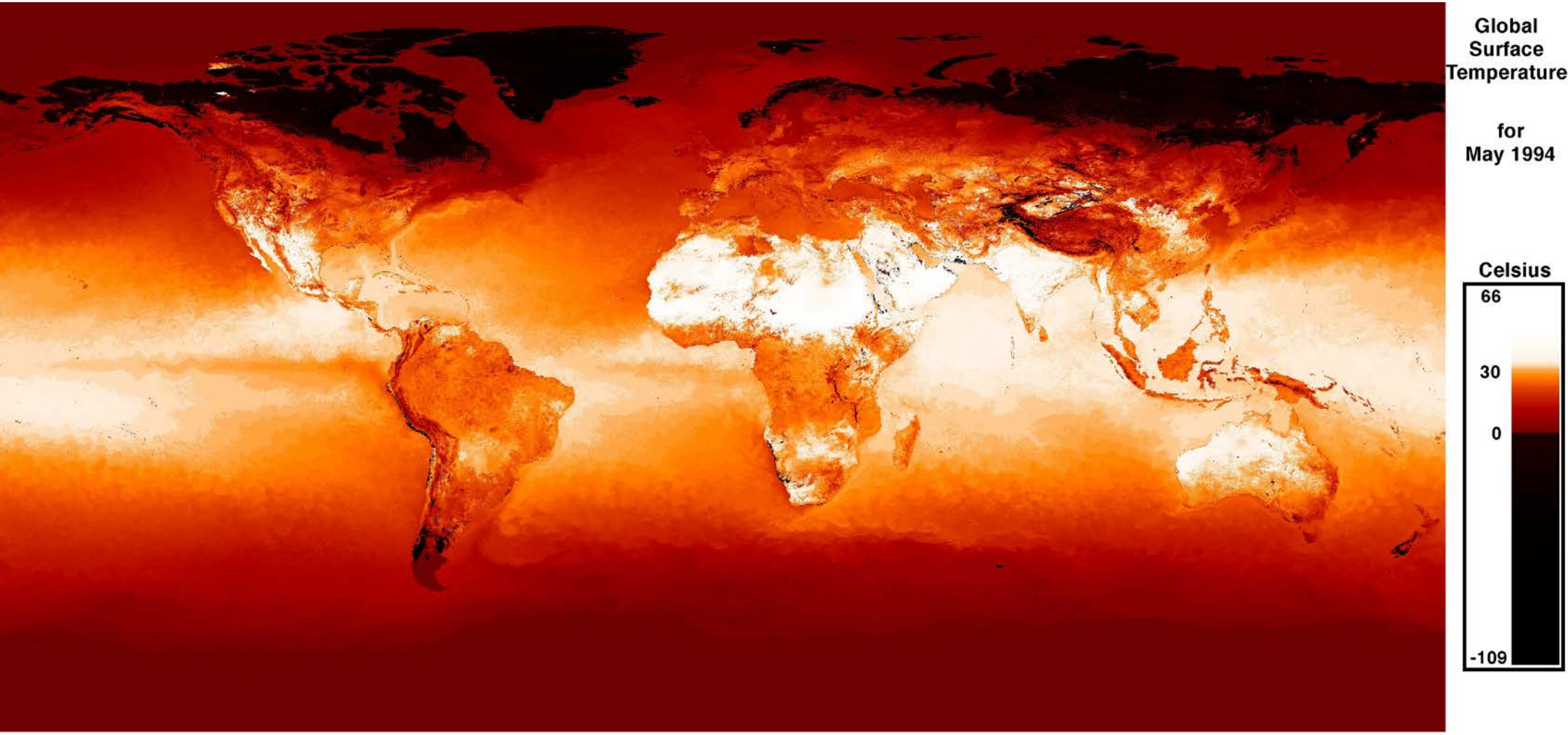
UNEP GRID Arendal

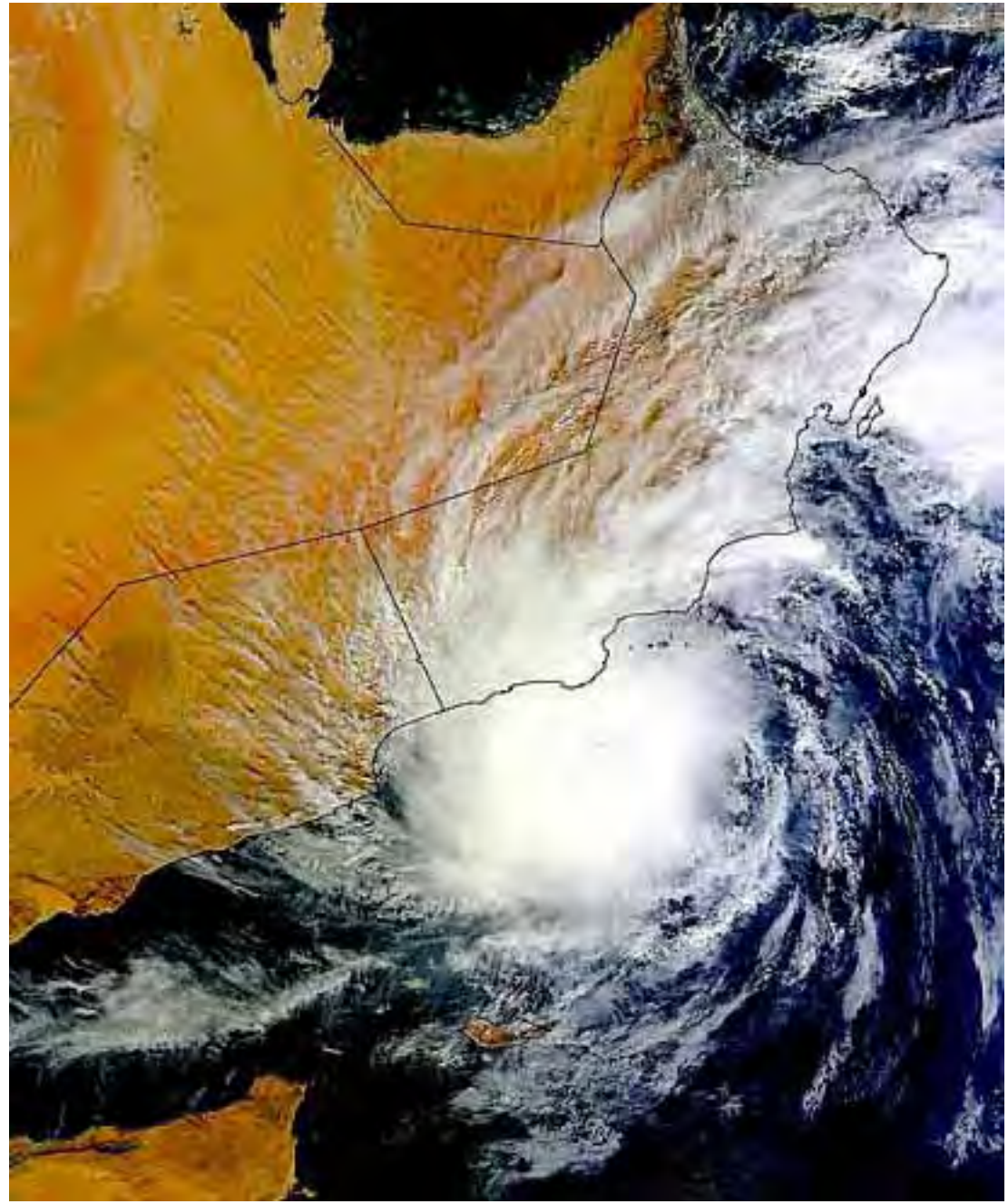
Arid Lands



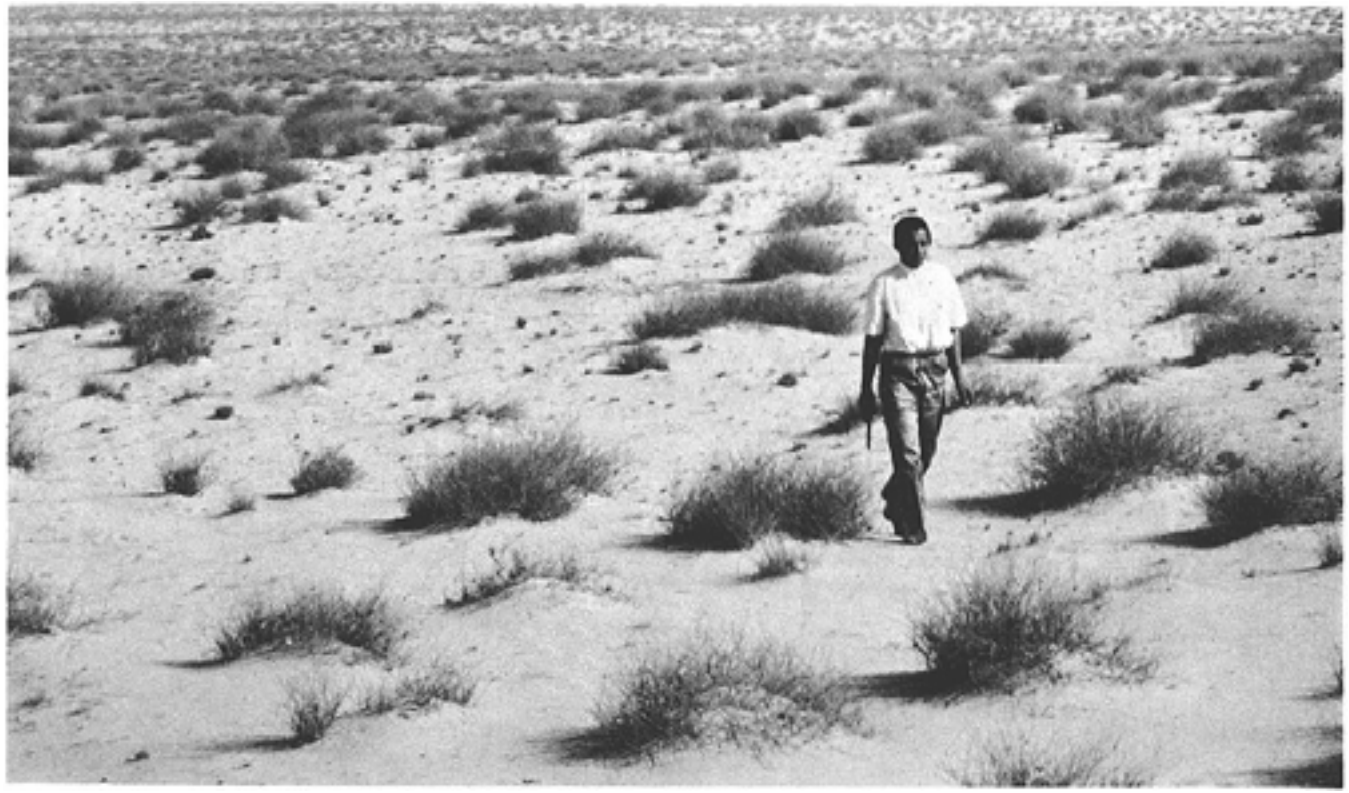
geology.com

Soil Temps All Over the World

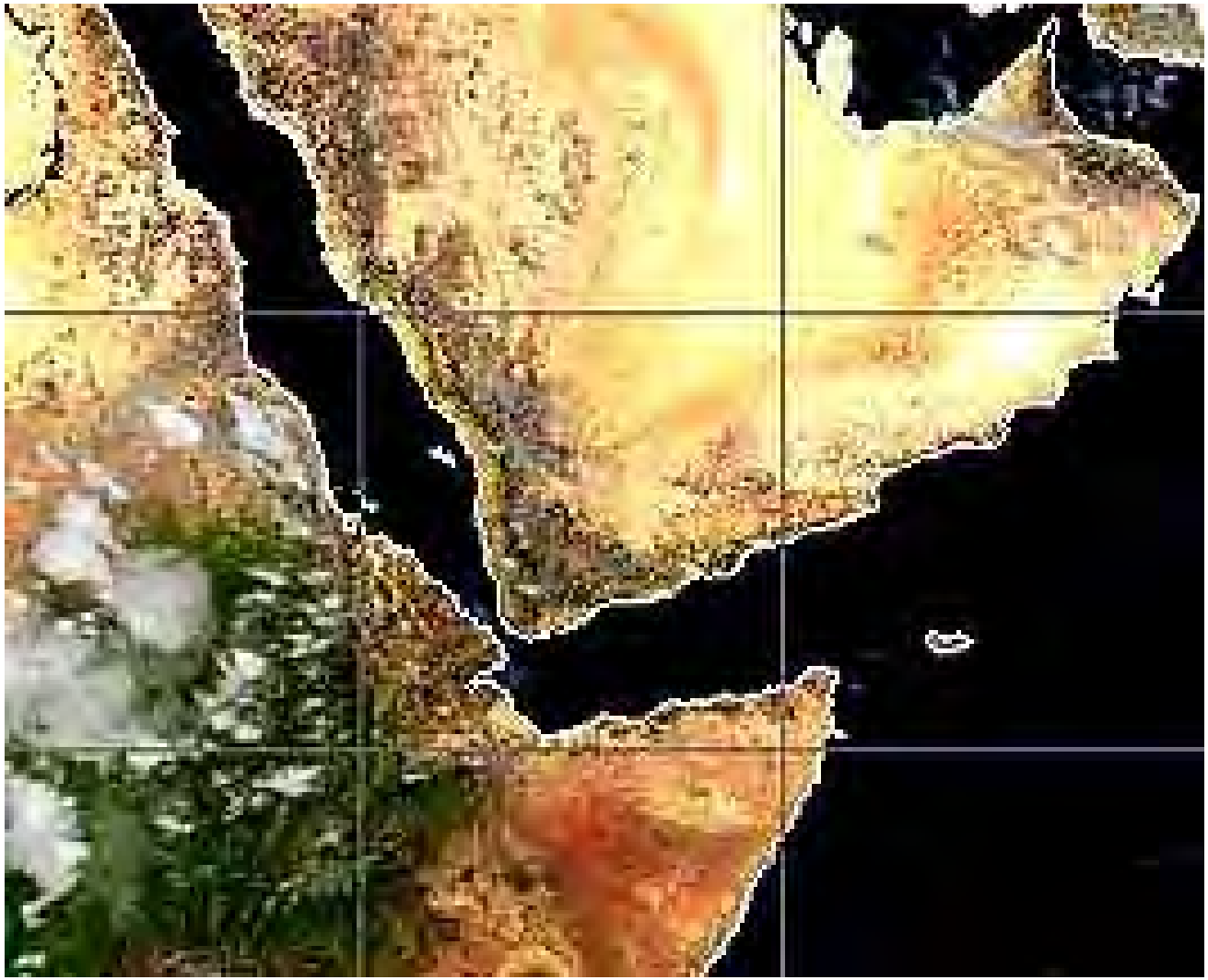




1961 Photo: Sahara Deseret



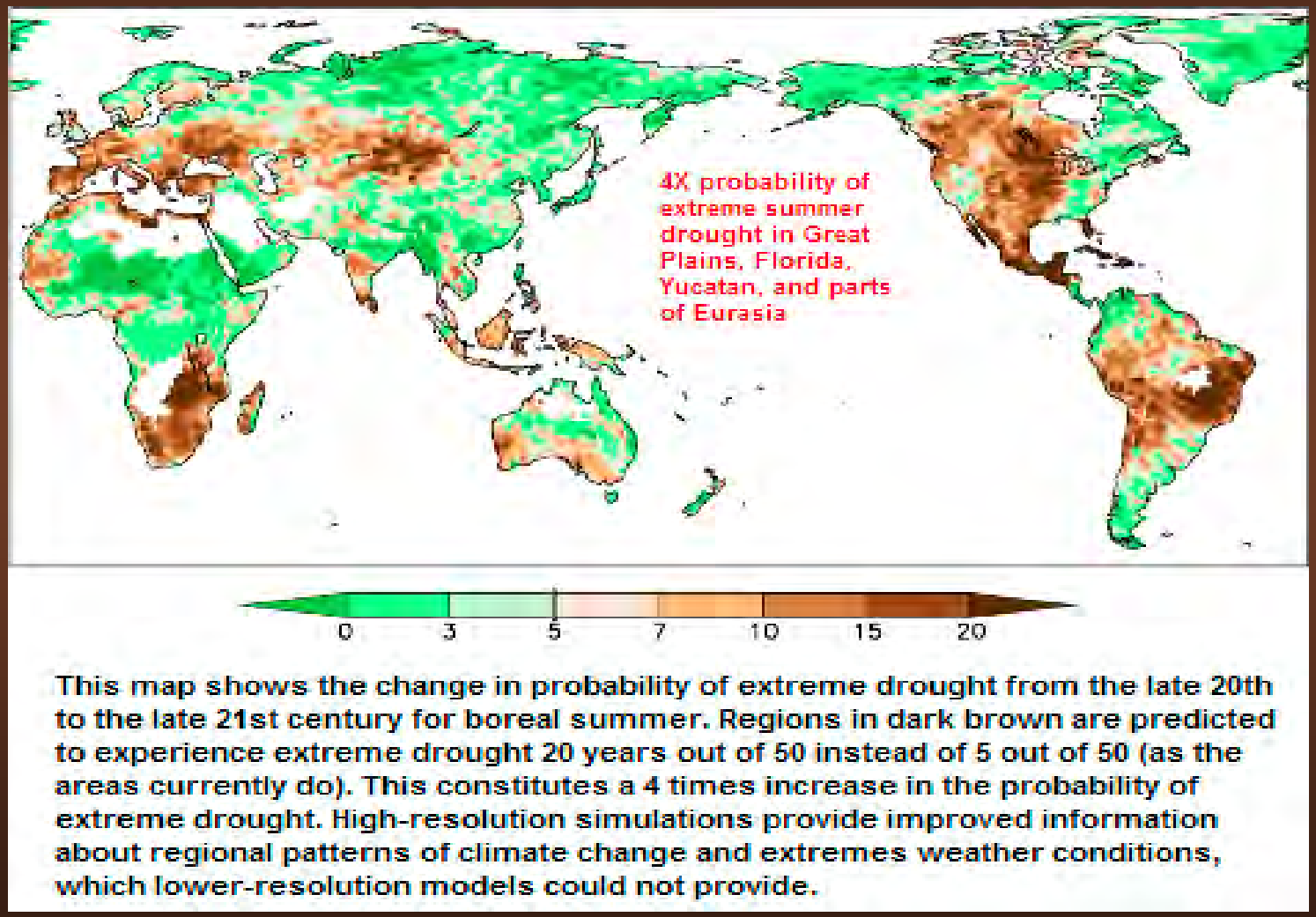
Re-vegetation brings the Rain



Answer: Ecological Restoration

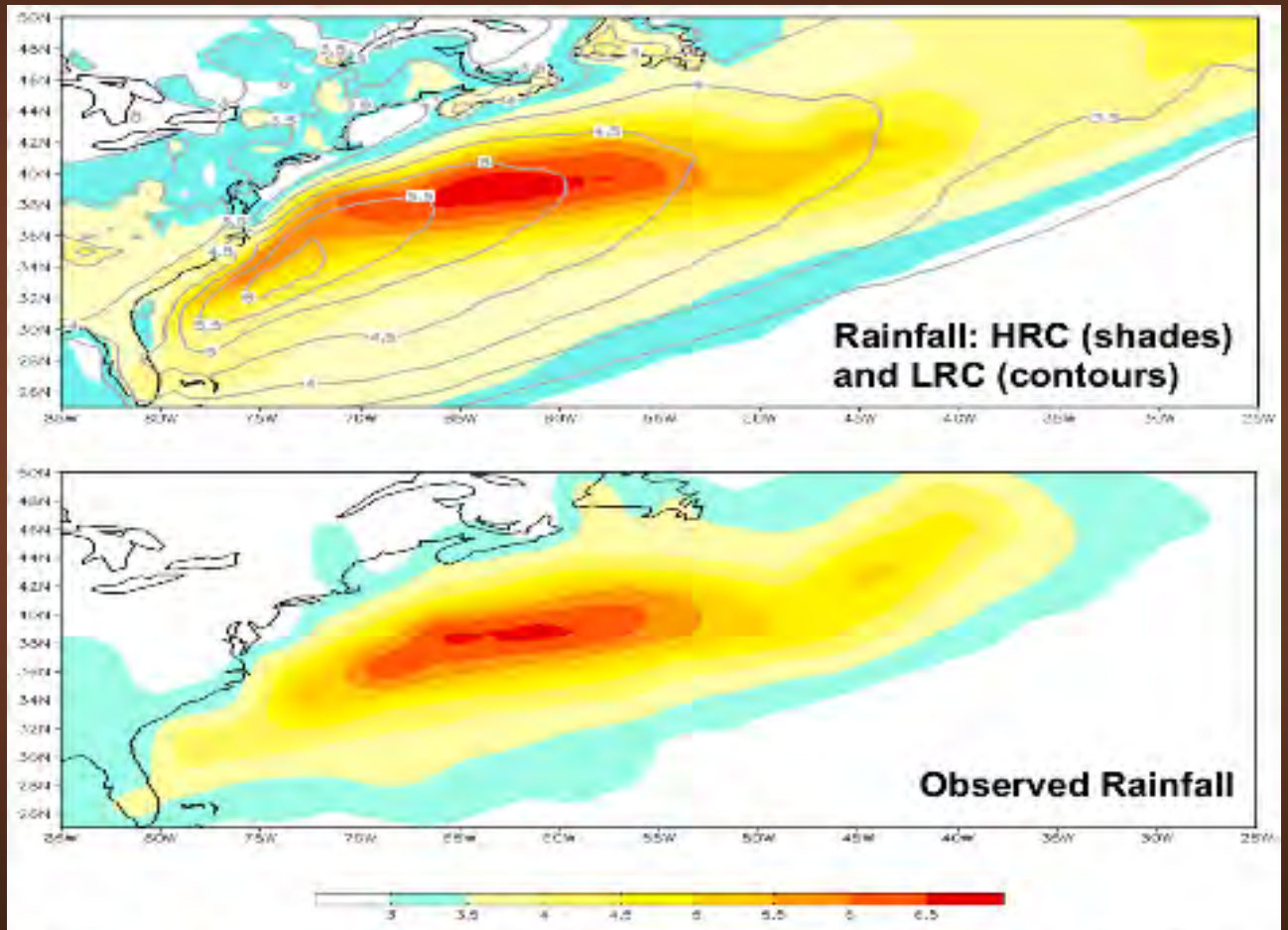
Restoration

James Kinter, director of the Center for Ocean-Land-Atmosphere Studies at the Institute of Global Environment and Society,



This map shows the change in probability of extreme drought from the late 20th to the late 21st century for boreal summer. Regions in dark brown are predicted to experience extreme drought 20 years out of 50 instead of 5 out of 50 (as the areas currently do). This constitutes a 4 times increase in the probability of extreme drought. High-resolution simulations provide improved information about regional patterns of climate change and extremes weather conditions, which lower-resolution models could not provide.

James Kinter, director of the Center for Ocean-Land-Atmosphere Studies at the Institute of Global Environment and Society,



Research by Kinter's collaborators showed that low-resolution models of the East Coast Gulf Stream put rain associated with the weather pattern in the wrong place, whereas high-resolution models delineate the bands of rain off the East Coast with accuracy.

In The African Sahel:
Trees Stop Sahara Desert

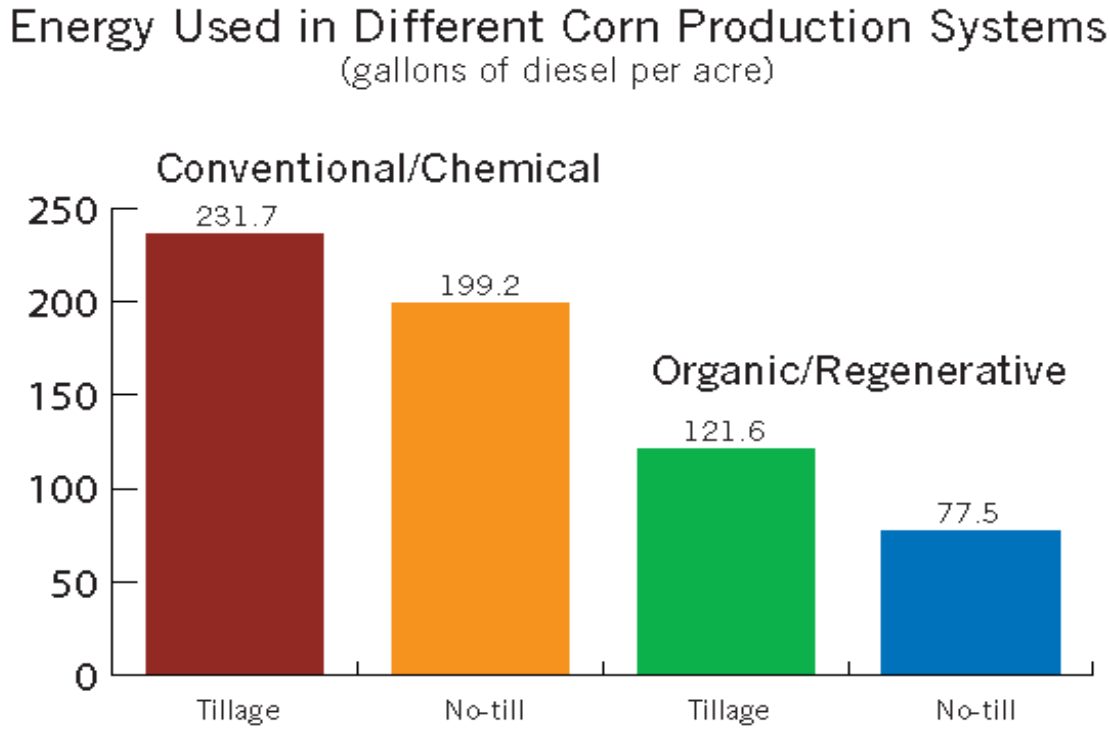
Bruce Wight NRCS National Forester (E&E News July 2012)

Energy Information Administration (EIA) (2008) Report : Estimated world oil consumption for the next 21 years (2009 to 2030)

Country/Region	Estimated Percent Increase
United States	6.3%
China	71.4%
India	58.8%
Middle East	42.0%
Africa	33.6%
Central and South America	29.4%
Total World	**25.2%**

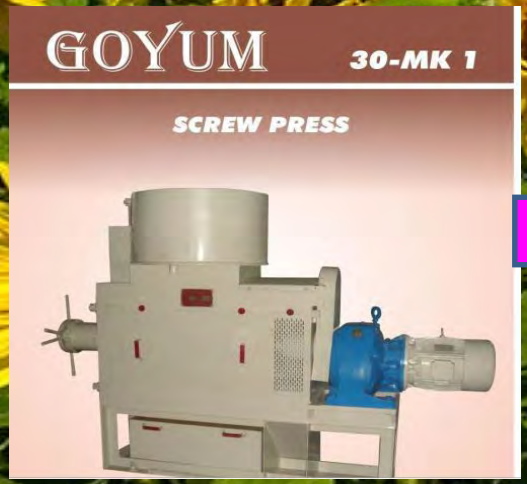
China and India combined will increase there oil consumption by 65.1% in next 21 years

Healthy Soils Save Oil and Toil!



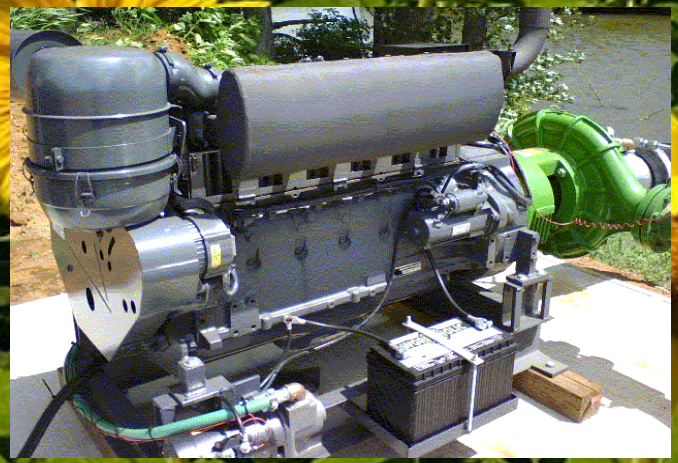
Regenerative organic systems sharply reduce energy use, according to research by David Pimentel, Ph.D.

Use Soil to make oil (biodiesel) for Transport, Planting, Spraying, and harvesting!



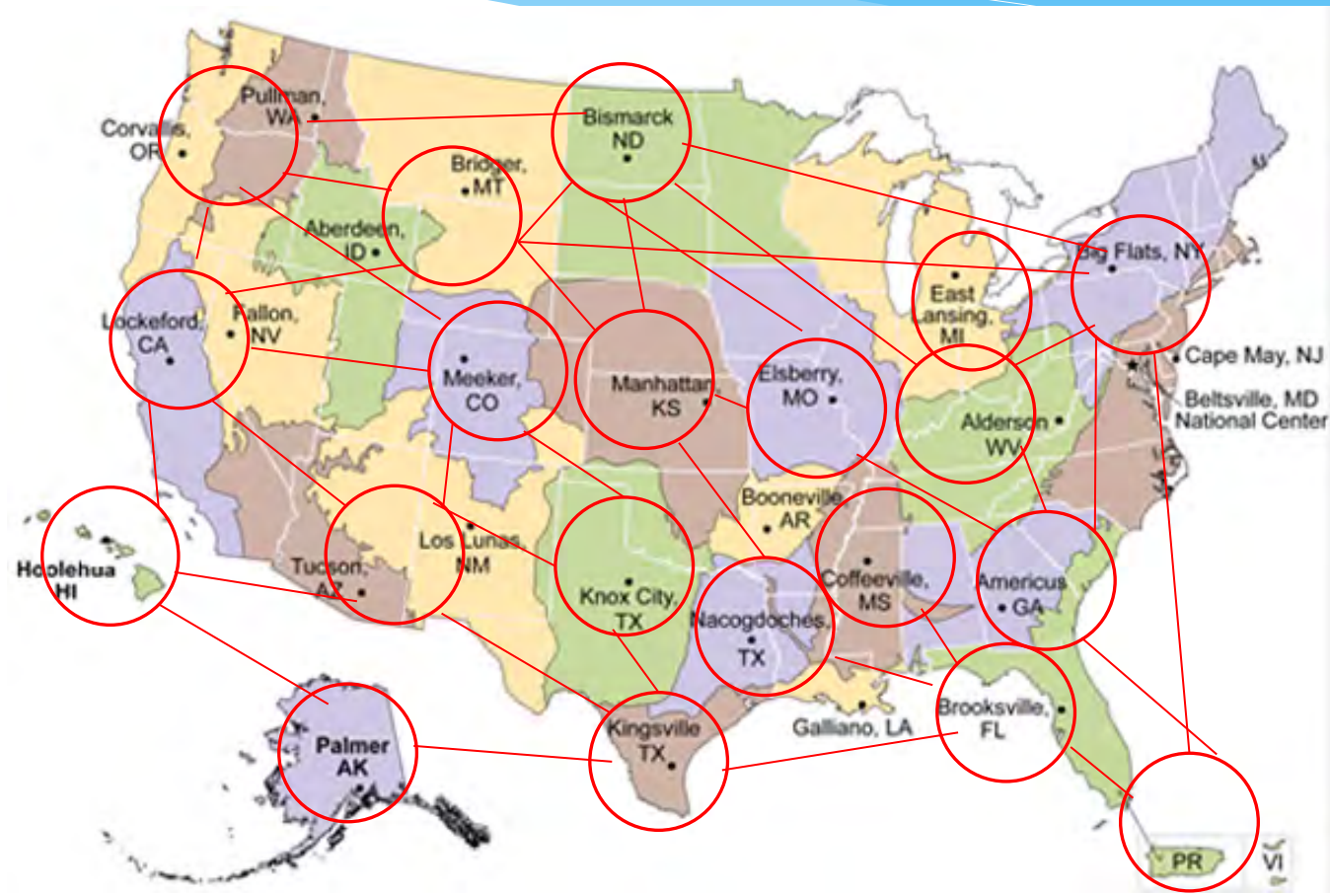
http://www.journeytoforever.org/biodiesel_link.html

Use Soils to make oil for irrigation!



http://www.journeytoforever.org/biodiesel_link.html

Creating Soil Health Demonstration Farms: Centers of Sustainability



ND Soil Health Center

ND PMC

150 acres

Cluster or Network of SH Farms

Missouri Chariton County SWCD Soil Health Center

Farm

Farm

Farm

Farm

Farm

110 acres

Cluster or Network of SH Farms

David Brandt Soil Health Center (Ohio)

Farm

Farm

Farm

Farm

Farm

Cluster or Network of SH Farms

Healthy Profit$ From Healthy Soil$

Soil Health Conference: Farming like Nature: “The Supreme Farmer”!


" it is time for the United States to STOP paying for the degradation of the soil!"

“You and your generation have a choice to make and the entire planet lies in the balance! You can continue the way your parents did and the planet will surely perish with you. Or, you can take what you know, never by afraid to try something new, continue to learn and ask questions, and completely change the face of agriculture, feed a growing planet along the way and hand the planet to your kids with much more pride than i am handing it to mine!! YOU have been CHOSEN to protect the planet while feeding it's people, an honor very few get! And, the planet is not handed to you from your parents, you are borrowing it from your kids!! “

Gail Fuller Kansas Farmer