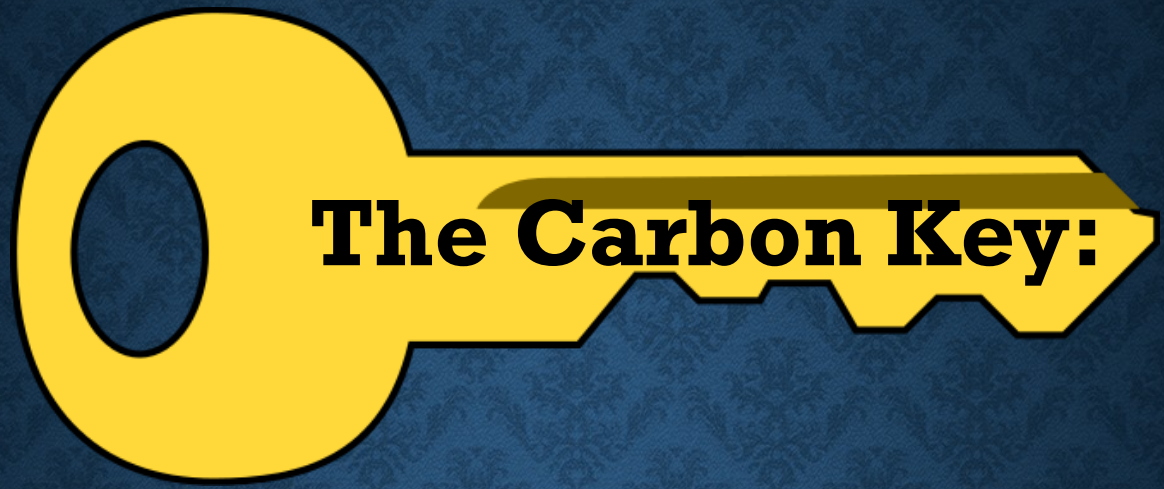

Linking Regenerating Soils to Human Health and Adapting to Climatic Uncertainty

Dr. Kris Nichols
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Pachaterrae Inc.
Kris@KRIS-systems.com

Plant Pathologist
Hydrologists
Microbiologist
Nutritionist
Animal Scientist
Ecologist
Economist
Salesman
Engineer
Mechanic
Chemist
Climatologist
Breeder

FARMER/RANCHER

Diseases
Equipment
Marketing
Ammonium Nitrate
Fungicides
Sodicity
Monocultures
Nutrition
Wind
Micronutrients
Drought
Nematicides
Potash
Irrigation
Over Grazing
Loans
Herbicides
Heat
Insecticides
Insect Pests
Prices
Bactericides
Weeds
Rock Phosphate
Urea
Frost
Salinity
Flooding
Tillage

Soil Health

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

KRIS Systems
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Knowledge for Regeneration & Innovation in Soil

Soil Health

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

Why?

- **Resilience**
- **Resistance**
- **Nutritive Quality**
- **Overall Profitability**

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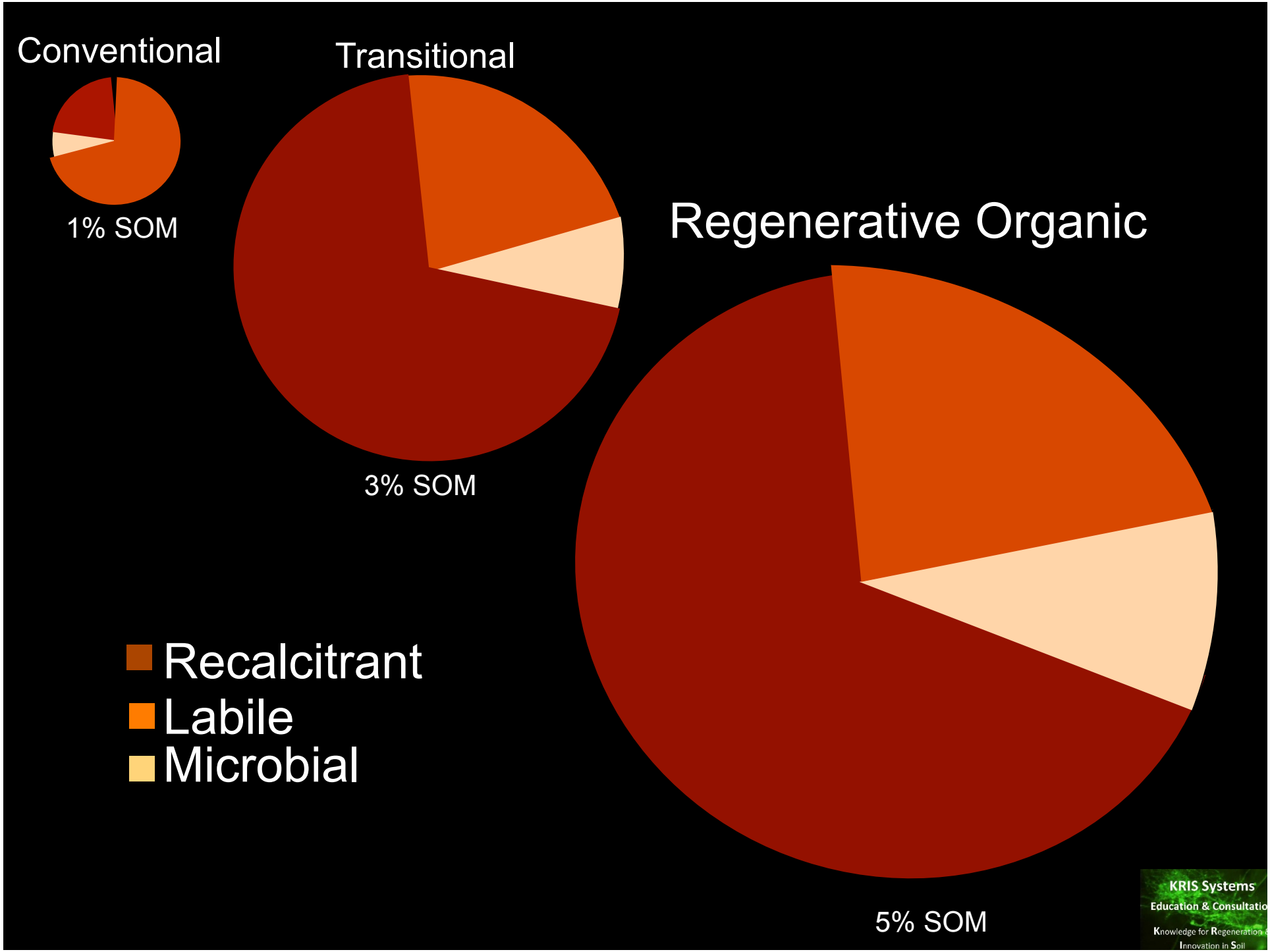
Soil Degradation

Hot Spots

Soils have been hemorrhaging but focusing **solely** on yield, no-till, or grazing just **stops** the **bleeding.**
The patient i.e. **soil** needs a transfusion and will die anyway without a **systems approach** that starts with **photosynthesis**.


The Carbon Problem
Soils Deficient in Carbon
Dave Brandt Farm
Carroll, Ohio
10.15.2013
Progress after 35 years


Conventional
1% SOM
Transitional
3% SOM
Regenerative Organic
5% SOM
Recalcitrant
Labile
Microbial
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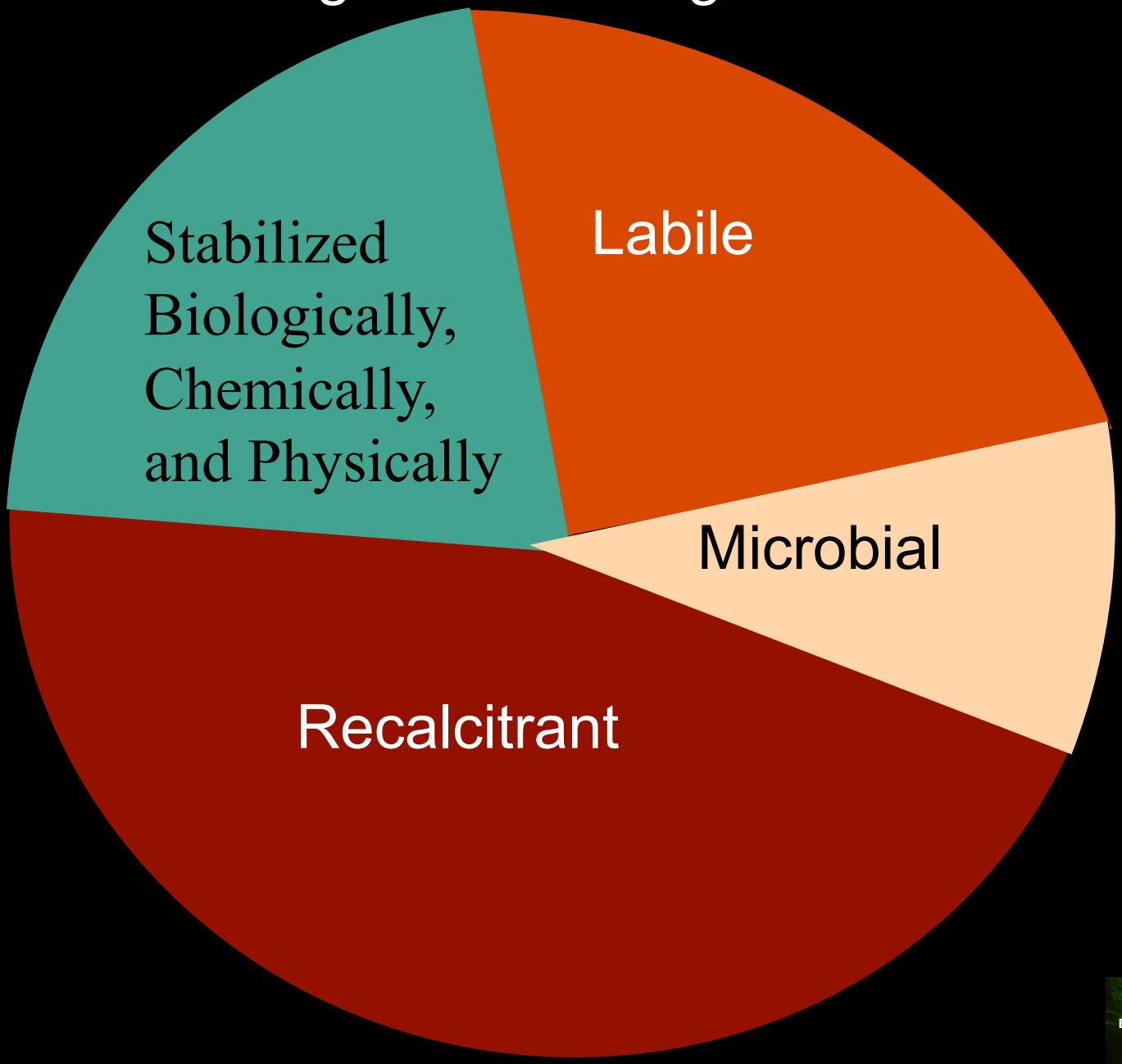
Knowledge for Regeneration
Innovation in Soil

Regenerative Organic



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Systems Approach that starts with **Photosynthesis**.

Photosynthesis – most efficient form of solar energy conversion to chemical energy in the bonds between carbon atoms or carbon atoms and other atoms.

TREAT SOIL LIKE YOU'RE SUPPOSED TO TREAT YOURSELF

- Eat small meals throughout the day (be a grazer).
- Eat a diverse diet.
- Exercise but don't over exercise – FIST (Frequency, Intensity, Scale, Timing).
- Protect your body from injury, radiation, temperature extremes, etc. (armor).

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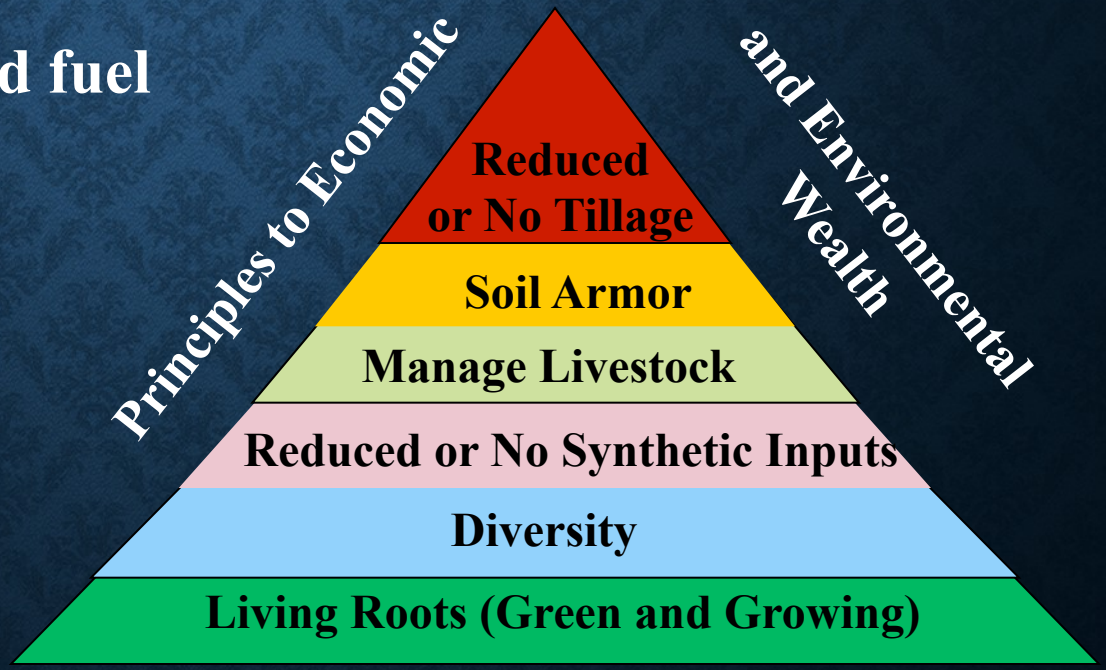
ECO-FUNCTIONAL INTENSIFICATION

- Maximize the use of the landscape
- Not more but less
- Multiple enterprises
- Everything costs but redistribute risk
- Nutrient density

THE BROWN REVOLUTION

- Recognize proper soil management as the most ecologically and economically regenerative form of agriculture to provide nutrient dense food.

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



Soil Regeneration Pyramid

THE BROWN REVOLUTION

Living Roots:

1. Growing Degree Days
2. Greenness Index
3. Vegetative Growth

Living Roots (Green and Growing)

Soil Regeneration Pyramid

GREENNESS INDEX AND VEGETATIVE GROWTH

- Harvesting sunlight
- Temperature vs sun
- Plant selection –
  - New/old plants
  - Relay/double/poly cropping
  - Perennials/annuals
- Carbon economy – costs and biomass of microbes

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

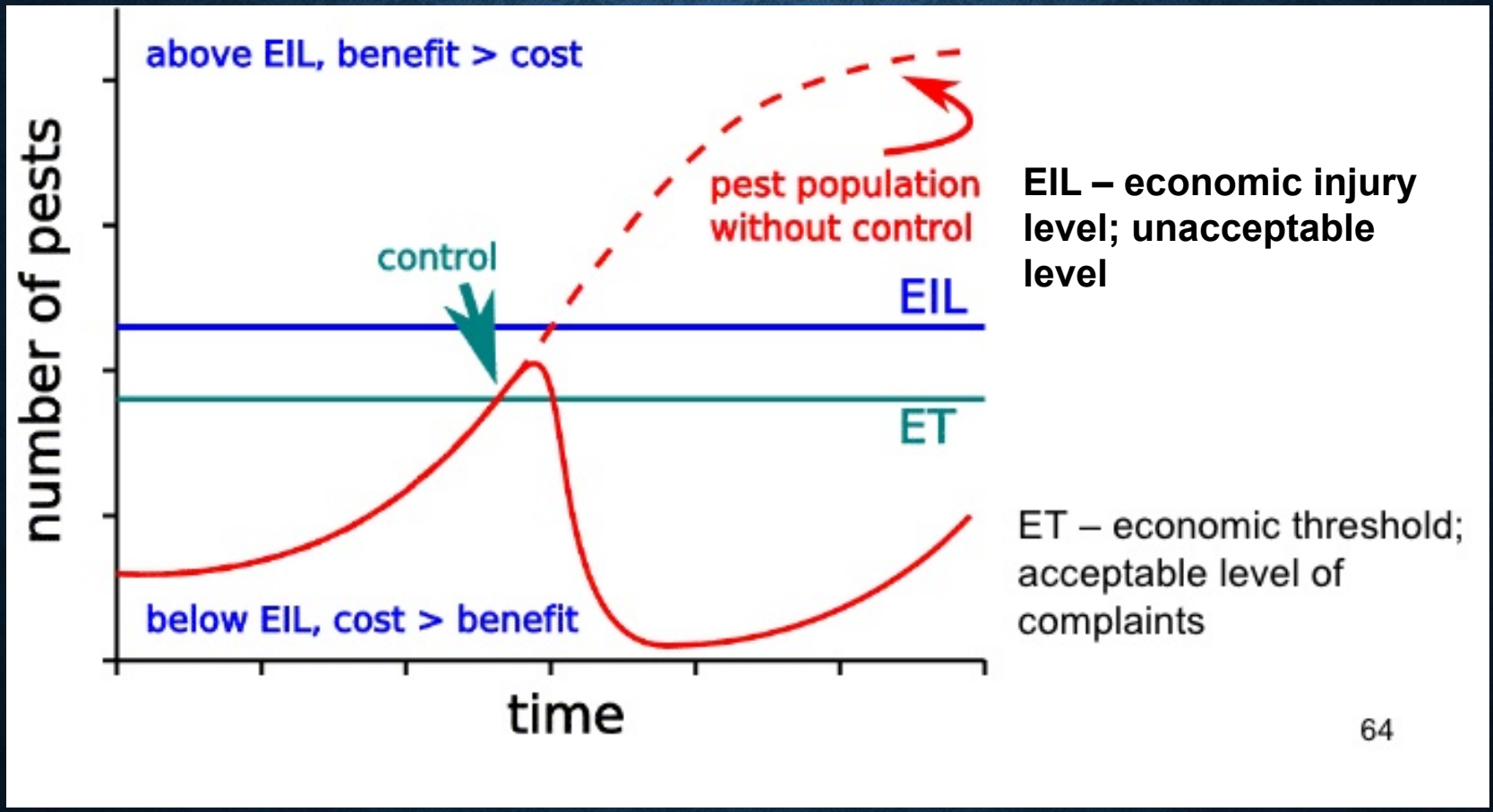
THE BROWN REVOLUTION

1. Plant Diversity
   a. C:N (Doughnut Diet)
   b. Weed management
2. Microbial and Macrobial Diversity
   a. Nutrient cycling
   b. Resilience
   c. Disease management
   d. Pest management

Soil Regeneration Pyramid

AGROECOSYSTEM RESILIENCE

Response to pest pressures



- Tracking insect and disease pests
- Tracking weed community dynamics
- Measuring yield declines from weeds

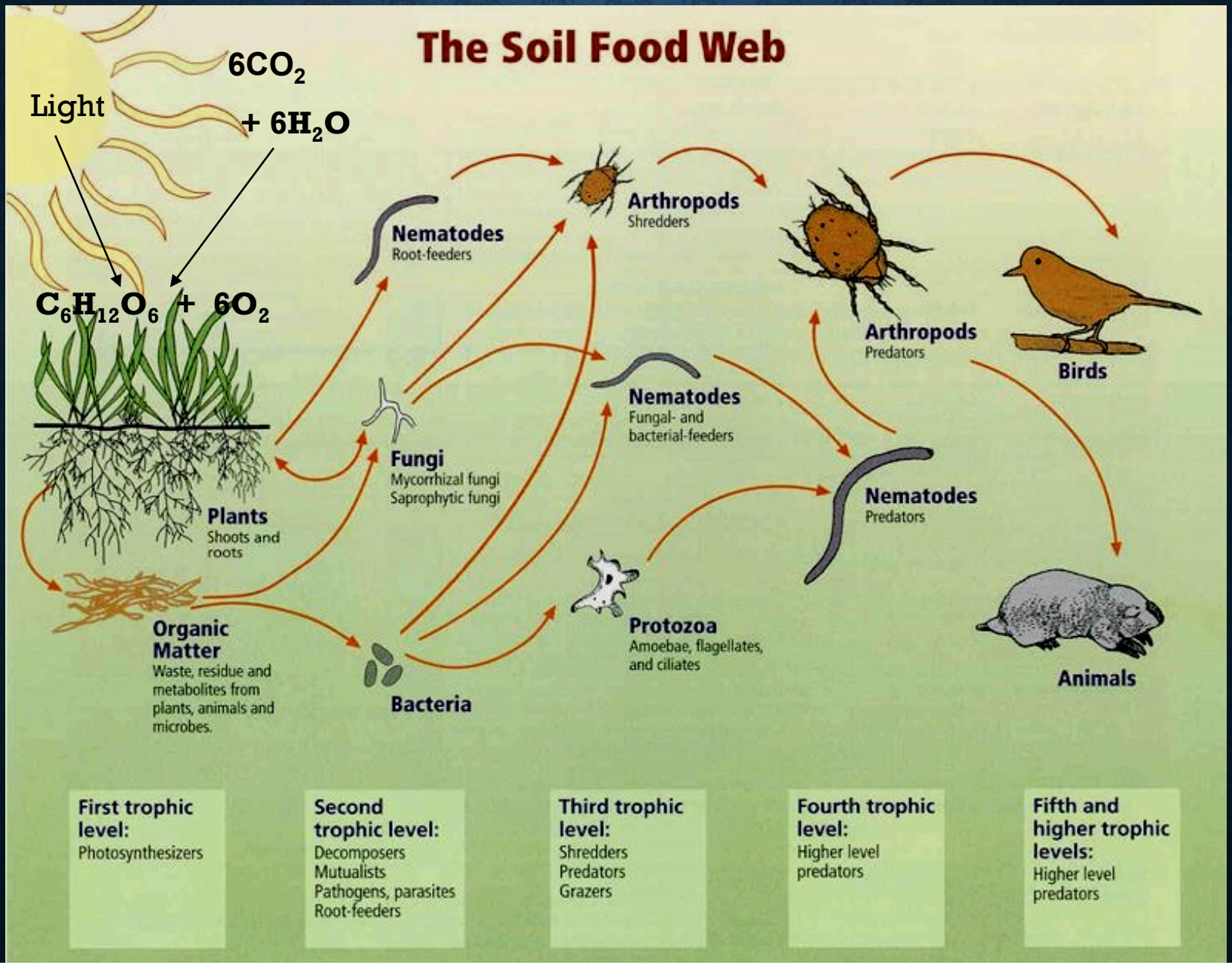
THE BROWN REVOLUTION

Reduced or No Synthetic Nutrients:

1. Carbonomics

Soil Regeneration Pyramid

Root of the Problem is the Root of the Solution



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**
- **Microarthropods prep residues for bacteria**

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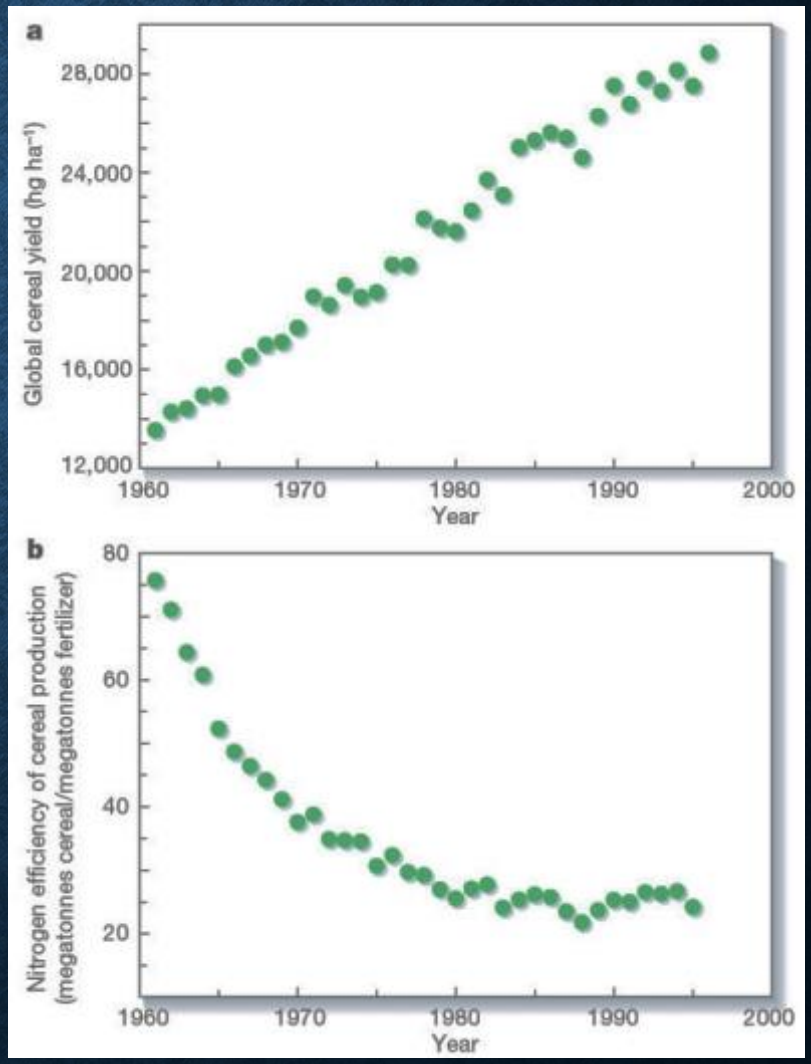
Nutrient Use Efficiency

- Plant available – synthetic vs. biologic
- 30-50% of nitrogen fertilizer is used by the plant (Hirel et al 2011)
- 30% of phosphorus is used by the plant
- Availability, timing, water, and pH



- Tilman et al., 2002

Test	Method	Results
Soil pH	1:1	7.3
Buffer pH		
Phosphorus (P)	M3	204 ppm
Potassium (K)	M3	324 ppm
Calcium (Ca)	M3	2119 ppm
Magnesium (Mg)	M3	218 ppm
Sulfur (S)	M3	14 ppm
Boron (B)	M3	1.4 ppm
Copper (Cu)	M3	4.1 ppm
Iron (Fe)	M3	100 ppm
Manganese (Mn)	M3	231 ppm
Zinc (Zn)	M3	11.4 ppm
Sodium (Na)	M3	34 ppm
Soluble Salts		
Organic Matter	LOI	3.6% ENR 116
Nitrate Nitrogen		

SOIL TEST RATINGS

Very Low | Low | Medium | Optimum | Very High

Calculated Cation Exchange Capacity

13.4 meq/100g

%Saturation

	%sat	meq
K	6.2	0.8
Ca	79.1	10.6
Mg	13.6	1.8
H	0.0	0.0
Na	1.1	0.1

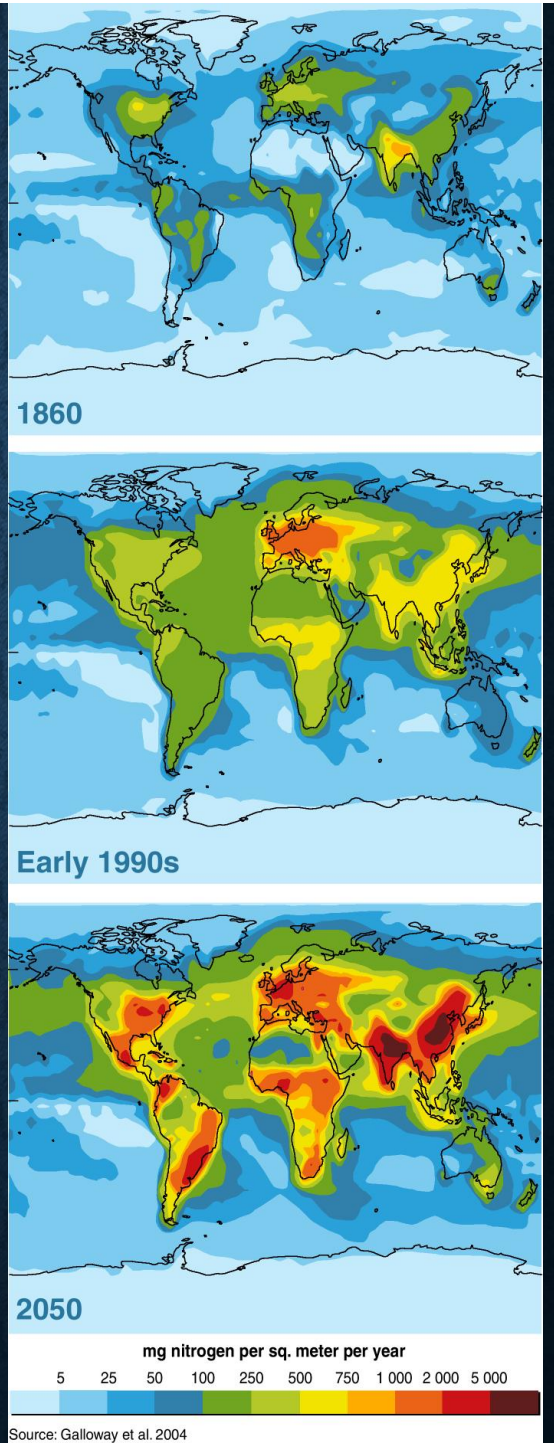
K/Mg Ratio: 0.46

Ca/Mg Ratio: 5.82

Near Steve Groff's Farm in south central PA

WHAT'S IMPORTANT TO ME?

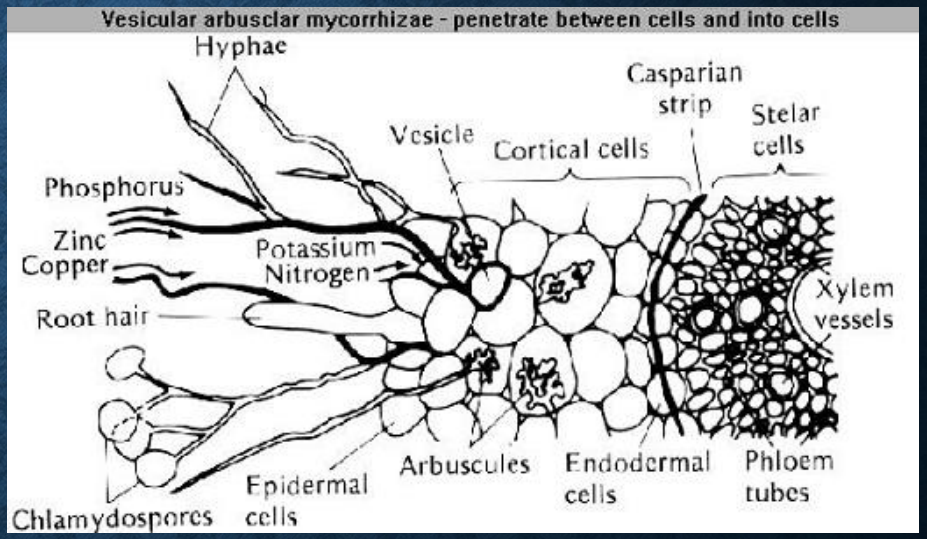
SW MN - Holland well field - water for 65,000 people



Source: Galloway et al. 2004

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



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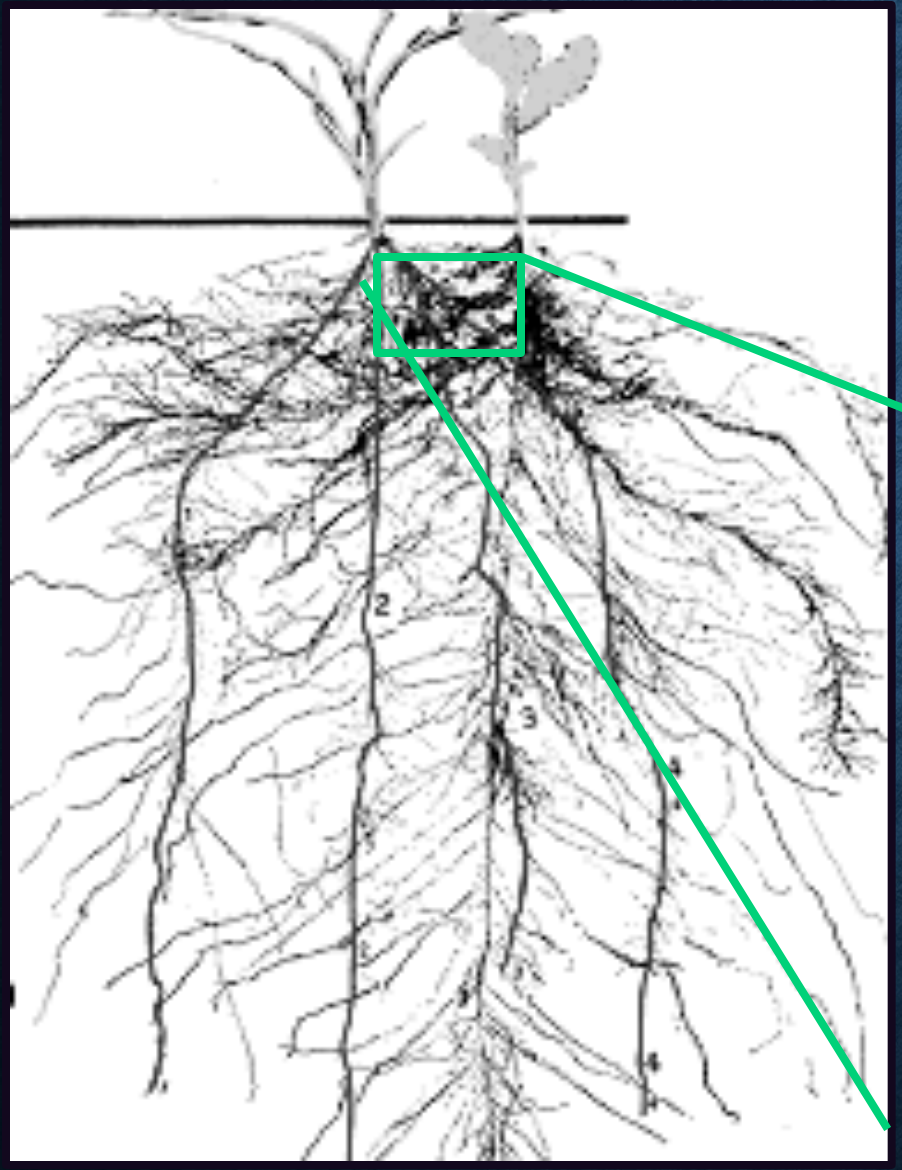
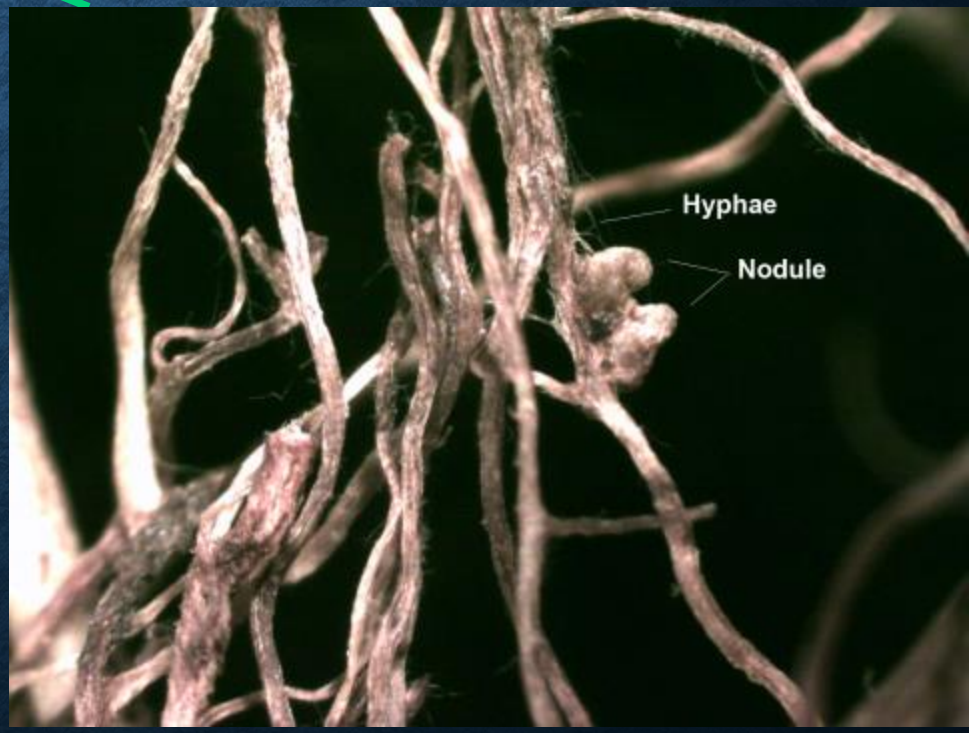
Plant to Plant Nutrient Exchange



Interplant transfer N for P and C

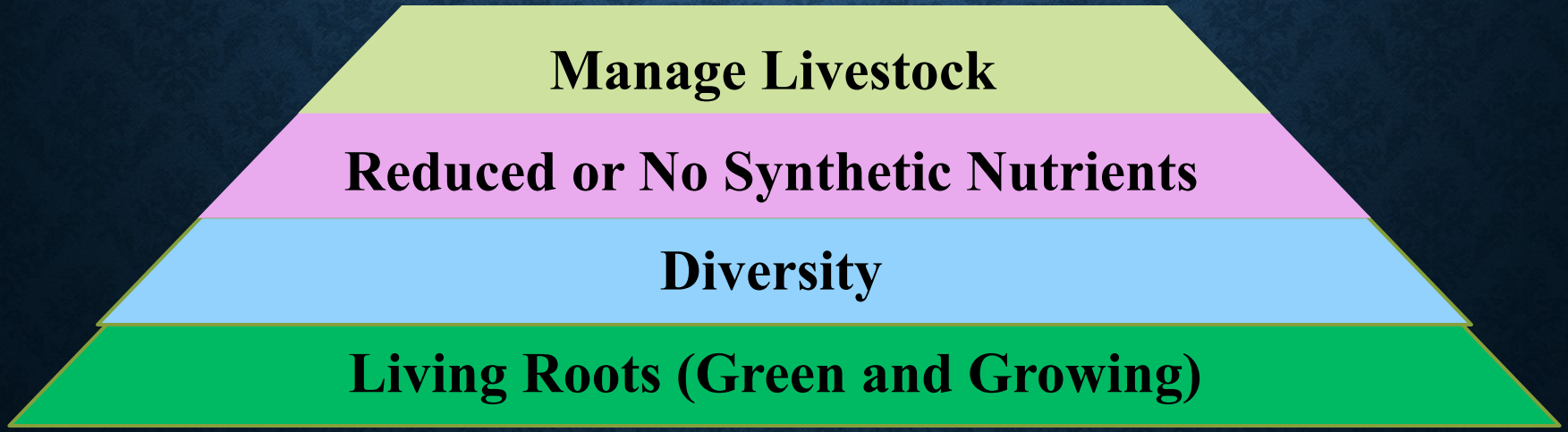
N fixation: N_2 via 32 ATP (needs 128 P and 320 C)



THE BROWN REVOLUTION

Manage Livestock:

1. Livestock of all sizes including insects
2. Carbon movement
3. Nutrient cycling
4. Tool



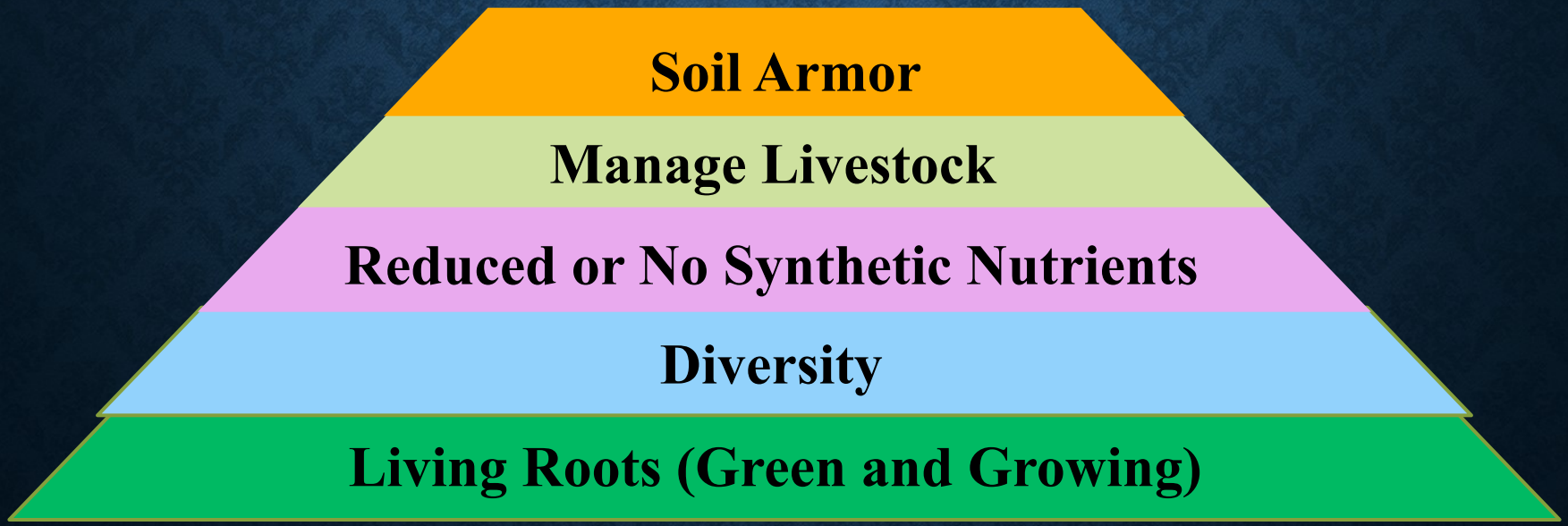
Soil Regeneration Pyramid

GRAZING AND CARBONOMICS

THE BROWN REVOLUTION

Soil Armor:

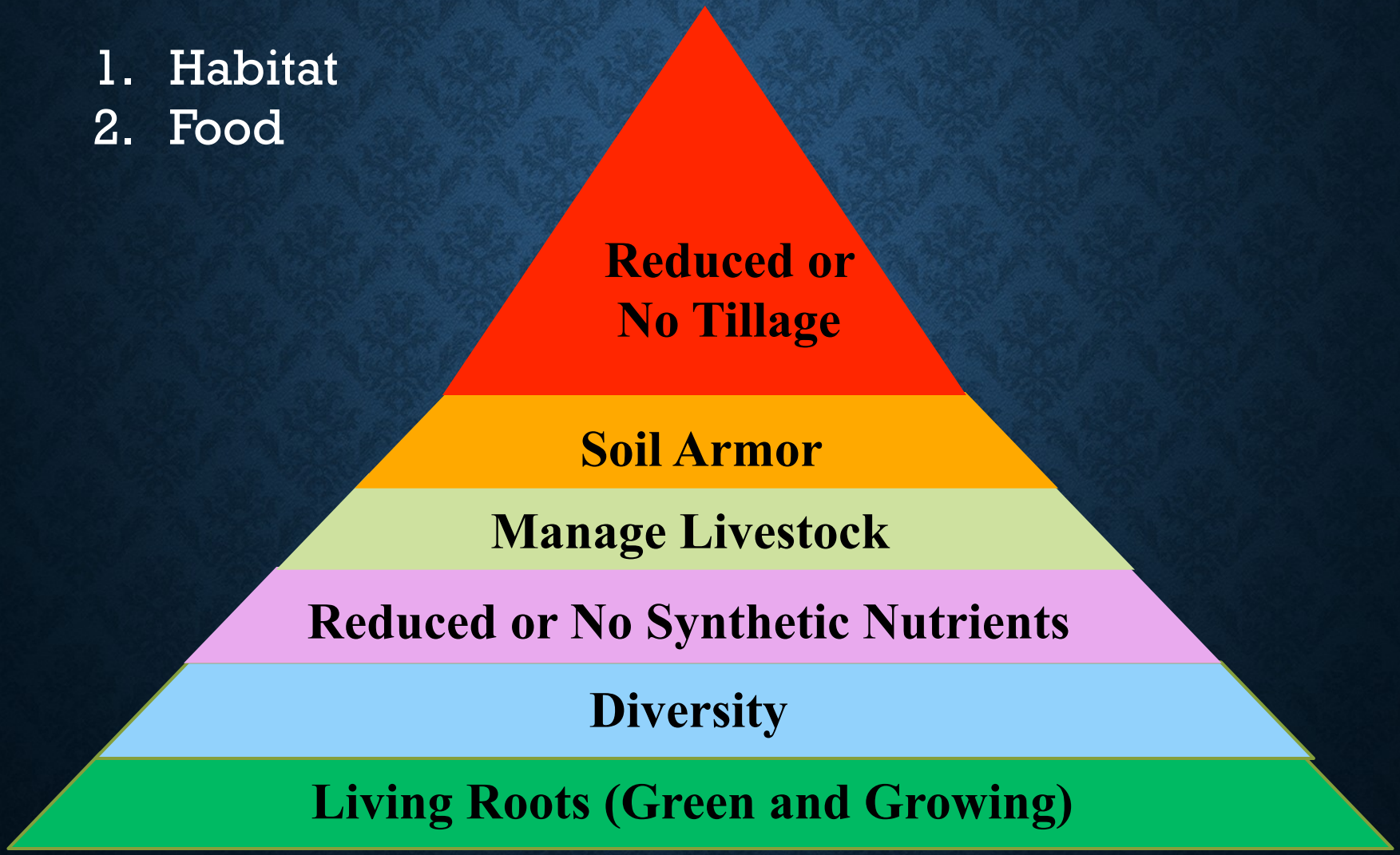
1. Protection
2. Food



Soil Regeneration Pyramid

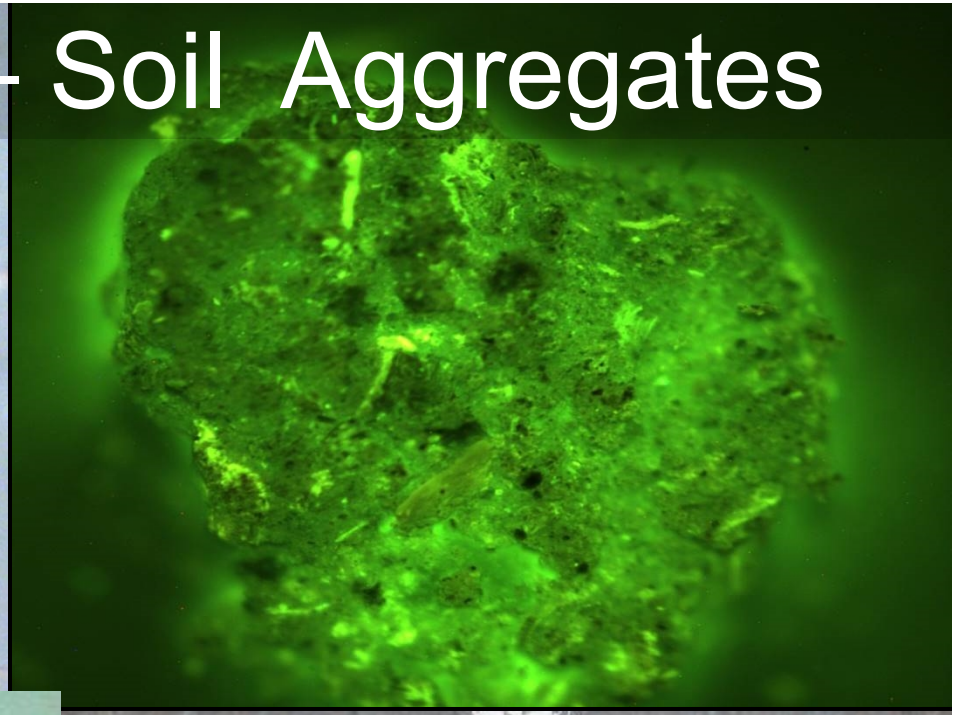
THE BROWN REVOLUTION

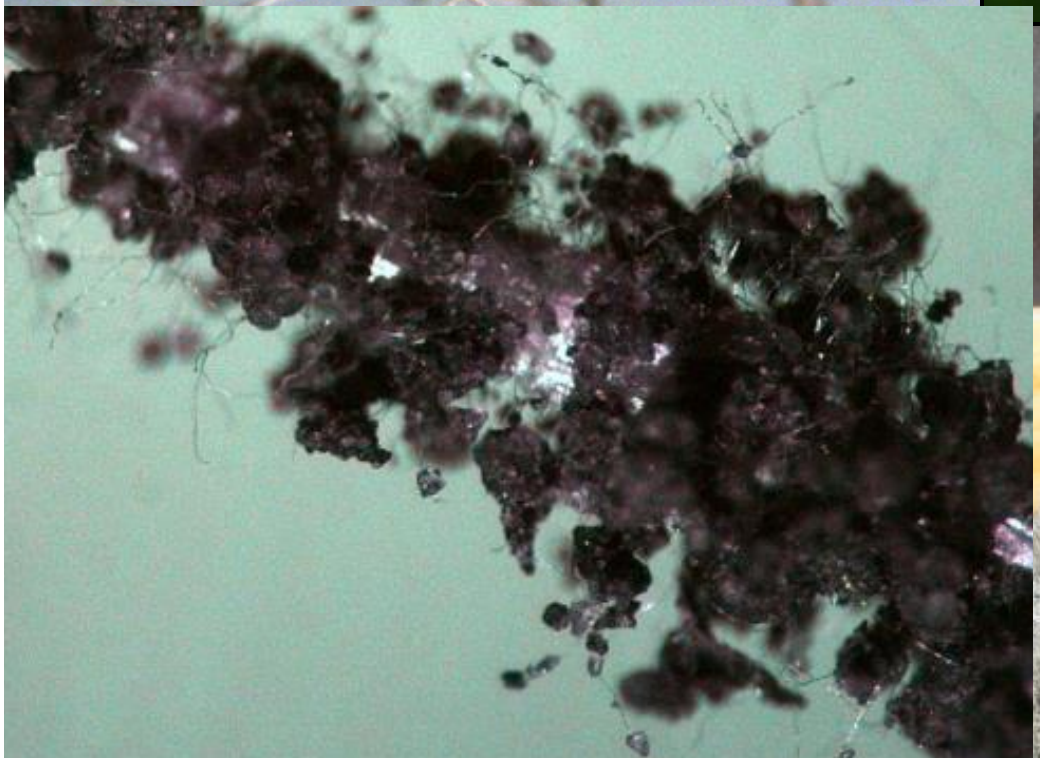
1. Habitat
2. Food



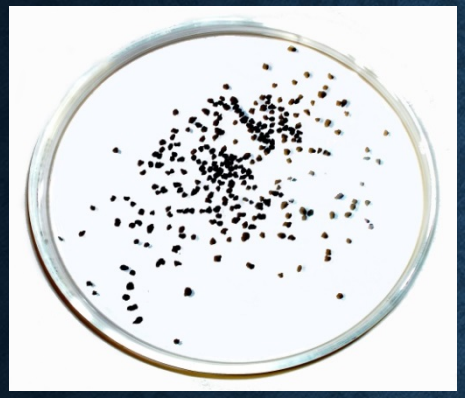
Soil Regeneration Pyramid

Soil Architecture – Soil Aggregates





Aggregate Stability



WSA = 14%

WSA = 47%

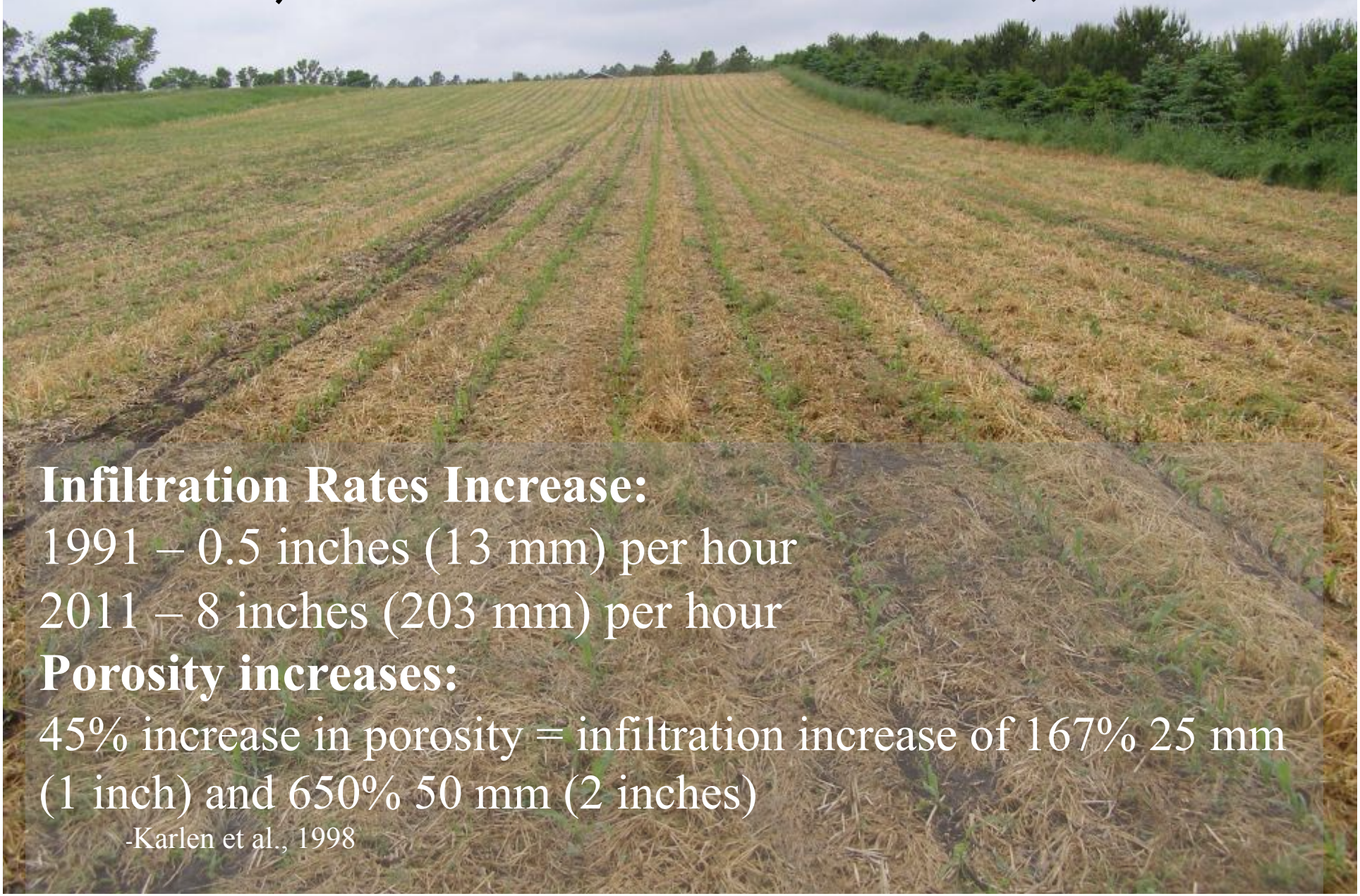
WSA = 93%

CT, SW-F

NT, SW-WW-SF

Moderately-grazed pasture

Brown Ranch near Bismarck, ND after 13.6 inches (330 mm) of rainfall in 24 hrs in June 15, 2009



Infiltration Rates Increase:

1991 – 0.5 inches (13 mm) per hour

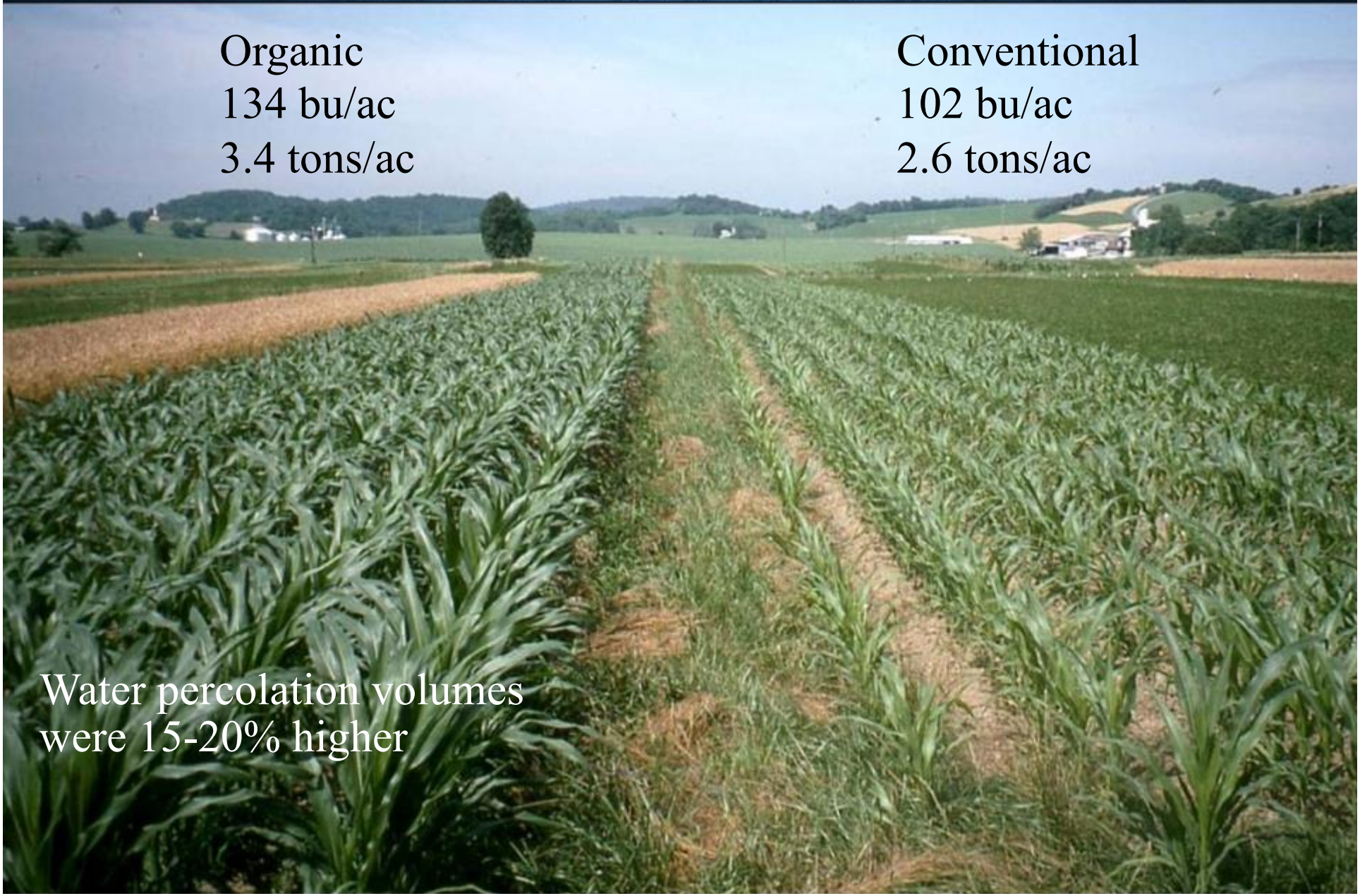
2011 – 8 inches (203 mm) per hour

Porosity increases:

45% increase in porosity = infiltration increase of 167% 25 mm (1 inch) and 650% 50 mm (2 inches)

-Karlen et al., 1998

Kutztown, PA Corn During 1995 Drought

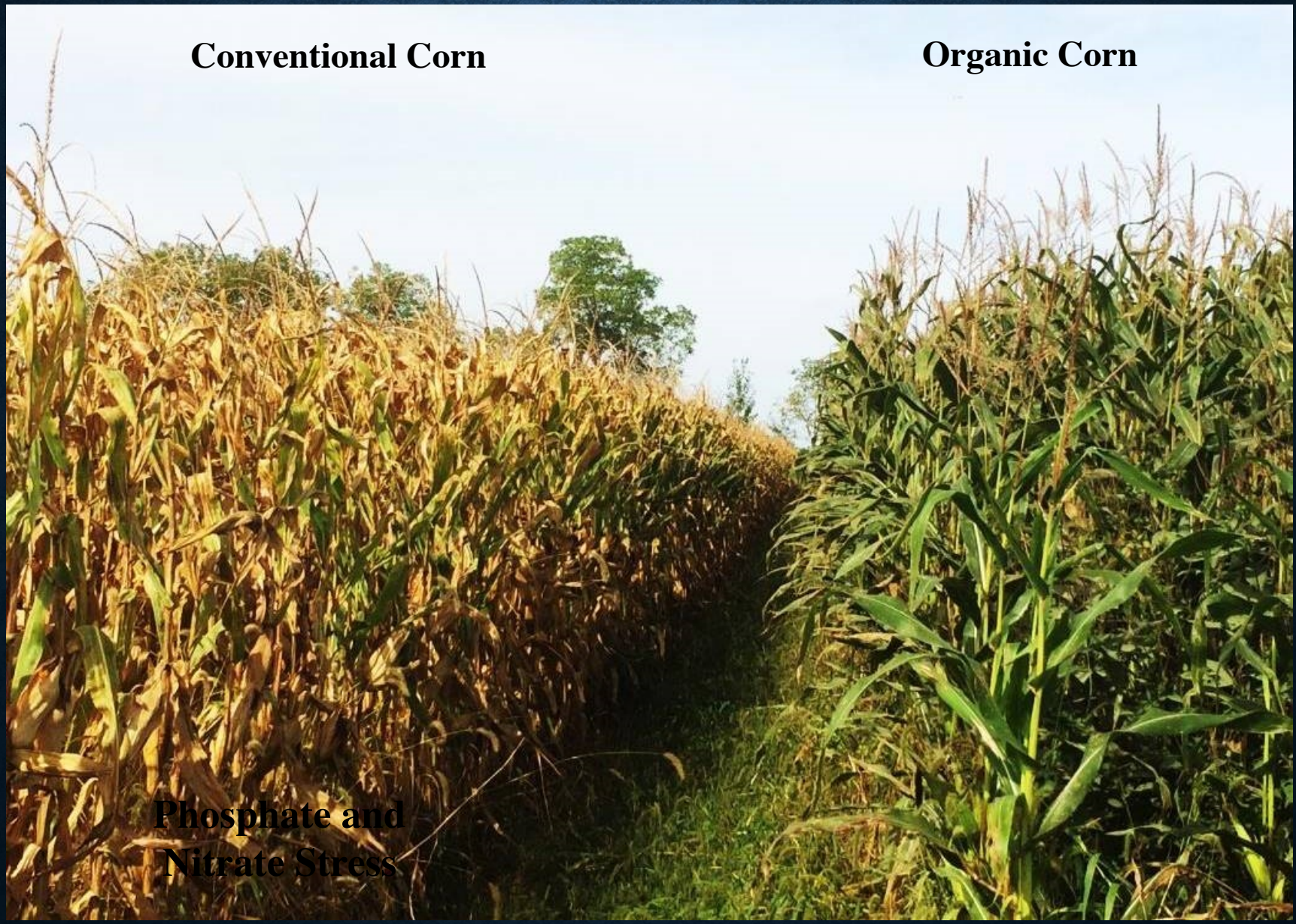


Kutztown, PA 2015

Organic Corn
18% higher yield

Conventional Corn

2016 Rodale Institute – Kutztown, PA



Water Used for Nutrition

FST 2015 – Nutrient Stress in Chemically-Intensive Corn - Leaching in spring due to higher than normal precipitation and drier than normal fall.

- **Unfertilized corn needed nearly 5 times the amount of water as the fertilized corn.**

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

GLEANINGS

Compiled by Gene Johnston

YOUR NEW BOSS: THE CONSUMER

What consumers, primarily women, say and do regarding food and food trends.

ABOUT GMOs

66% *support mandatory labeling*

40% *reduce or avoid GMO ingredients (up 10% since 2010)*

48% *say GMO-free is important in food decisions*

ABOUT PAYING MORE

25% *is how much extra they will pay for food they see as fresher, healthier, and more nutritious*

ABOUT THE INTERNET

45% *use it for recipe information*

ABOUT ORGANICS

73% *buy at least occasionally (up from 55% in 2000)*

SODA SALES HAVE DROPPED 25% SINCE 1998,

replaced mostly by bottled water

AND THOSE DARN MILLENNIALS (UNDER 35):

76% *buy local foods (up 20% in two years)*

81% *are willing to pay a premium for foods with a health benefit*

50% *have or would buy groceries online*

#1 HEALTHY-EATING STRATEGY IS EATING MORE FRUITS AND VEGGIES

followed by

- ***eating at home***
- ***eating less sugar***
- ***eating less processed food***
- ***eating healthier snacks***

For more on the rapidly changing food trends, see "Meet Your New Boss" starting on page 26.

Source: Better Homes and Gardens®, The Hartman Group, Mintel Group, Pamela Koch with Columbia University, and The Nielsen Company

Illustrations: tora-nosuke, iStock.com

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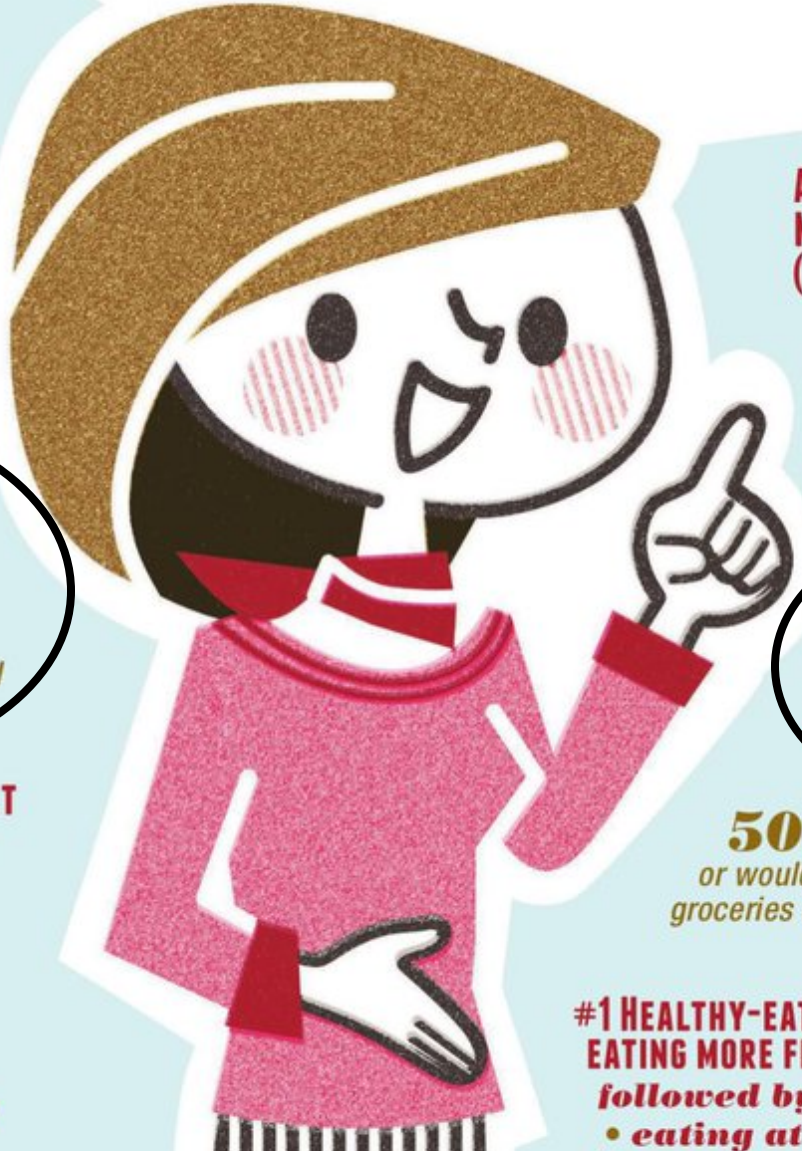

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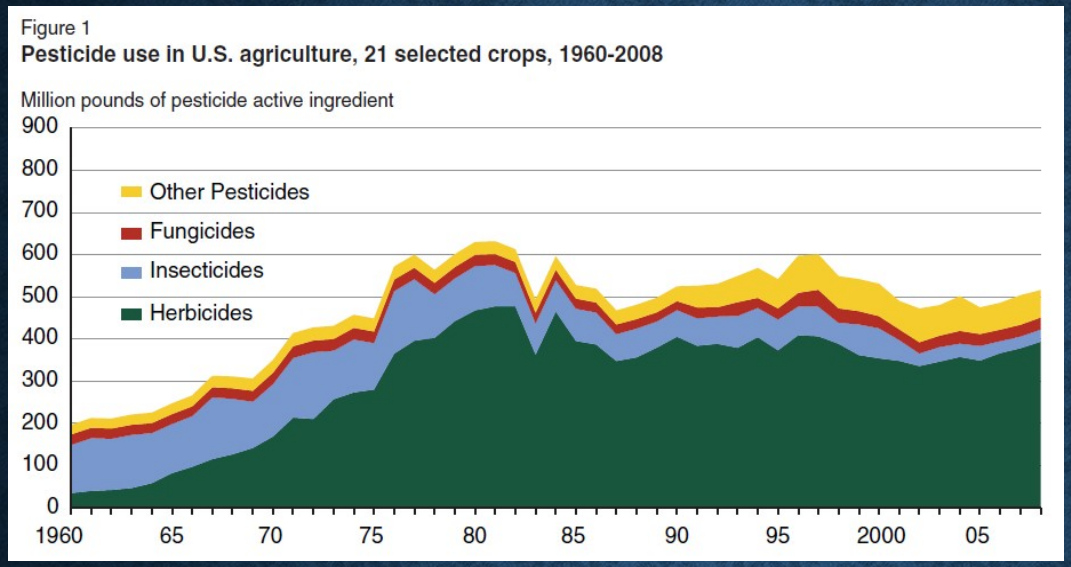
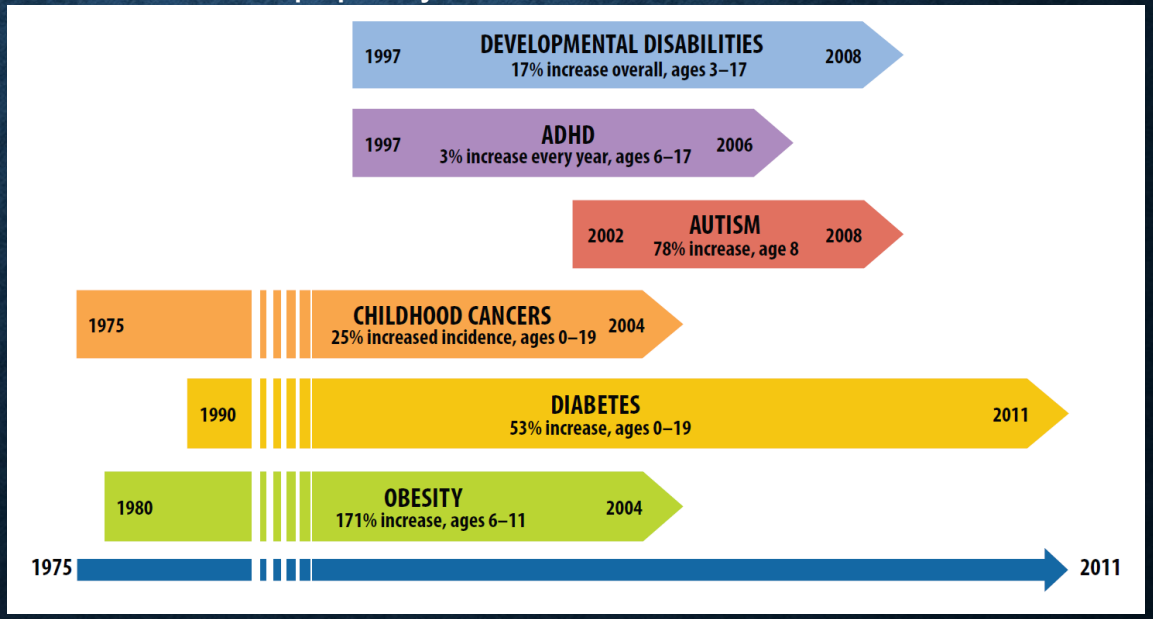
- *eating at*

HUMAN HEALTH



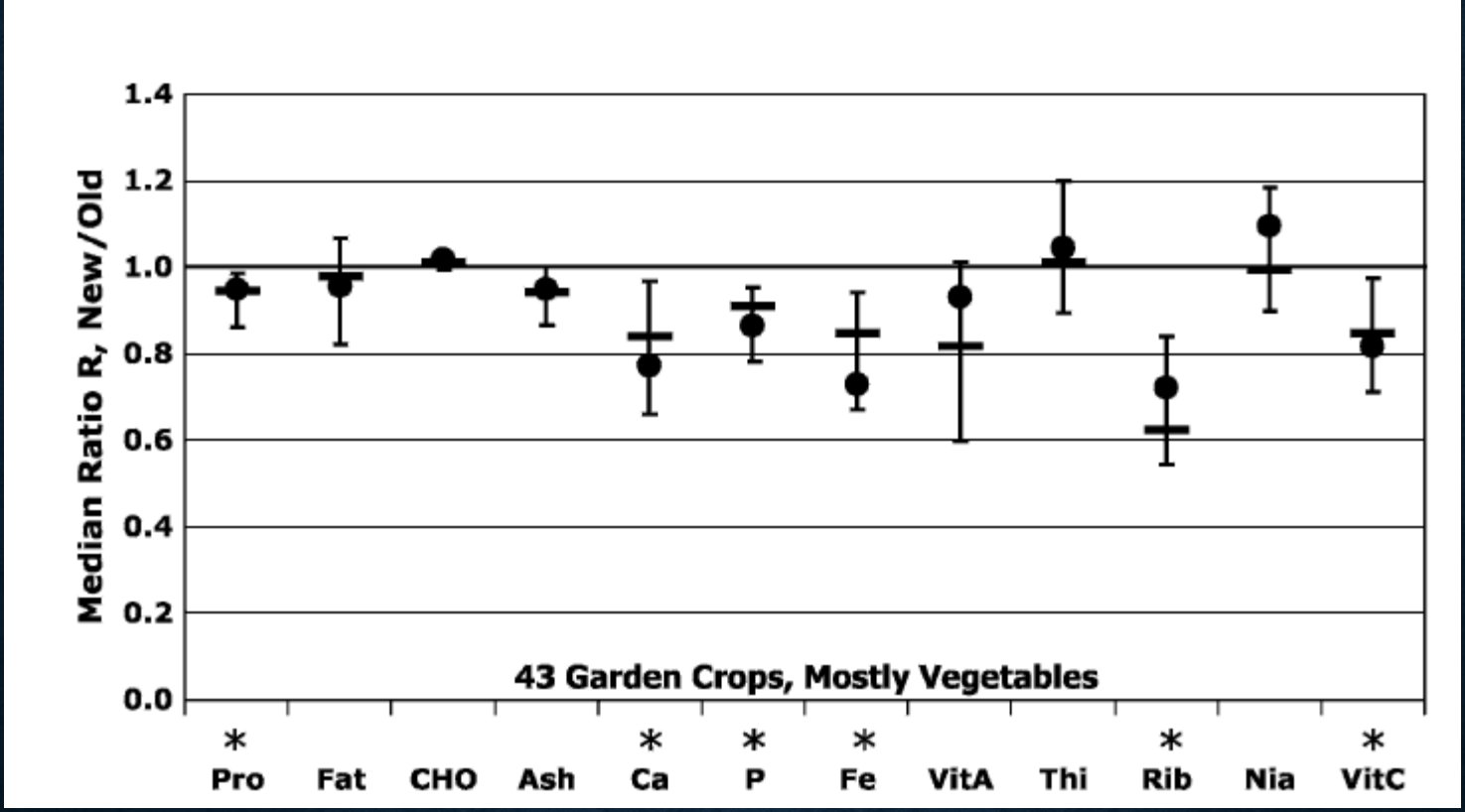
Source: Economic Research Service with USDA and proprietary data



Pesticide Action Network North America 2012

NUTRIENTS AND HEALTH

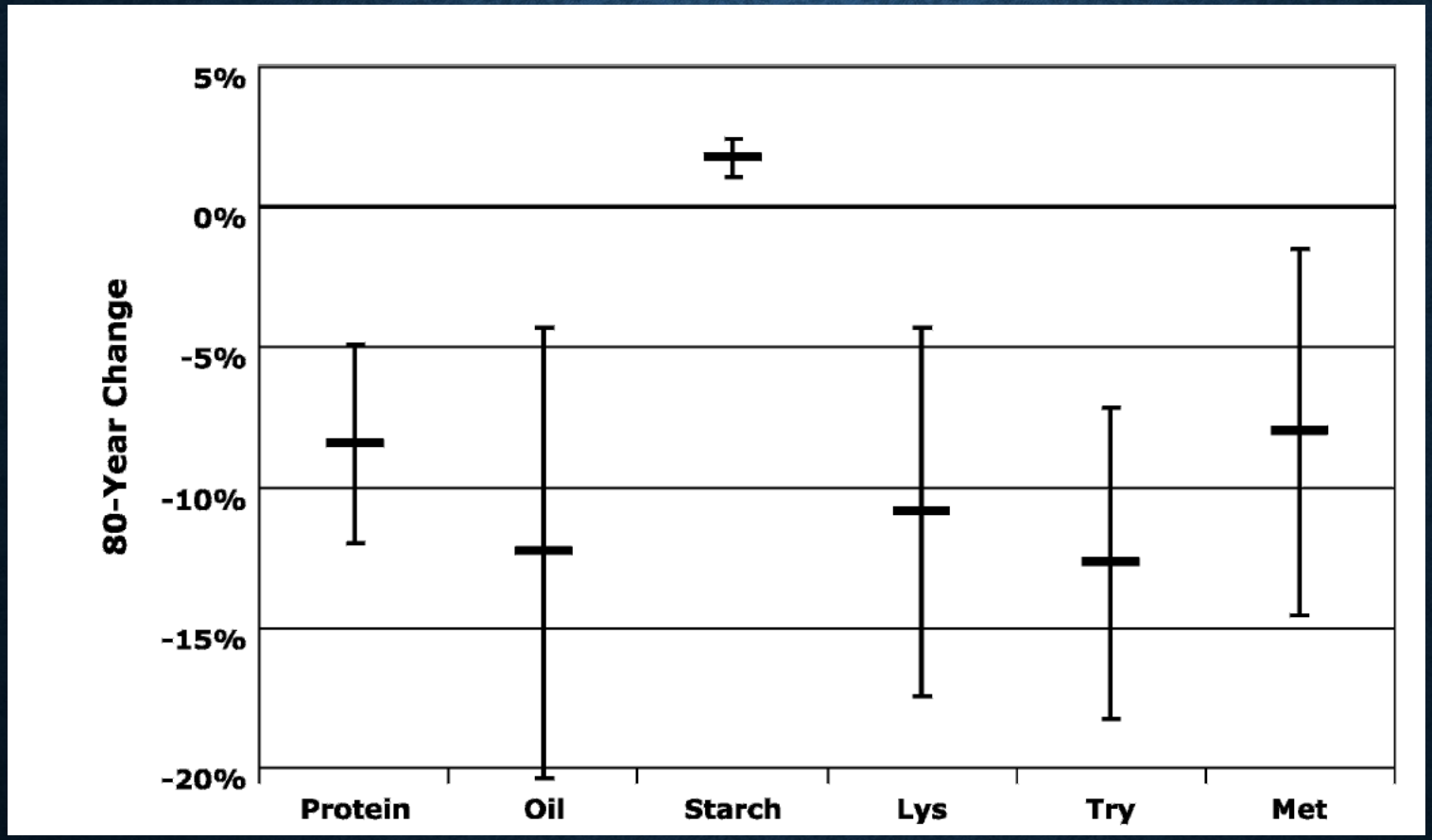
Change in fruit and vegetable nutrient status from tests in 1950 and 1999.



Davis 2009

NUTRIENTS AND HEALTH

80 year changes in maize nutrient content in 45 varieties released between 1920 and 2001



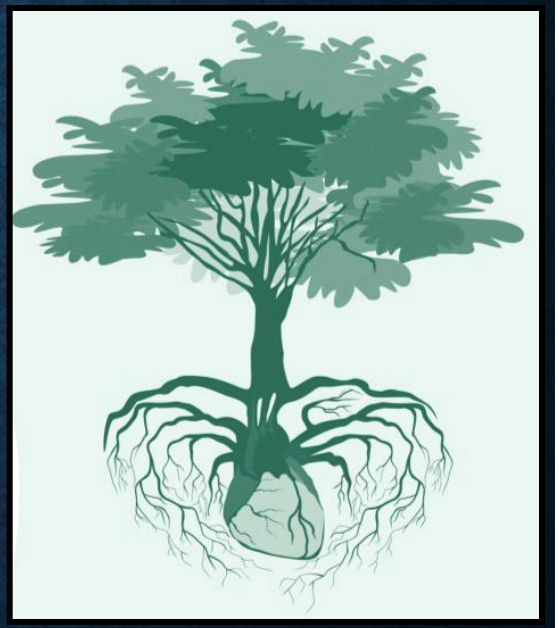
Davis 2009

Soil Health = Plant Health = Human Health

POLYCULTURE SYSTEM – MICROBES AND CROPS

The Brown Revolution Principles
Solving the Carbon Problem

1. **MAXIMIZE LIVING ROOTS – diversify and lengthen the rotation; use carefully chosen cover crops; manage livestock – Adding, Keeping, and Diversifying Carbon**
2. **ENERGIZE WITH DIVERSITY – diversify and lengthen rotation; use cover crops and compost – Adding and Diversifying Carbon (Best weed management tool - C.E. Leighty. 1938 Yearbook of Agriculture)**
3. **REDUCE CHEMICAL INPUTS – allows for plant microbe carbon trading – Adding Carbon**
4. **INSERT LIVESTOCK – manage animals including insects for soil – Adding, Keeping, and Diversifying Carbon**
5. **MINIMIZE SOIL DISTURBANCE – reduce tillage; use cover crops, compost, and mulch; manage livestock – Keeping not Adding Carbon**
6. **KEEP THE SOIL COVERED – reduce tillage; retain residue; use cover crops, compost, and mulch – Keeping, Adding, and Diversifying Carbon**



Soil is the Heart of the System

KRIS Systems
Education & Consultation
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It really boils down to this: that all life is interrelated. We are all caught in an inescapable network of mutuality, tied into a single garment of destiny. Whatever affects one destiny, affects all indirectly.

Martin Luther King Jr., Christmas Eve Serman, 1967

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Founder and Principal Scientist
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