Mitigating and Adapting to Climate Change with Regenerative Organic Agriculture

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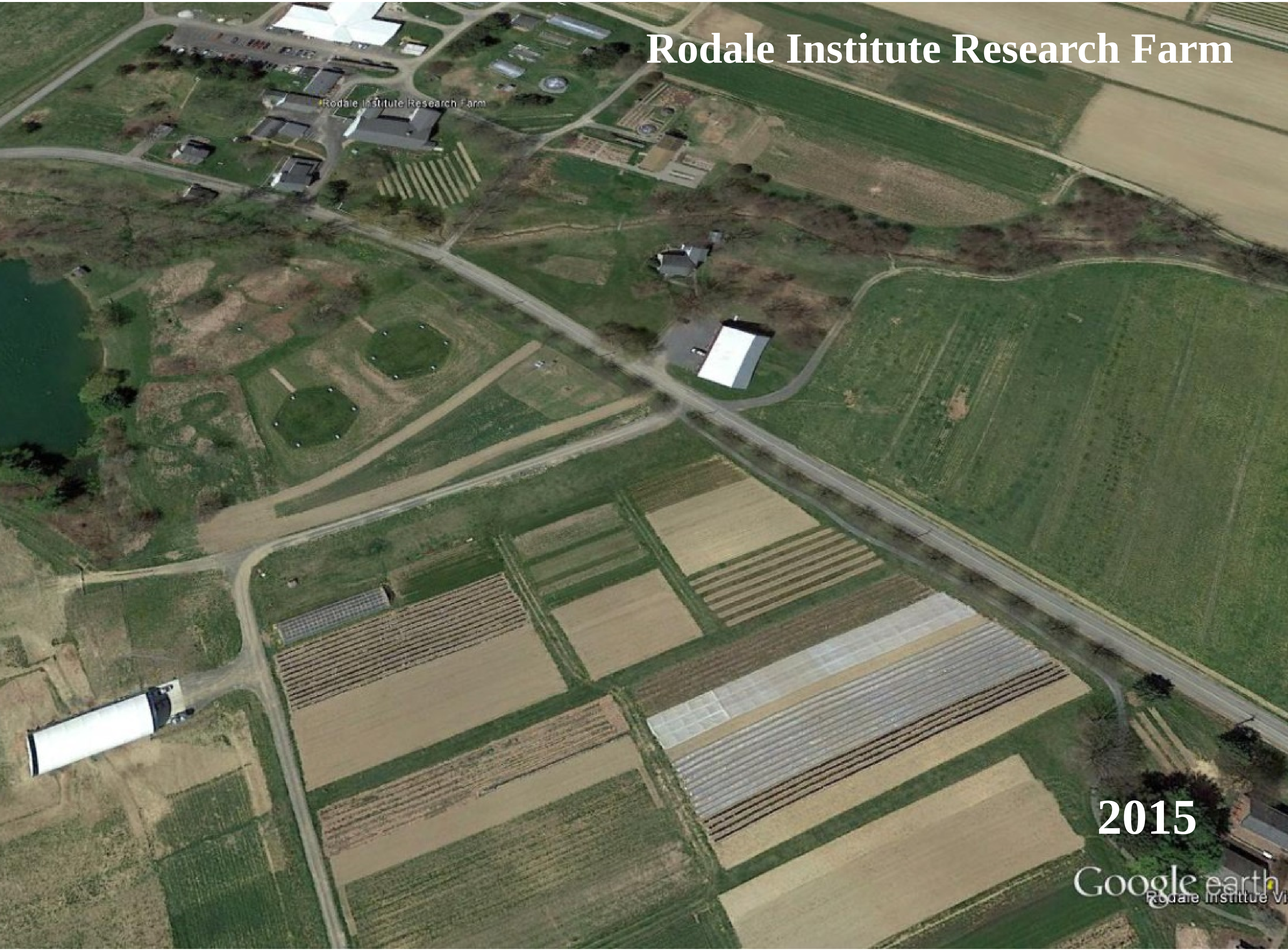
Rodale Institute Research Farm


Rodale Institute Research Farm
Rodale Institute Research Farm
2015
Google earth

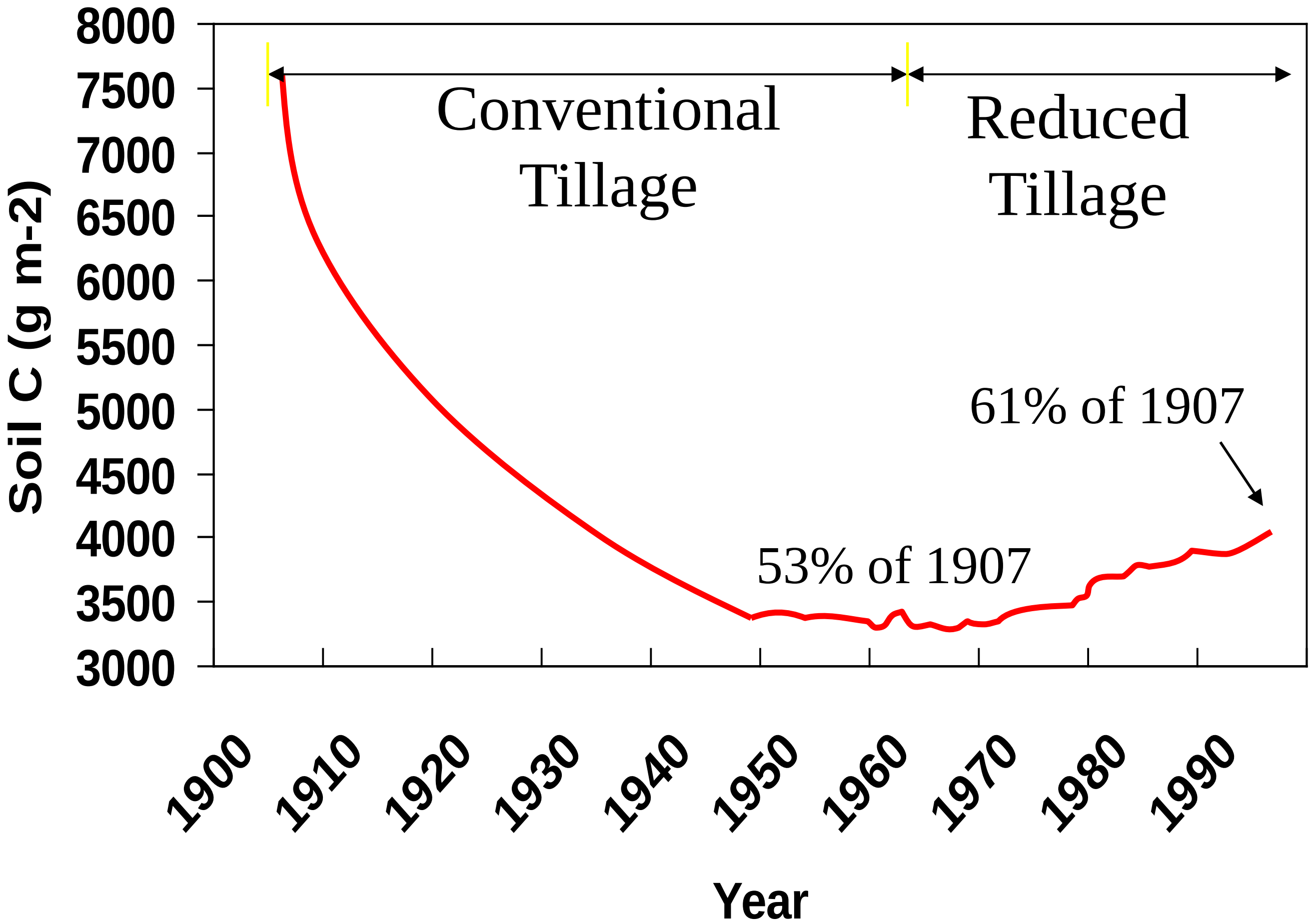
J.I. Rodale – Organic Agriculture

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

Wrote on a blackboard in 1942.

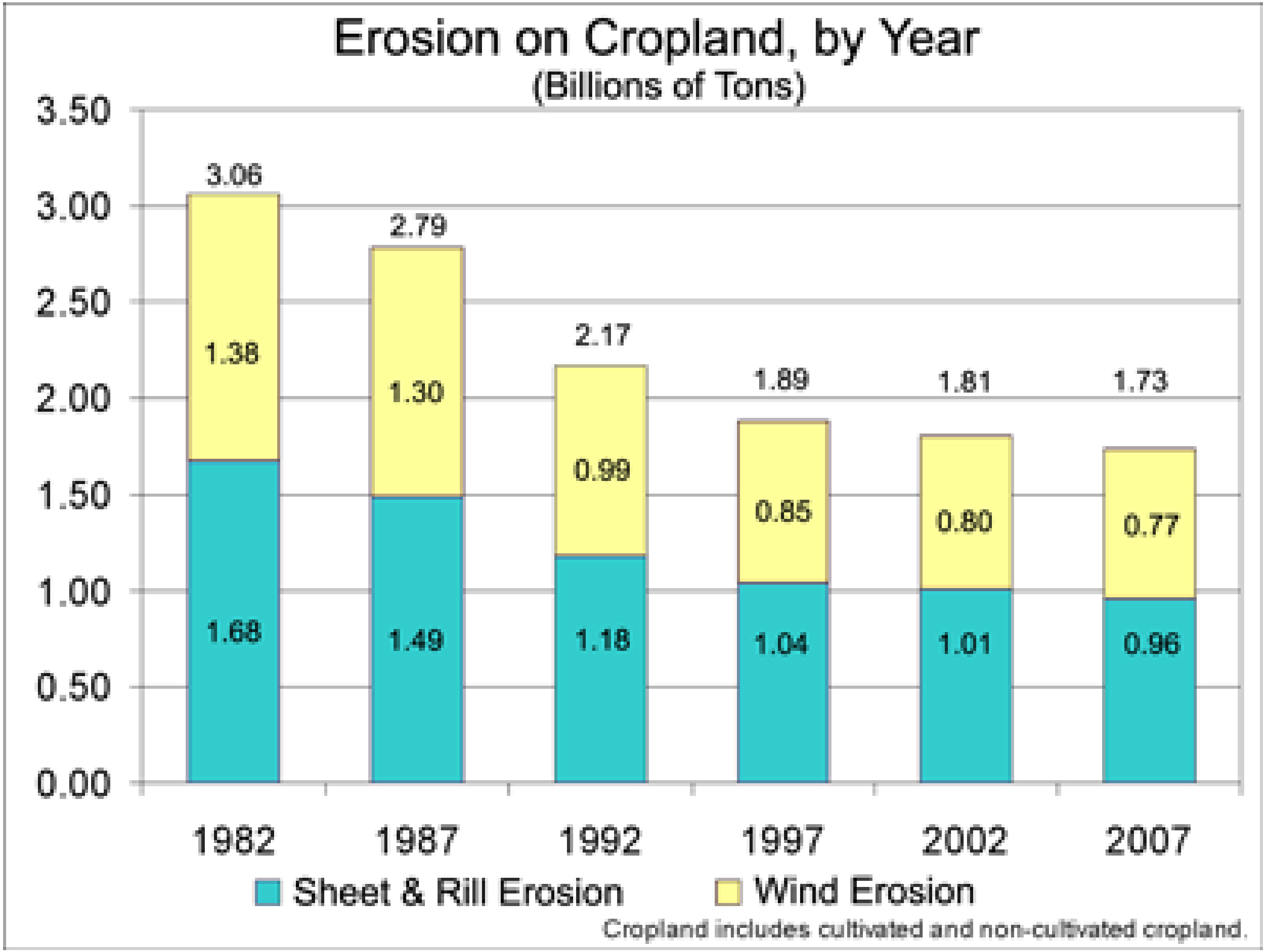

The Carbon Problem
Soils Deficient in Carbon
Dave Brandt Farm
Carroll, Ohio
10.15.2013

The Carbon Problem

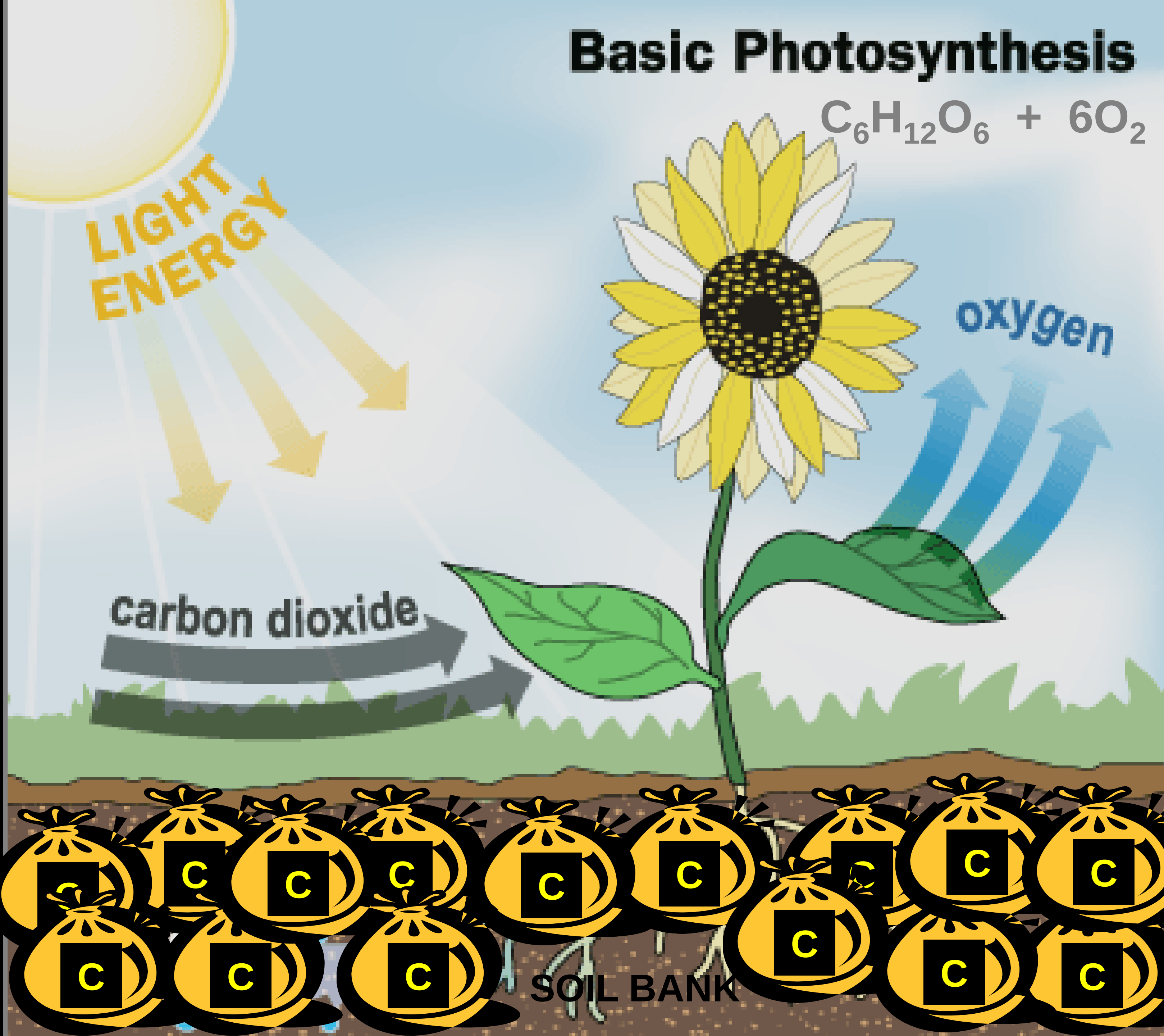


From Lal et al., 1998

Texas Dust Storms in 1930s and 2012



Erosion on Cropland, by Year
(Billions of Tons)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
3.06
2.79
2.17
1.89
1.81
1.73
1.38
1.30
0.99
0.85
0.80
0.77
1.68
1.49
1.18
1.04
1.01
0.96
1982
1987
1992
1997
2002
2007
Sheet & Rill Erosion
Wind Erosion
Cropland includes cultivated and non-cultivated cropland.


Basic Photosynthesis
$C_6H_{12}O_6 + 6O_2$
LIGHT ENERGY
oxygen
carbon dioxide
C
SOIL BANK

What does Solving the Carbon Problem do?

- **Mitigates climate change while helping crops thrive under weather uncertainty.**
- **Increases\Improves:**

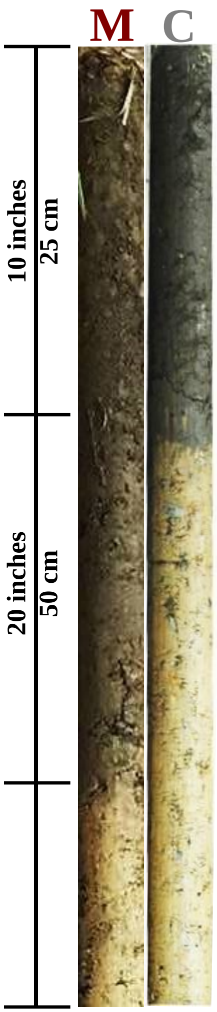
1. Healthier People
2. Biological activity – growth and diversity of microflora
3. Water infiltration, holding capacity, quality, and efficiency of use
4. Soil tilth and structure
5. Natural fertility – nutrient cycling and storage and capacity to handle manure
6. Cation and anion exchange capacity
7. Adsorption of pesticides

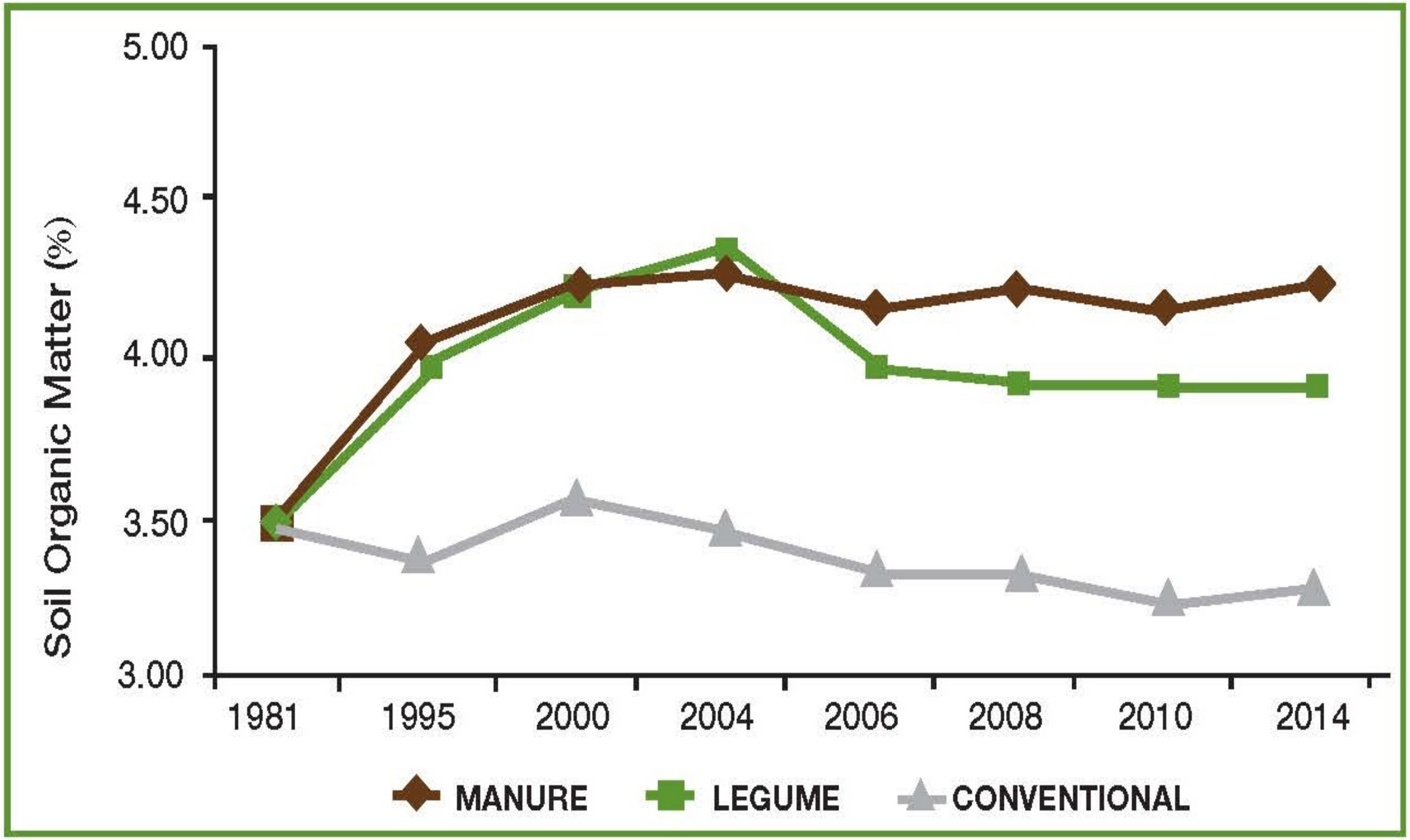
Carbon is the hub, each spoke is an environmental benefit which adds strength and support to the wheel to maintain environmental quality.

- **Decreases\Reduces:**

1. Soil erosion
2. Soil compaction
3. Air pollution

FST Soil Carbon Data – Kutztown, PA



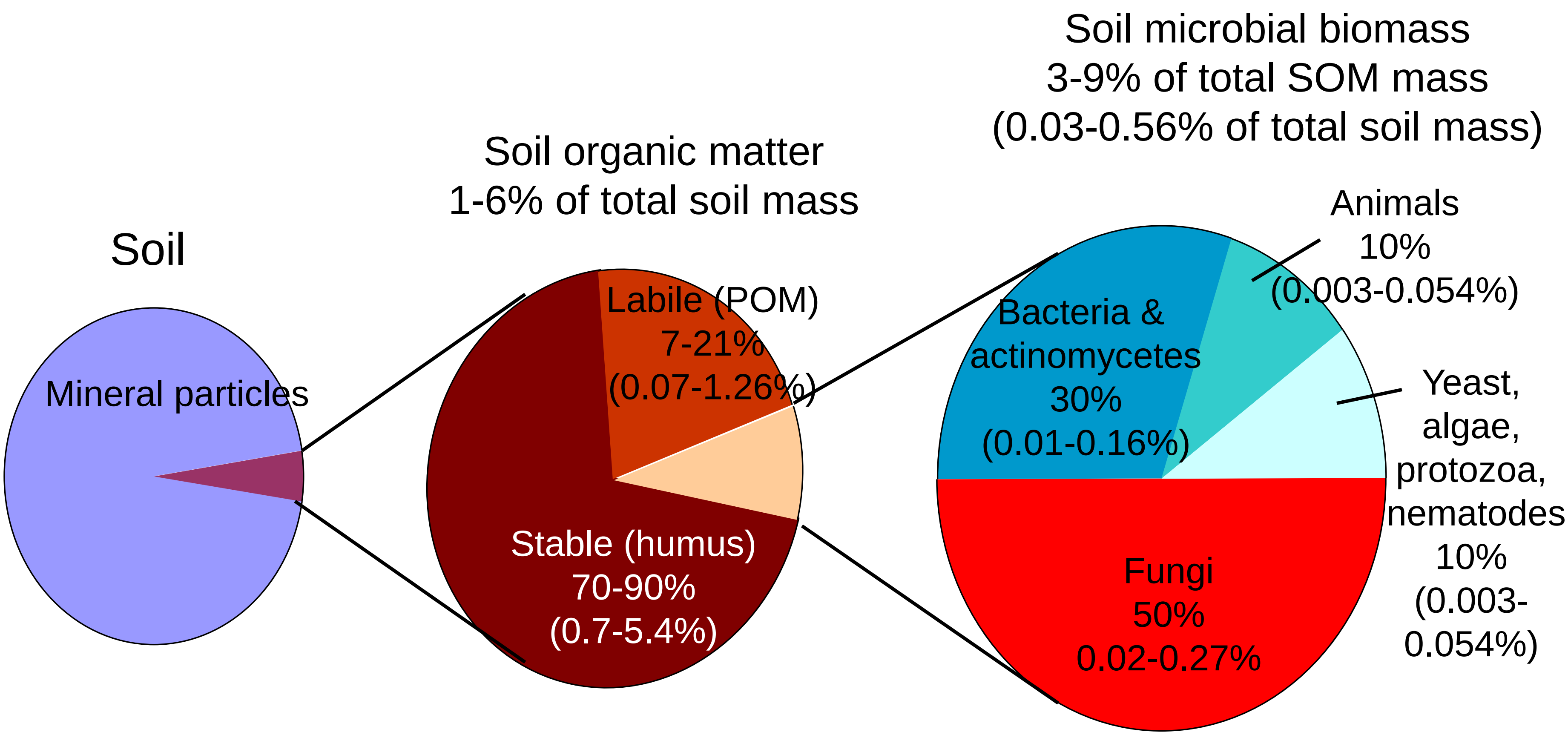


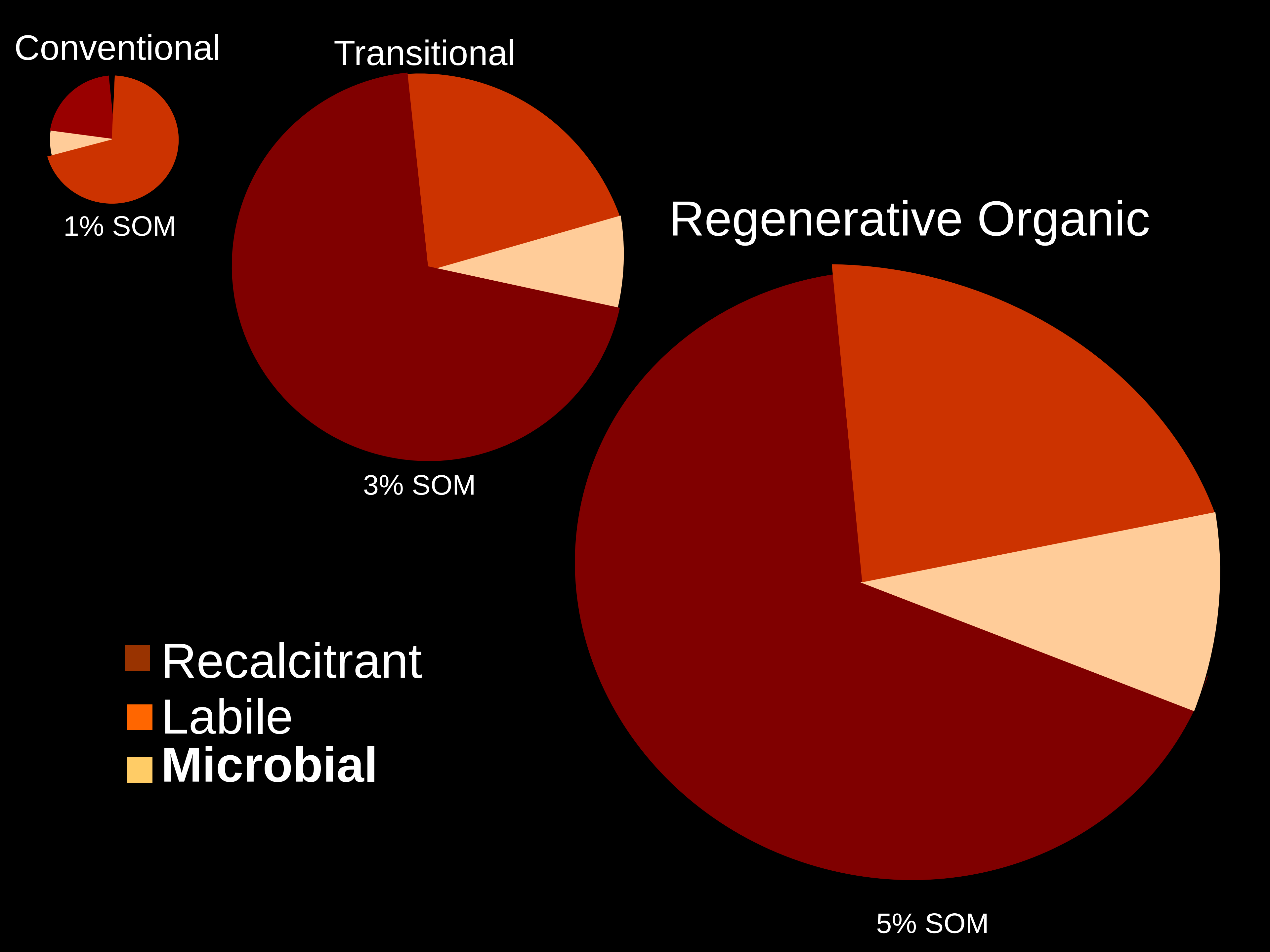
Growing topsoil in decades rather than centuries.

FST Soil Results – Kutztown, PA

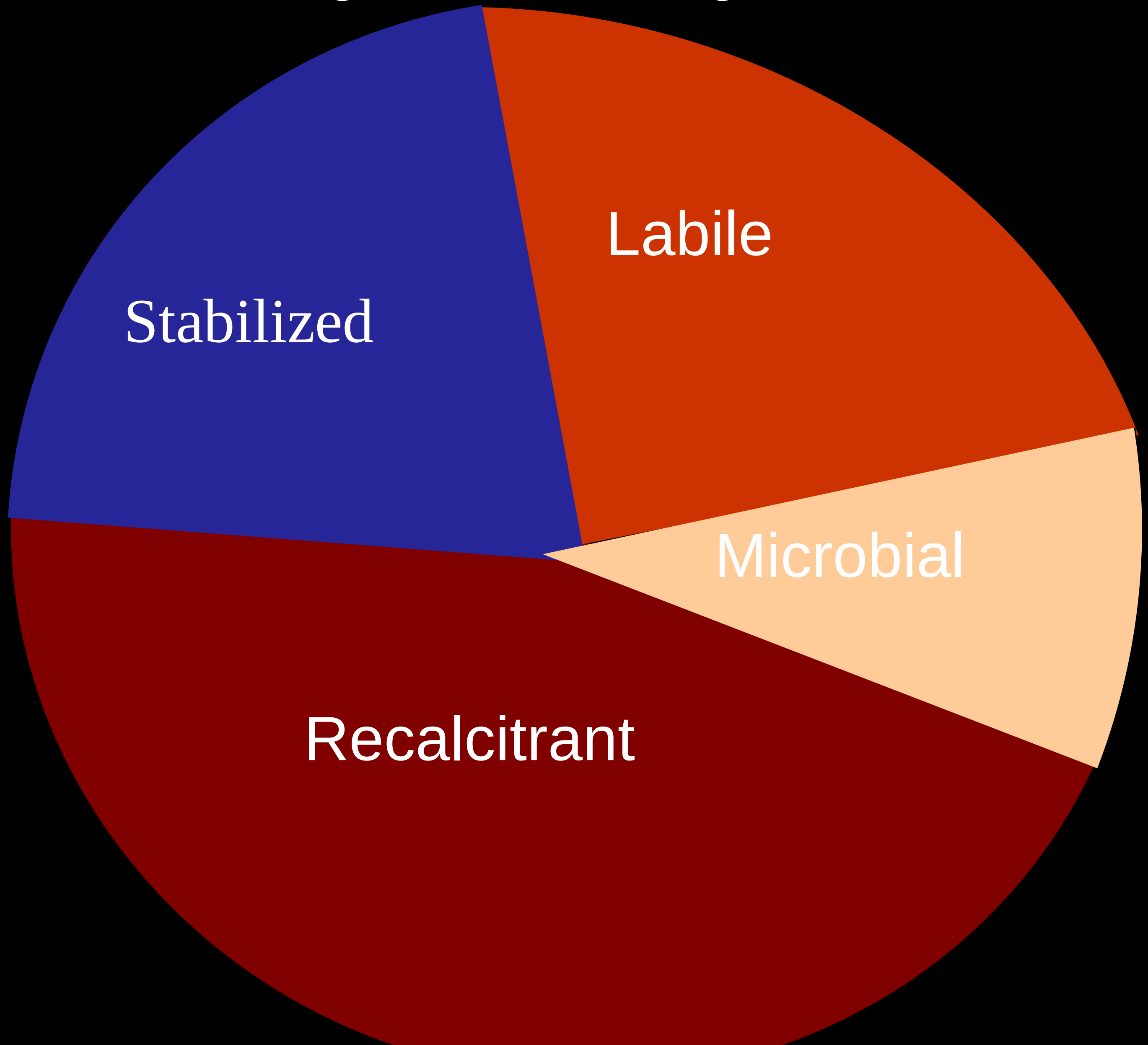
- Higher percentages of water stable aggregates
- Higher carbon levels
- Higher levels of glomalin
- Potentially more arbuscular mycorrhizal (AM) fungi

Soil Organic Matter Composition




Conventional
1% SOM
Transitional
3% SOM
Regenerative Organic
5% SOM
Recalcitrant
Labile
Microbial

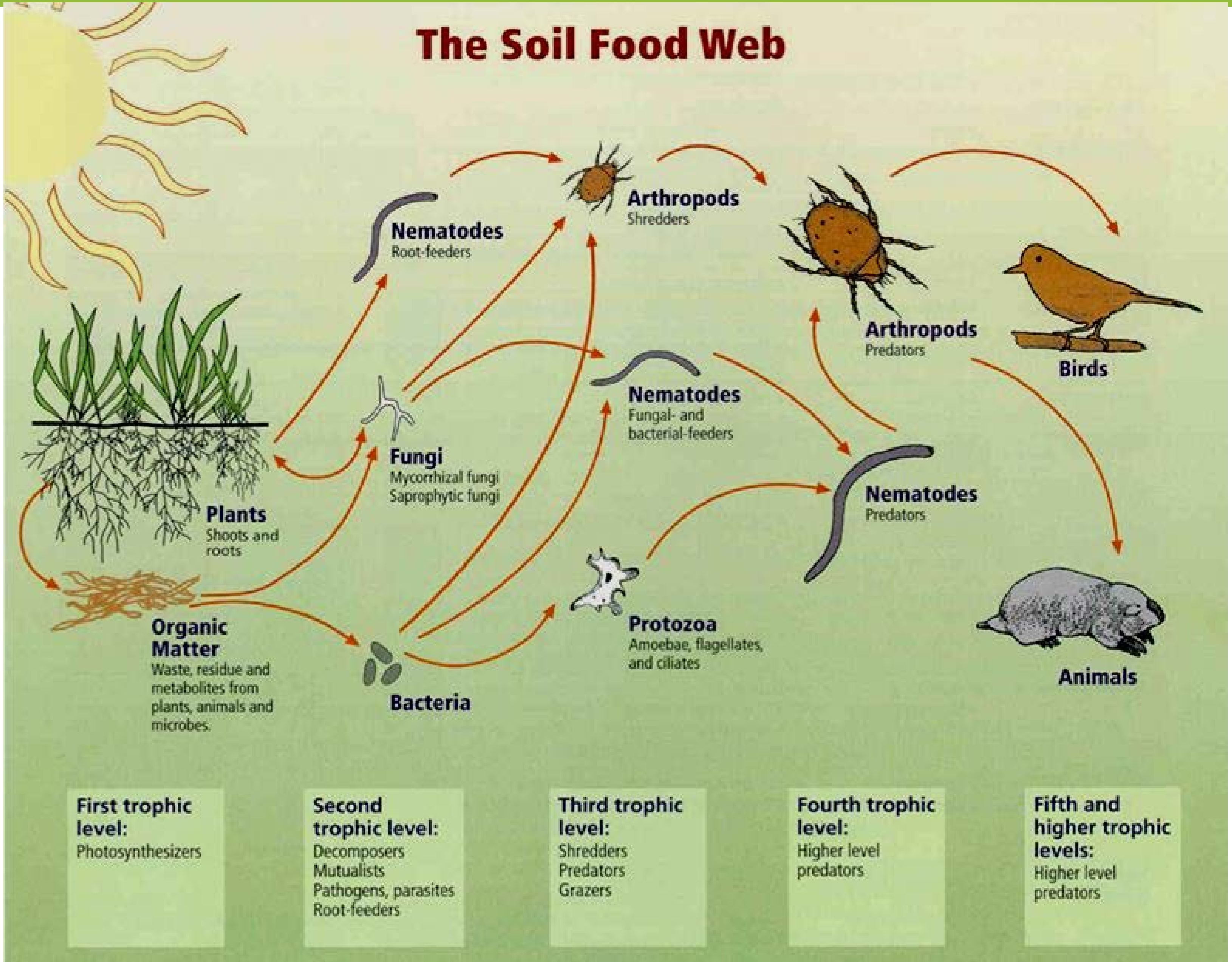
Regenerative Organic



Interactive Carbon Economy

- **Plants trade carbon to fungi and bacteria**
  - Mycorrhizal fungi
  - Rhizobium – N fixation
  - P-solubilization
  - Aggregate formation
    - Porosity
    - Soil structure
- **Nematodes and Protozoa eat bacteria and fungi for N**
- **Microarthropds prep residues for bacteria**

Root of the Problem is the Root of the Solution




A
P
C
C
Intraradical hyphae
Arbuscules

STARVING AND HOMELESS

- Soil is organic (i.e. living)
- Billions of different organisms from millions of species
- Total weight of living organisms in the top six inches of an acre of soil can range from 5,000 to 20,000 lbs.
- Soil from one spot may house a very different community from soil just a yard (meter) away

Water Use Efficiency

- **Porosity - 45% increase in porosity equals infiltration increase of 167% 25 mm (1 inch) and 650% 50 mm (2 inches)**

  -Karlen et al., 1998

- **Water holding capacity doubles when soil organic matter increases from 0.5-3% depending on soil texture**

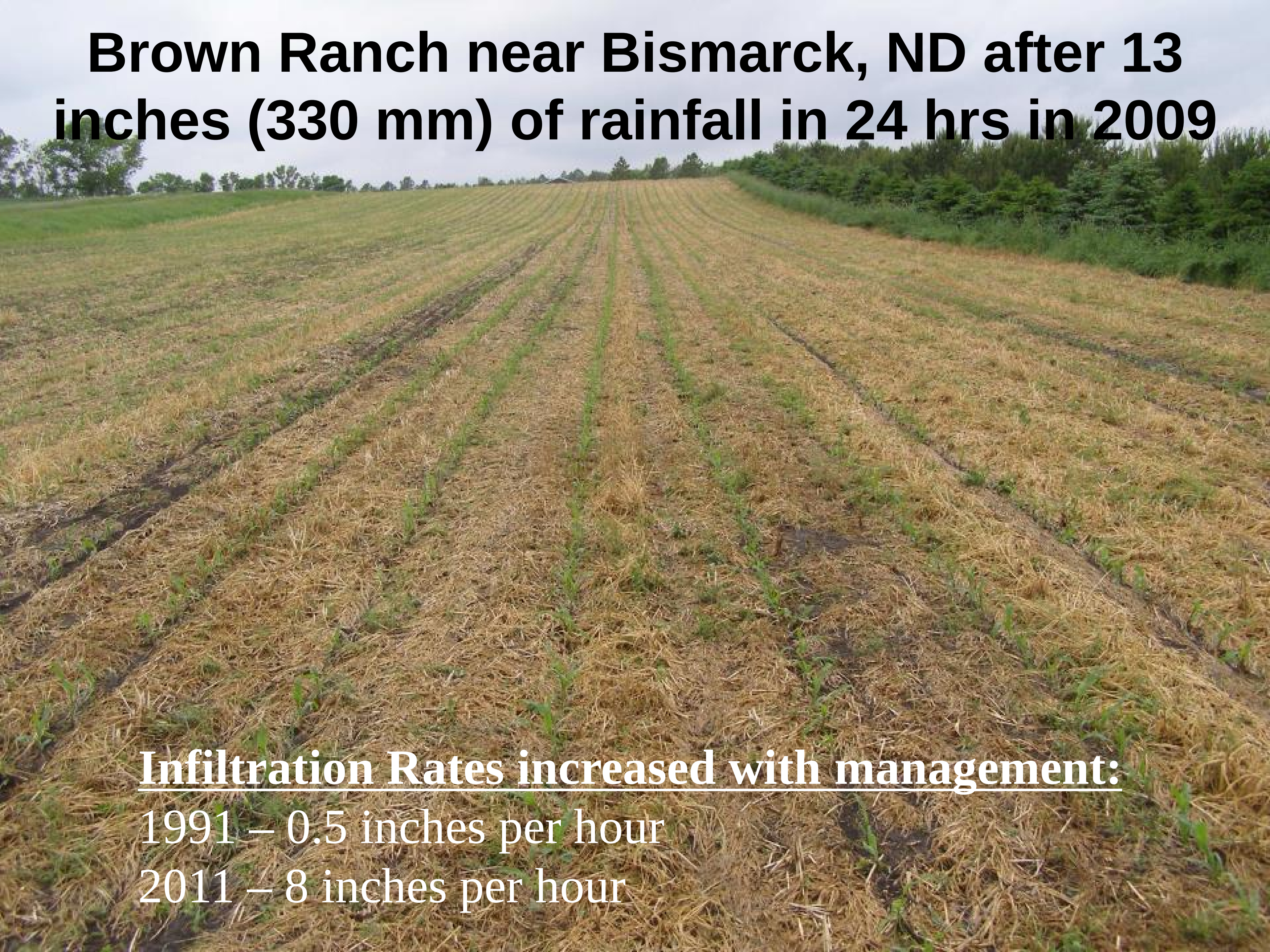
  – Hudson, 1994

- **Water used for nutrition**

  – W.A. Albrecht, University of Missouri, 1950's

  - Unfertilized corn needed nearly 5 times the amount of water as the fertilized corn.
    - Achieve efficient fertility biologically rather than chemically.

Wheat fields at Rodale Institute's Farming Systems Trial after a rain event.


Brown Ranch near Bismarck, ND after 13 inches (330 mm) of rainfall in 24 hrs in 2009
Infiltration Rates increased with management:
1991 – 0.5 inches per hour
2011 – 8 inches per hour

Farming Systems Trial (FST)

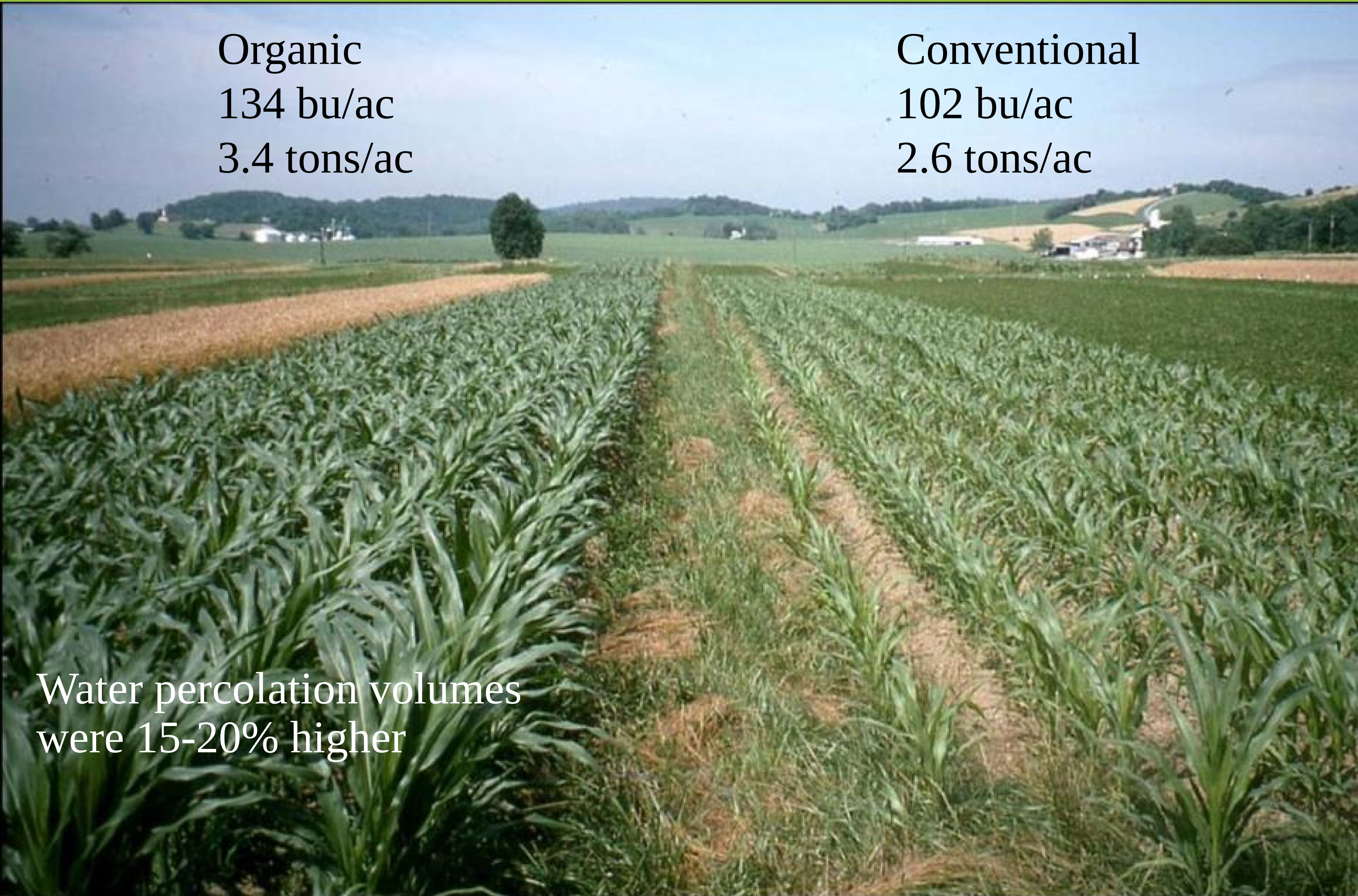
Tilled vs. No-Till

- **Organic-manure based**
  - 8-year rotation (Oat/rye - Soybean/wheat - Wheat/hay - Hay - Hay - Silage/wheat - Wheat/vetch - Corn/rye)
  - 10-year rotation (Oat/rye - Soybean/wheat - Wheat/hay - Hay - Hay -Hay -Hay - Silage/wheat - Wheat/vetch - Corn/rye)

- **Organic-legume based**
  - 4-year rotation (Corn/rye - Oats-clv/barley or rye - Soybean/wheat - Wheat/vetch)
  - 4-year rotation (Corn/rye - Oats-clv/barley or rye - Soybean/wheat - Wheat/cover crop mix)

- **Conventional-chemically based**
  - 3-year rotation (Corn – Corn - Soybean
  - 3-year rotation (Corn/rye – Corn/rye – Soybean/rye)

FST Corn During 1995 Drought



2015 Rodale Institute
Kutztown, PA

Organic Corn
Fertilizer only from legume cover and cash crops
18% higher yield

Conventional Corn

- **150 pounds N mostly as urea**
- **60 pounds phosphate**

Phosphate and Nitrate Stress

- **Spring rains = nutrient runoff, leaching, or unavailable**
- **Late summer and fall dry period = no nutrients during seed fill**

2016 Rodale Institute – Kutztown, PA

Organic Corn – Almost Double Yield
Fertilizer only from legume cover and cash crops

Conventional Corn
150 pounds N mostly as urea
60 pounds phosphate

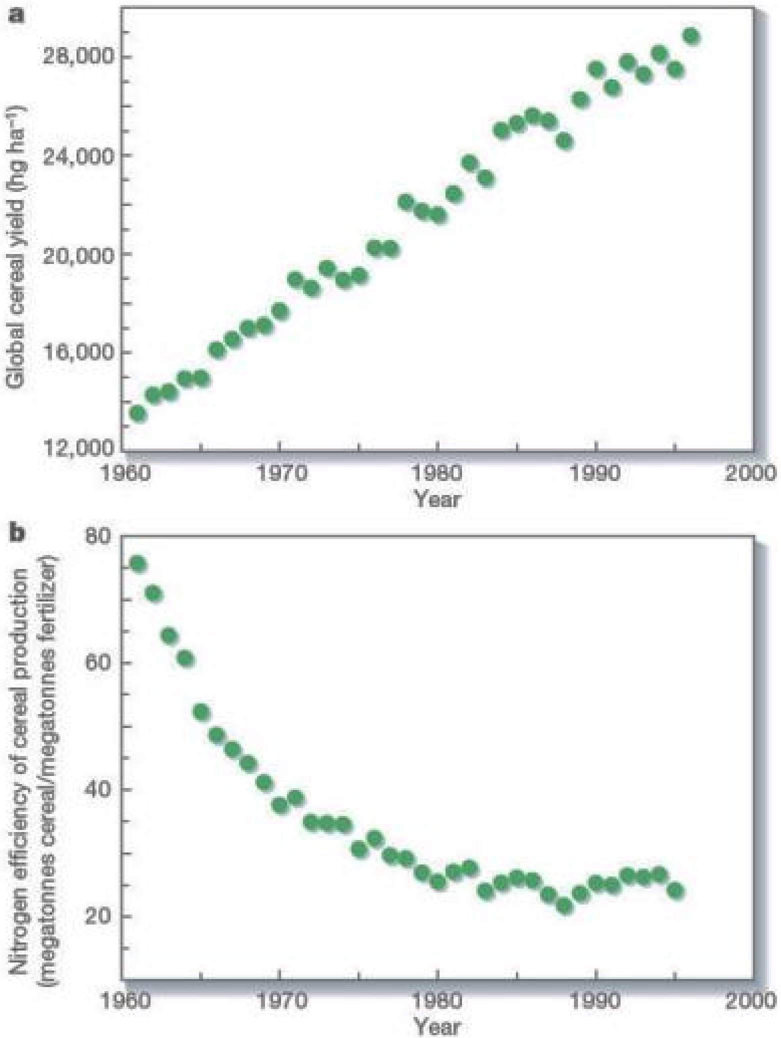
2015 FST Soybeans

Conventional

Organic – more nodulation and nitrogen fixation

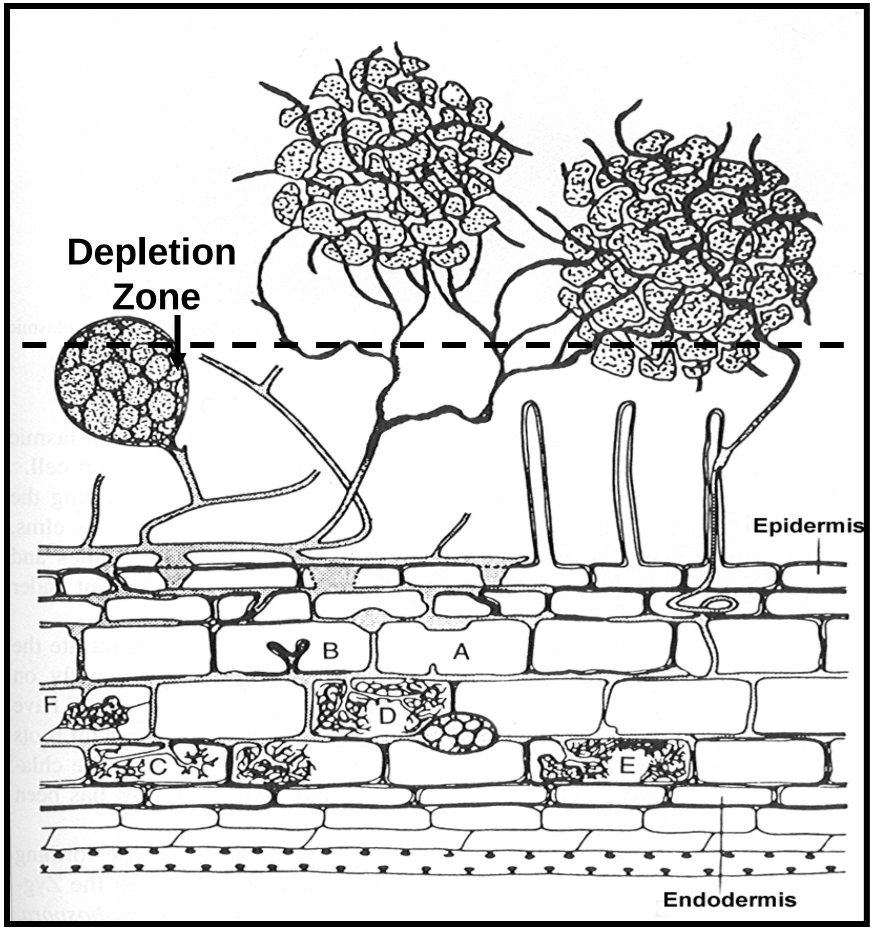
Nutrient Use Efficiency

- Plant available – synthetic vs. biologic
- 30-50% of nitrogen fertilizer is used by the plant
- 30% of phosphorus is used by the plant
- Availability, timing, water, and pH



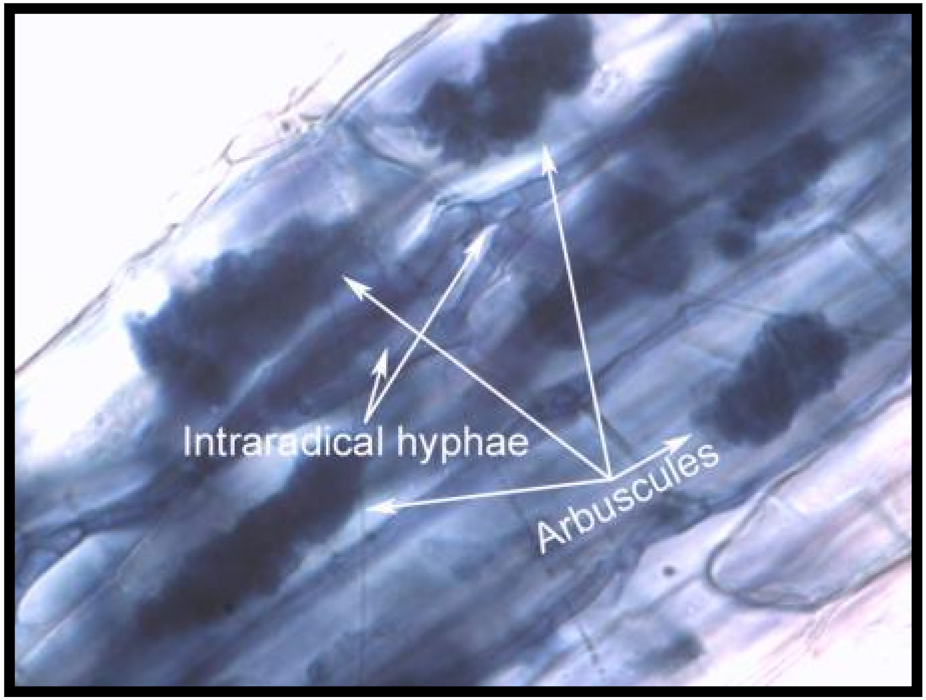
Arbuscular Mycorrhizal Fungi

- 4-30% of C is transferred to AM – Jansa et al 2013
- Affected by:
  - rotation (incl. cover crops)
  - fallow
- Create mycorrhizo-sphere in soil
- Hyphal networks can fuse together – Giovannetti et al., 2004
- Form soil aggregates

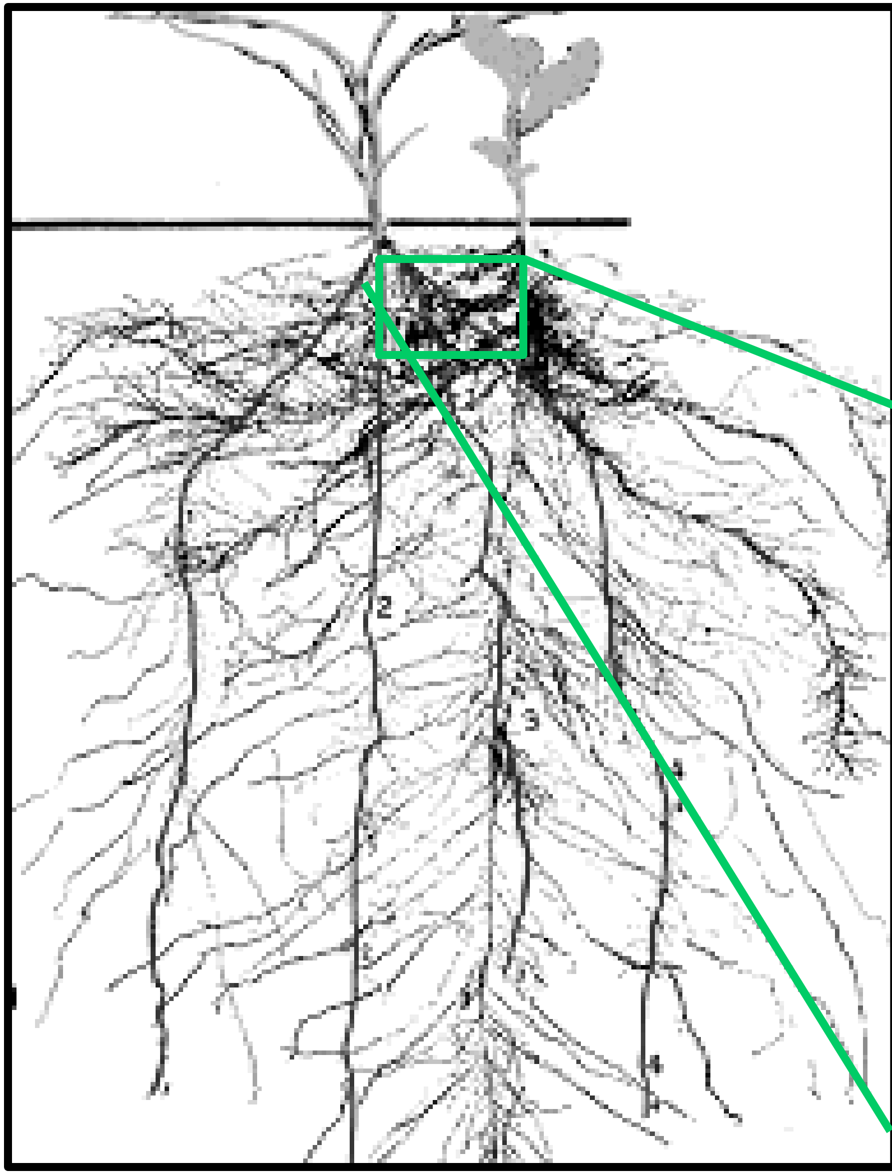


Arbuscular Mycorrhizal Fungi

- Obtain nutrients (up to 90% of N and P) – Smith and Read, 2008
  - Phosphate-solubilizing bacteria – Toro and Barea, 1996
  - Mixed cultures more efficient, but this was also AMF species dependent – Walder et al 2012
  - Non-legume trades P for N via AMF and rhizobia activity

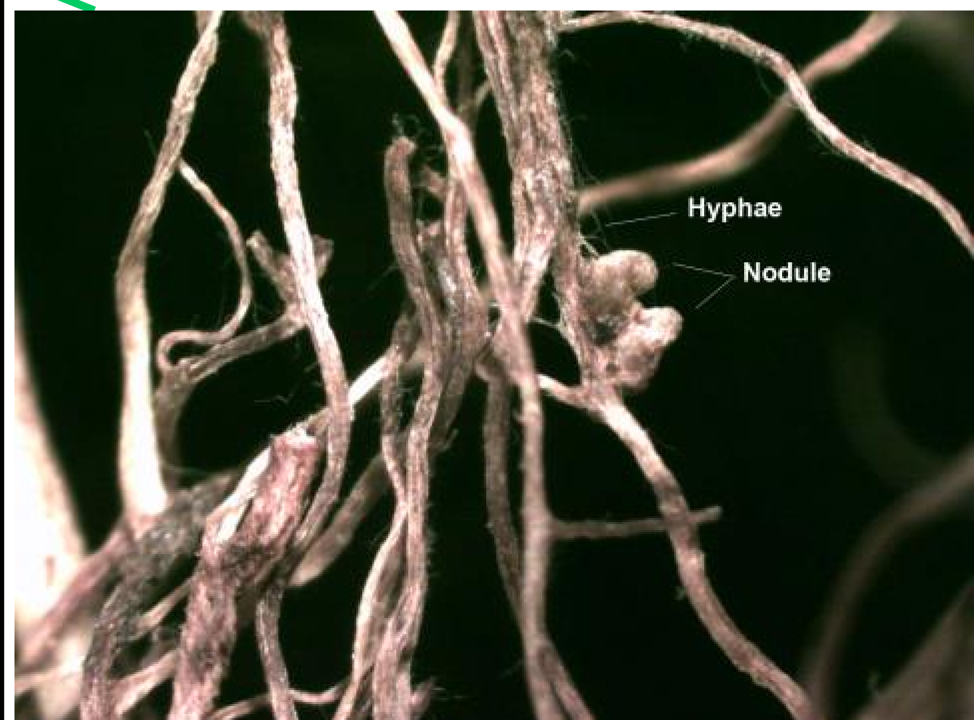


Plant to Plant Nutrient Exchange



Interplant transfer N for P and C

N fixation: N_2 via 32 ATP (needs 128 P and 320 C)



Organic Corn – Kutztown, PA

PLOW TILL

- **PLOW**
- **DISC**
- **PACK**
- **PLANT**
- **ROTARY HOE**
- **ROTARY HOE**
- **CULTIVATE**
- **CULTIVATE**
- **HARVEST**
- **3.63 ton/ac (143 bu/ac)**

NO-TILL

- **ROLL/PLANT**
- **HARVEST**
- **4.1 ton/ac (160 bu/ac)**

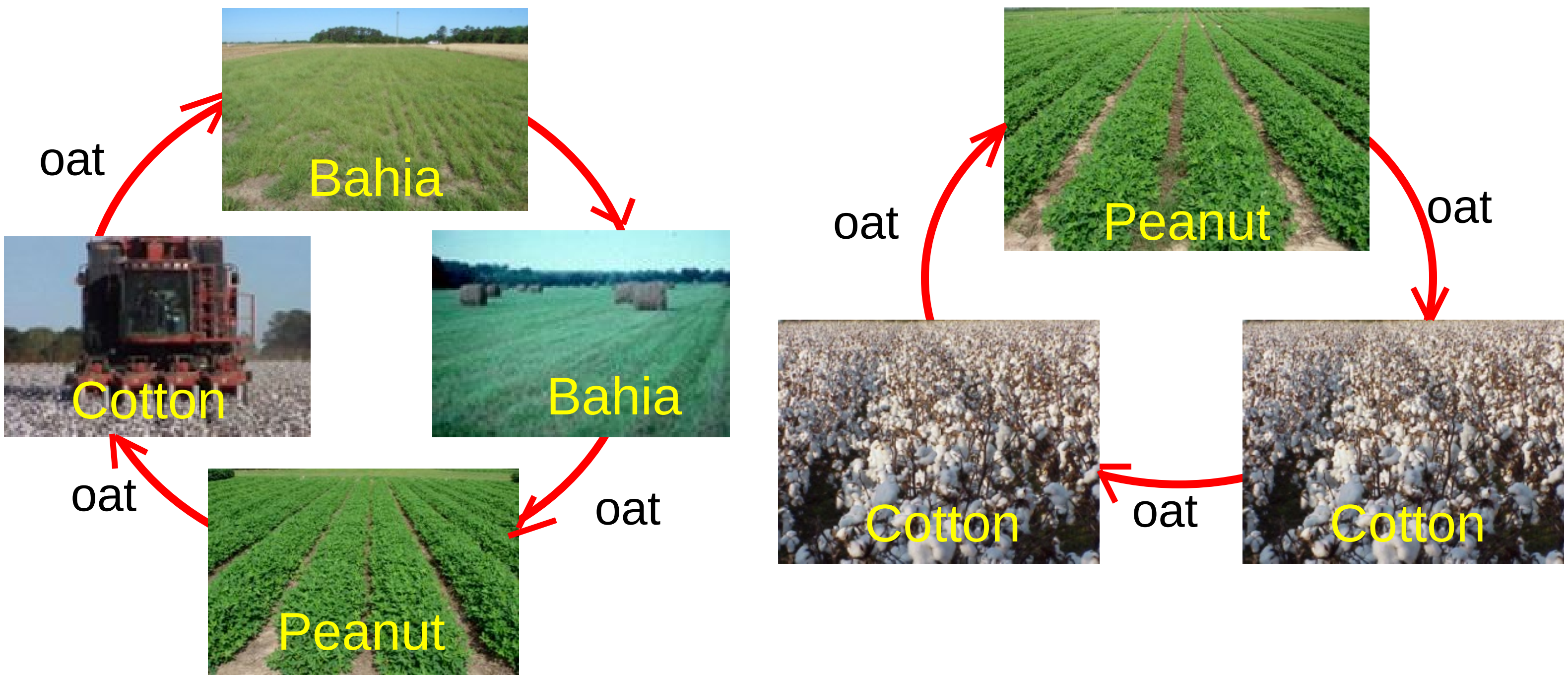
A two step organic production system Plant and Harvest!

Production budgets for corn

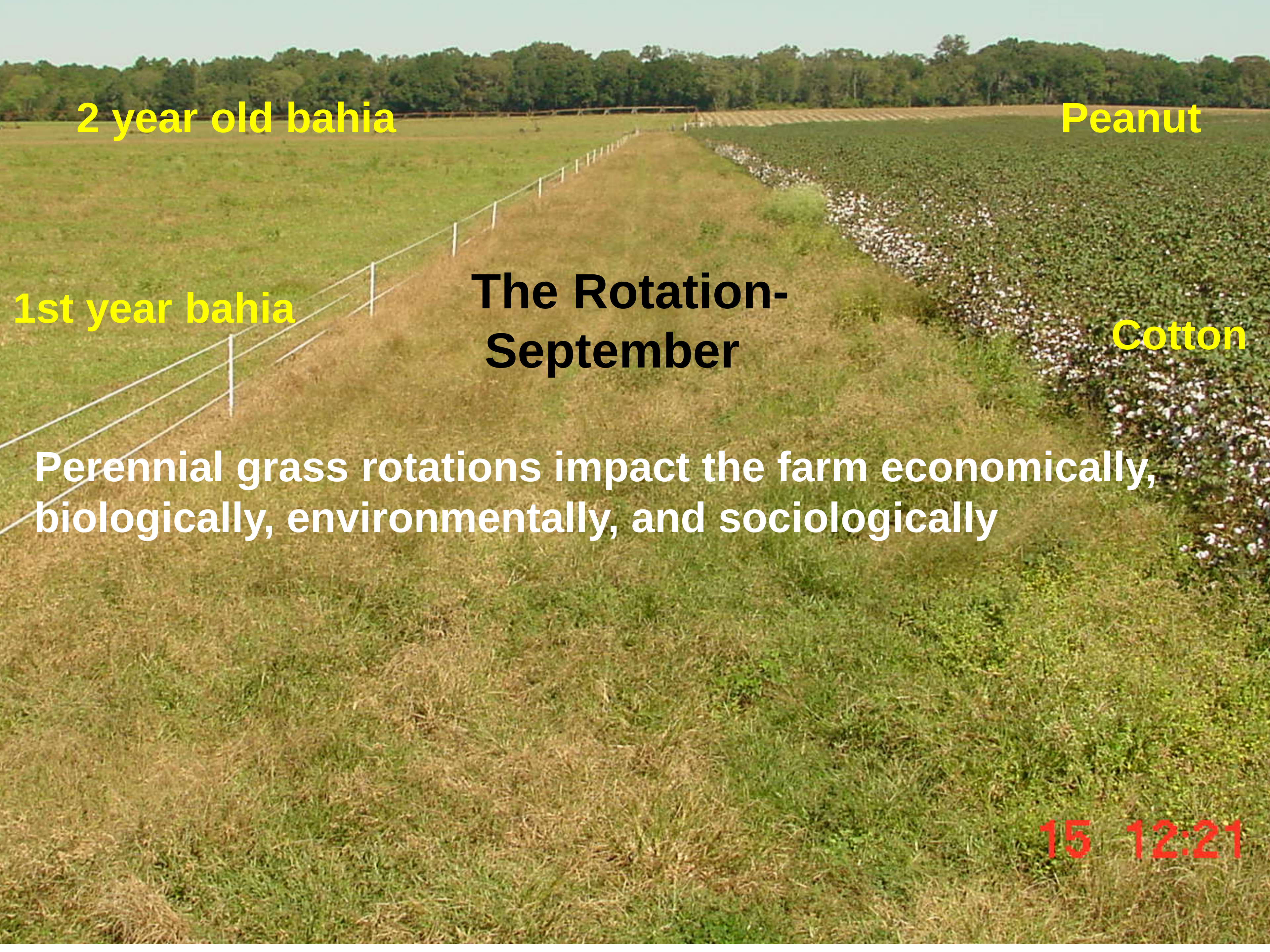
	Organic Tilled	Organic No-till	Conv Tilled	Conv No-till
	vetch+ corn	vetch+ corn	corn	vetch+ corn
Expenses				
fertilizer	0.00	0.00	118.04	90.44
herbicide	0.00	0.00	108.19	144.56
seeds	139.40	139.40	88.15	148.35
custom haul	30.00	30.00	30.00	30.00
labor	39.35	18.61	15.78	16.14
fuel	47.60	23.96	23.76	20.67
repair & maintenance	17.56	10.35	8.42	8.97
interest on op.capital	6.35	4.54	11.50	13.50
fixed expenses	52.02	30.98	27.31	27.46
Total Expenses ($/acre)	**332**	**258**	**431**	**500**
Profit ($/acre) *				
@ 100 bu/a yield	**504**	**578**	**-16**	**-85**
@ 150 bu/a yield	**922**	**996**	**191**	**122**
@ 200 bu/a yield	**1,340**	**1,414**	**399**	**330**
Break-even price ($/bu)				
@ 100 bu/acre	**3.32**	**2.58**	**4.31**	**5.00**
@ 150 bu/acre	**2.22**	**1.72**	**2.87**	**3.33**
@ 200 bu/acre	**1.66**	**1.29**	**2.16**	**2.50**

These production budgets were calculated using the free on-line Mississippi State Budget Generator (MSBG), developed by the Department of Agricultural Economics at Mississippi State University, (http://www.agecon.msstate.edu/what/farm/generator/). When available, input and price data were taken directly from data collected at the Rodale Institute (2008-2010), otherwise default values from the Budget Generator were used.
* The 3-year average price for organic corn was $8.36/bu, for conventional corn $4.15/bu.

Integrated Crop-Livestock(GA, FL, AL)



Oat Winter Cover Crop Following Peanut and Cotton in Both Systems


2 year old bahia
Peanut
1st year bahia
The Rotation-
September
Cotton
Perennial grass rotations impact the farm economically,
biologically, environmentally, and sociologically
15 12:21


Peanuts grown in soil
without Bahia roots
Peanuts grown in soil
with Bahia roots

2015 Grazing

- Forage biomass differences between grazing strips with G_2 having highest biomass dry weight (**4.12±0.85** kg m^{-2}) while G_3 (**2.52±0.24** kg m^{-2}) and G_4 (**2.46±0.36** kg m^{-2}) the lowest
- Biomass in the exclosures was only **1.85** kg m^{-2}.
- Nine steers grazed for 150 days
- Average daily rate of gain of 1.68 lbs day^{-1}

Food Safety

E.coli O157:H7

- one fecal sample from Rodale (4.76% prevalence rate) and two feed samples from Rodale (11.7% prevalence rate)

Salmonella

- One feed sample from Rodale (5.89% prevalence rate) and no fecal samples positive

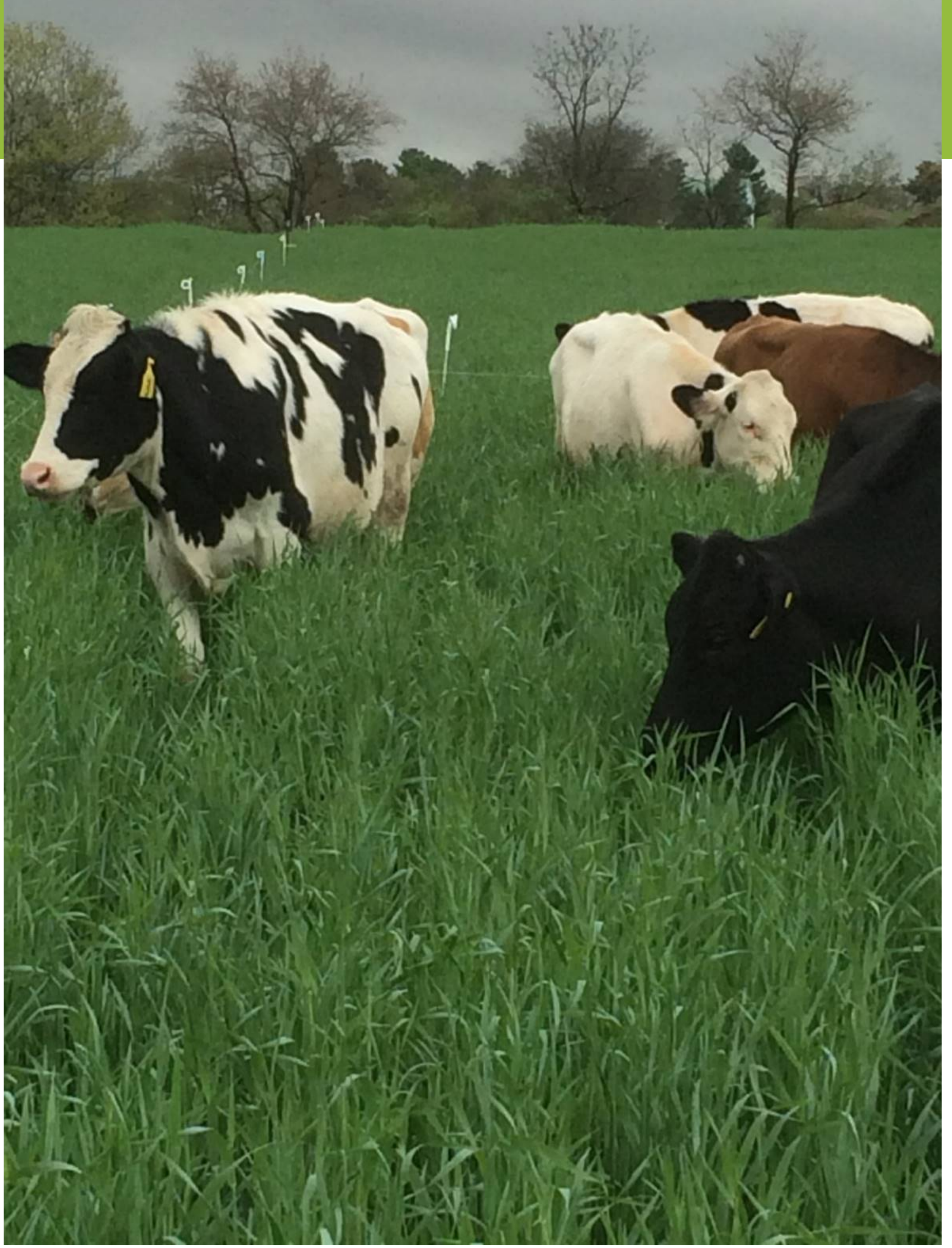
Rates below published reports:

E.coli O157:H7

- 30.1% in livestock feed
- 14.8% in fecal sample

Salmonella

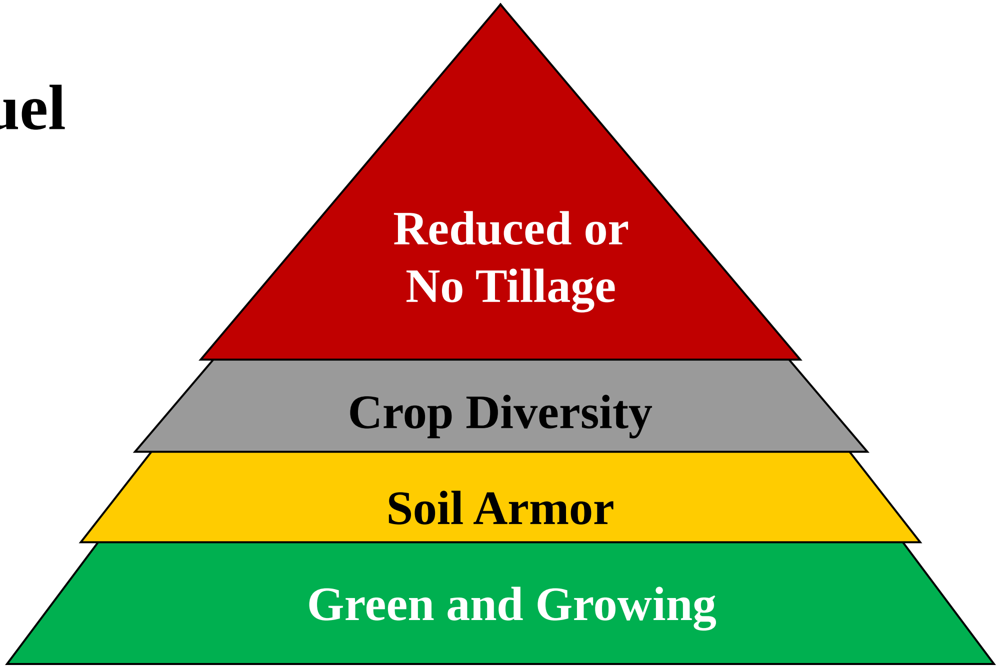
- 12-86% livestock feed
- 4-34% in fecal samples



The BROWN REVOLUTION

Recognize proper soil management as the most ecologically and economically sustainable form of agriculture.

- Provide food, fiber, and fuel
- Provide nutrients
- Protect the soil
- Manage pests
- Consistency
- Resiliency
- Moisture to roots
- Maximize efficiency
- Make money



We speak a lot of the importance of sustainable food systems for healthy lives. Well, it starts with soils.

- José Graziano da Silva, FAO Director-General

Thank You!

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A Nation that Destroys its Soil, Destroys Itself.
– Franklin Roosevelt