

# **Regenerative Agriculture Builds Resilience with Soil Biology**

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**Regina: Nov. 7-8, 2016 – 12 – 14 C**  
**Today - -22 C**



# Soil Health

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



**FARMER - Chemical &  
Mechanical Management**

**NATURE**



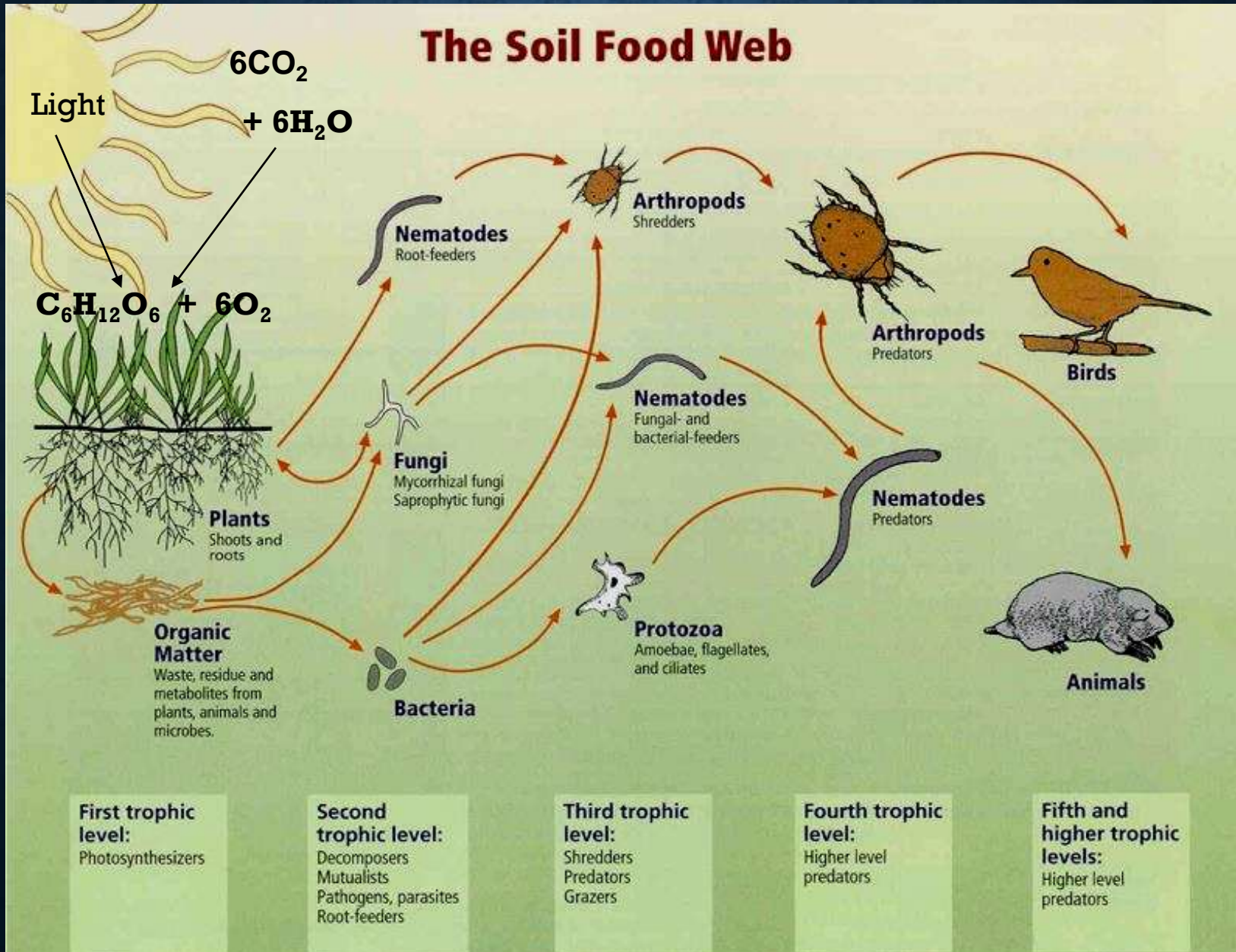
# Soil Health


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

# Root of the Problem is the Root of the Solution





**Systems Approach** that starts with **Photosynthesis.**

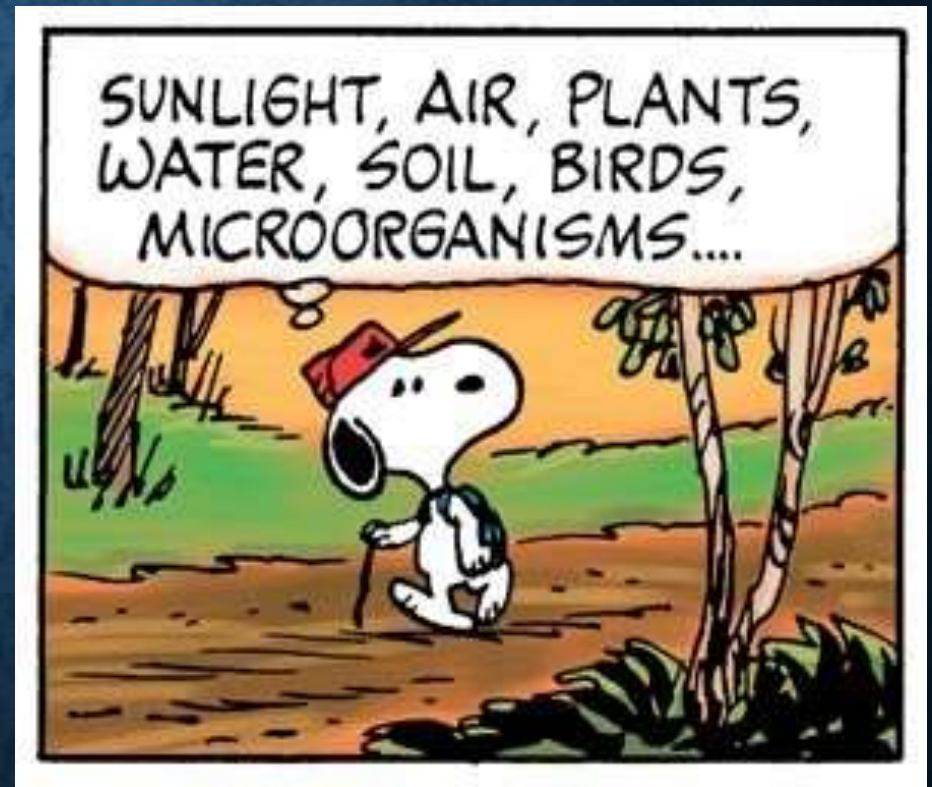


**Photosynthesis** – most efficient form of solar energy conversion to chemical energy in the bonds between carbon atoms or carbon atoms and other atoms.

# THE BROWN REVOLUTION

## ➤ Eco-Functional Intensification

- Optimize landscape use
- Maximize efficiencies
- Not more but less
- Multiple enterprises
- Everything costs
- Redistribute risk
- Nutrient density

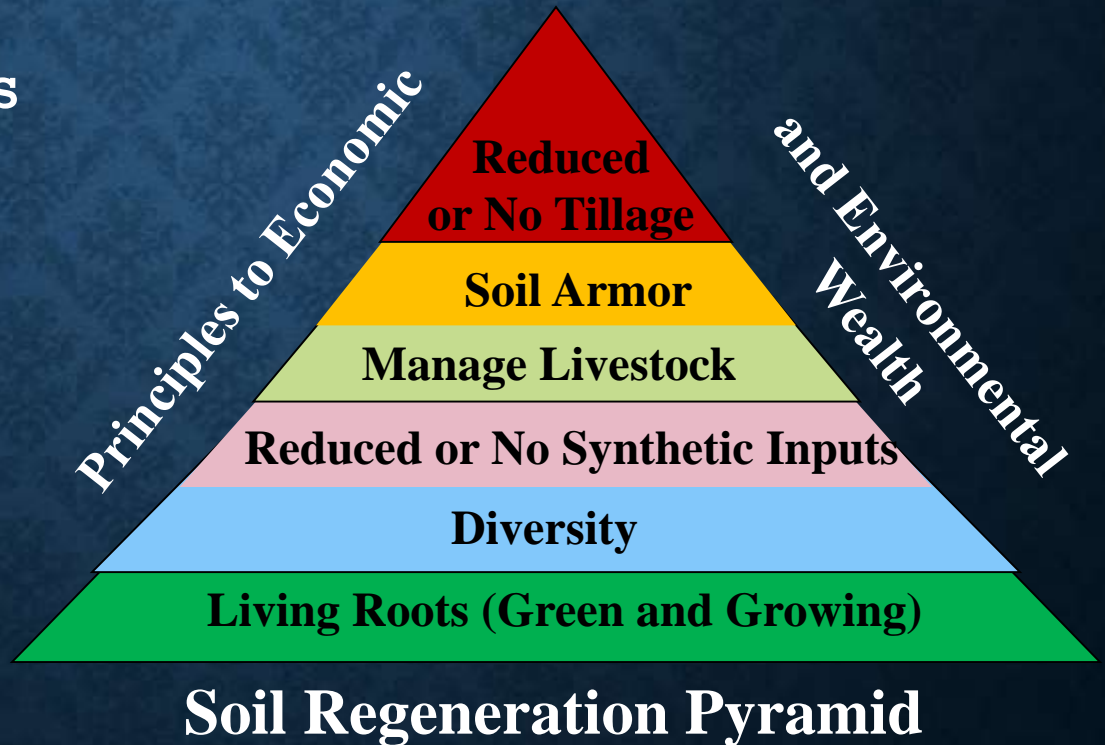




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# TREAT SOIL LIKE YOU'RE SUPPOSED TO TREAT YOURSELF



- Eat small meals throughout the day (be a grazer).

# 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



SOIL BANK

# STARVING AND HOMELESS



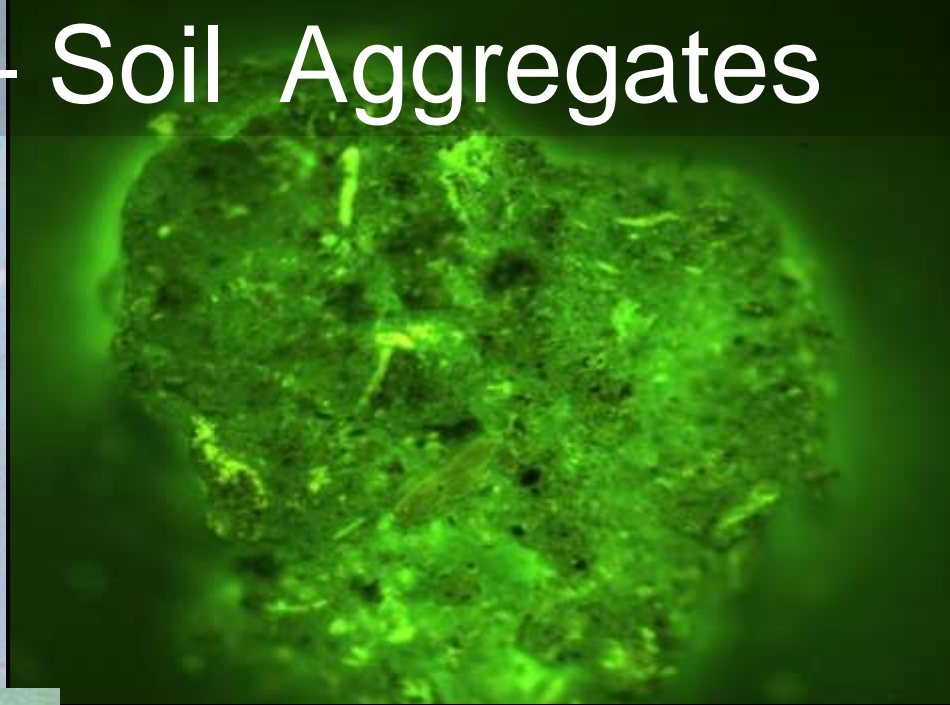
- Soil is organic (i.e. living)
- Billions of different organisms from millions of species
- Total weight of living organisms in the top six inches of an acre of soil can range from 5,000 to 20,000 lbs
- Soil from one spot may house a very different community from soil just a yard (meter) away

# 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**



# Soil Architecture – Soil Aggregates



# Aggregate Stability



**WSA = 14%**

**CT, SW-F**



**WSA = 47%**

**NT, SW-WW-SF**

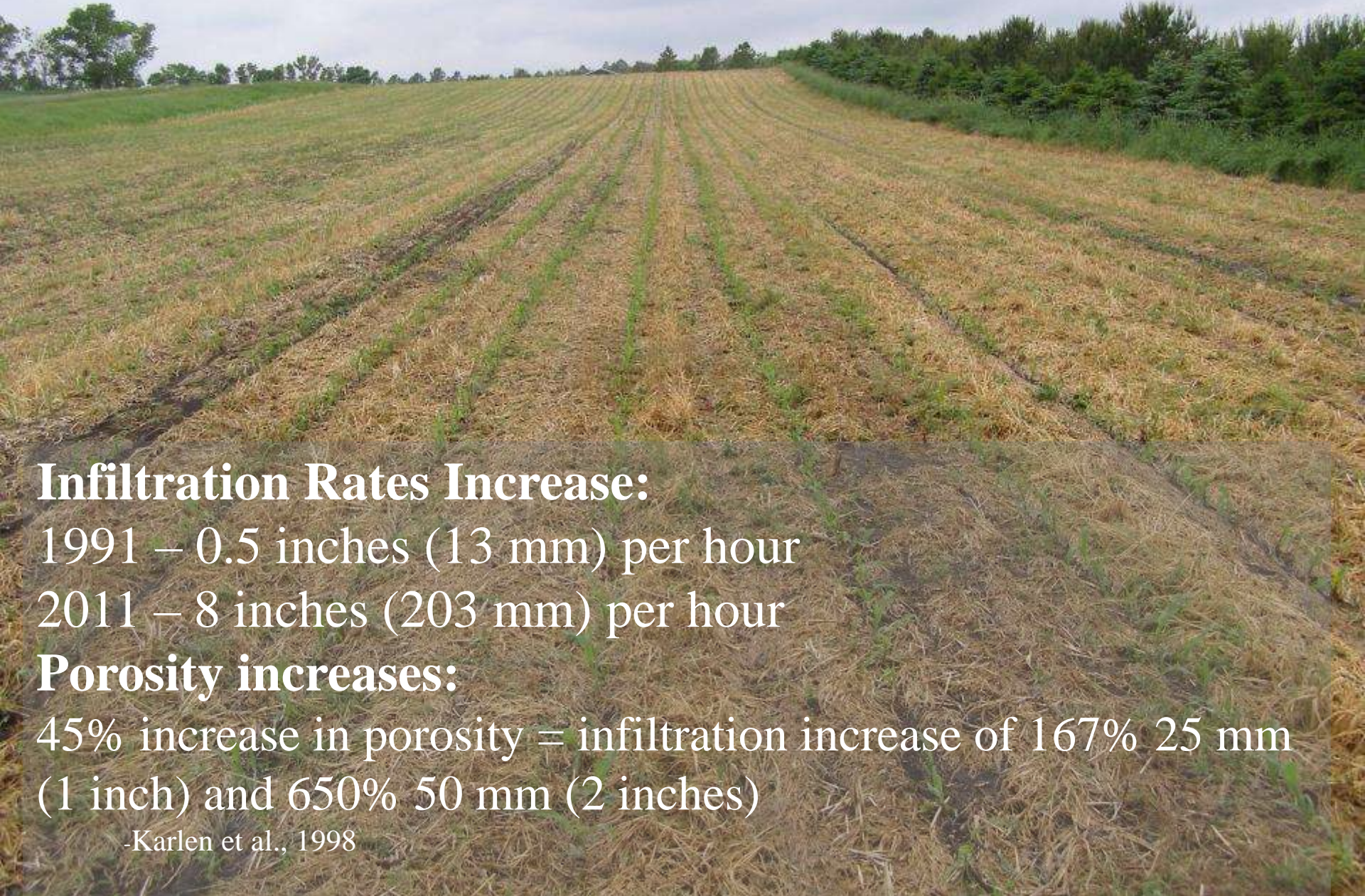


**WSA = 93%**

**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

# Water Use Efficiency

- The Drought Myth - a case of plant hunger rather than thirst - unfertilized corn required 26,000 gallons of water per bushel yielded 4X less than a fertilized field receiving only 5,600 gallons of water per bushel. – W.A. Albrecht, 2000
- Seven-way cover crop mix yield almost 3 times higher than of single crop on 7 in of soil moisture. Field with manure and no commercial fertilizer yielded the same as a fertilized field and plant tissues tested sufficient or high for N, P, K, and S – North Dakota, 2006
- 45% greater porosity increases infiltration rate by 167% for the first inch and 650% for the second inch - Karlen et al., 1998
- Loose soil has a slower rate of drying compared to packed soil, because the water films are discontinuous and moisture is not readily conducted to the surface.



# TREAT SOIL LIKE YOU'RE SUPPOSED TO TREAT YOURSELF



- Eat small meals throughout the day (be a grazer).
- Eat a diverse diet (not donut diet).

# 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



**Diversity**

**Living Roots (Green and Growing)**

**Soil Regeneration Pyramid**

# 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).

# THE BROWN REVOLUTION

Carbonomics – Work for  
Food (Carbon)



**Soil Regeneration Pyramid**

# Resource-intensive food production systems vs. biological systems.

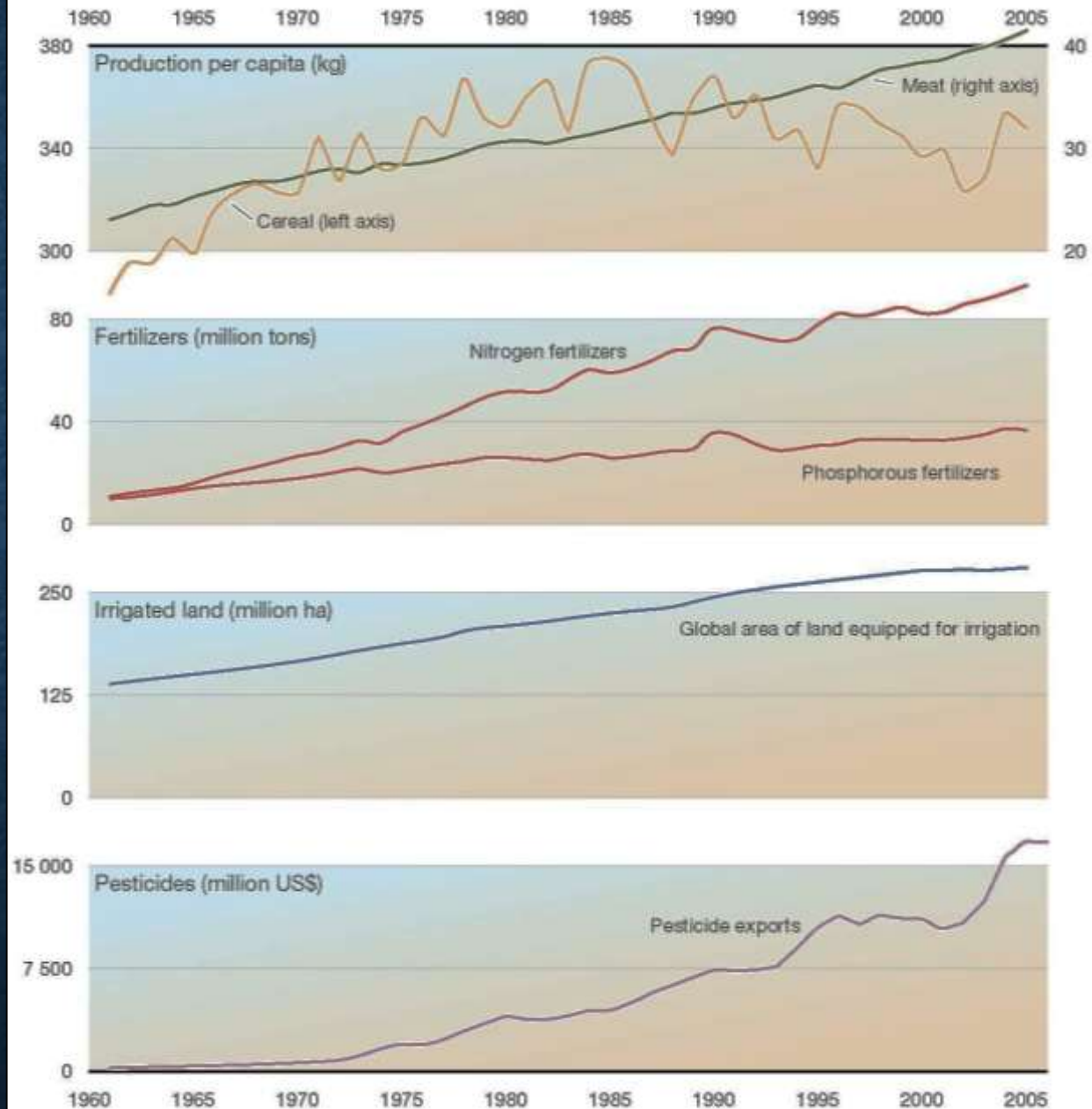
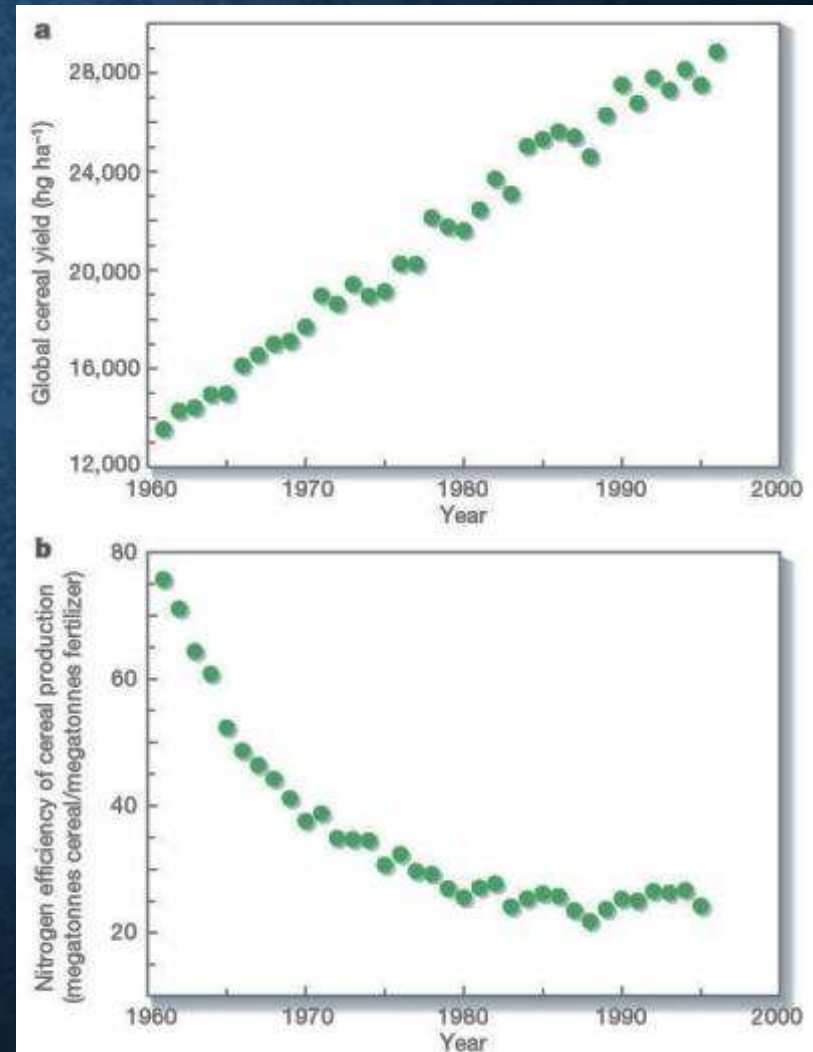


Figure 8: Global trends (1960–2005) in cereal and meat production, use of fertilizer, irrigation and pesticides. (Source: Tilman, 2002; FAO, 2003; International Fertilizer Association, 2008; FAOSTAT, 2009).

# 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





# ARBUSCULAR MYCORRHIZAL FUNGI

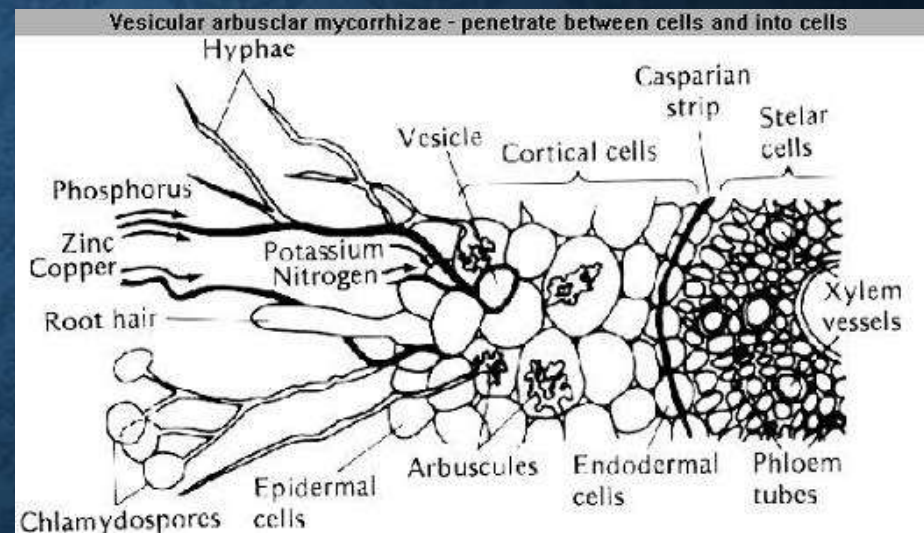
## ➤ Obtain nutrients (up to 90% of N and P) -

Smith and Read, 2008

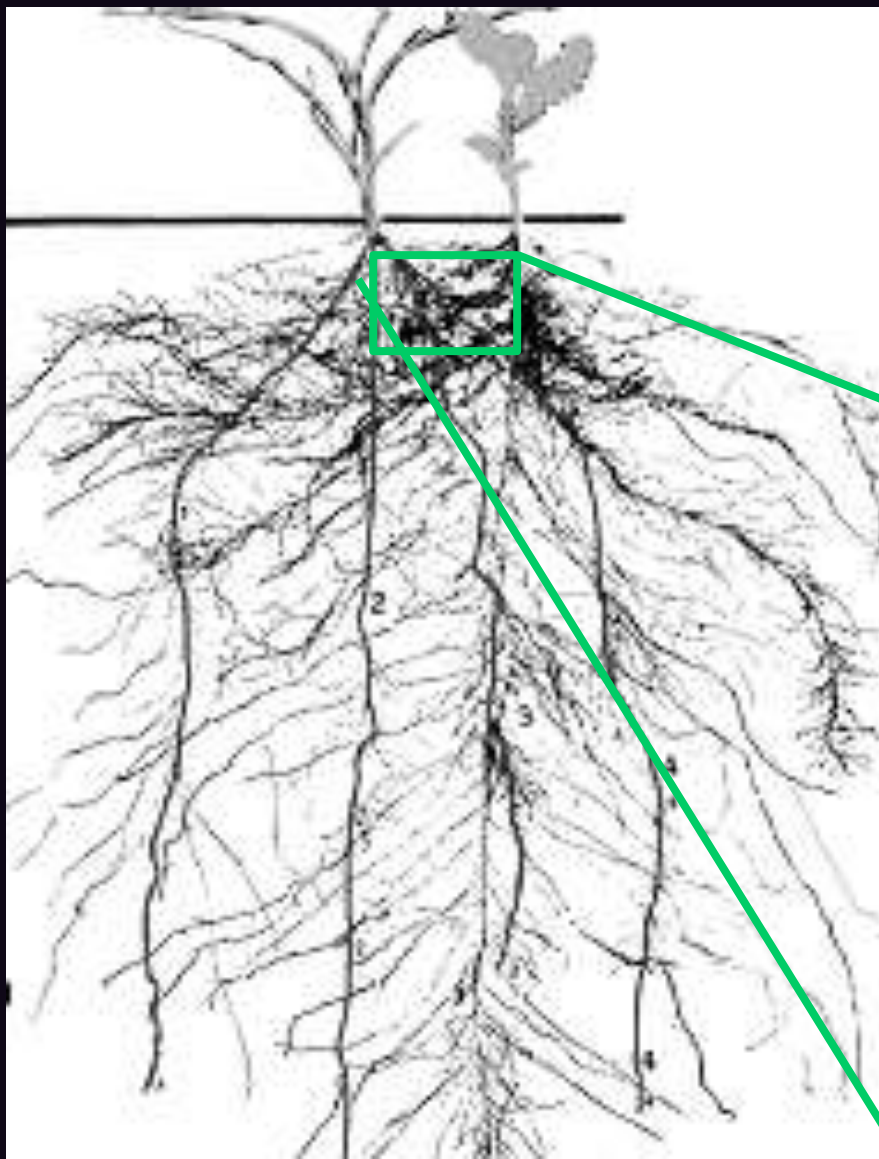
- Phosphate-solubilizing bacteria – Toro and Barea, 1996
- Mixed cultures more efficient, but this was also AMF species dependent – Walder et al 2012
- Non-legume trades P for N via AMF and rhizobia activity – Chalk et al, 2014

## ➤ Transfer water

## ➤ Induce antioxidants (Garcia-Sanchez et al., 2014)

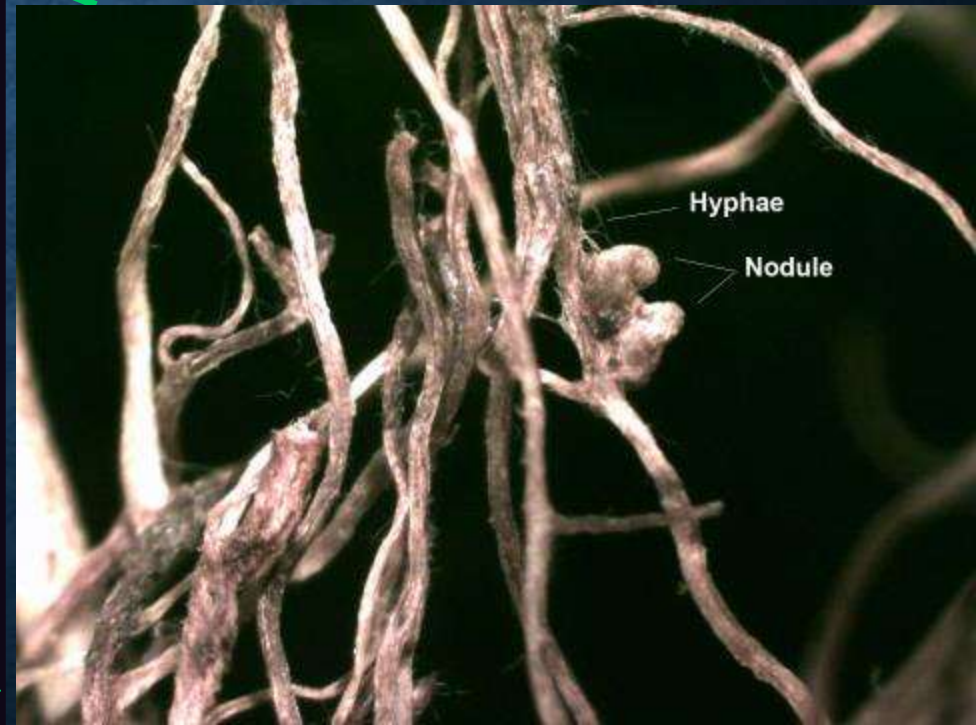


# Plant to Plant Nutrient Exchange



**Interplant transfer N for P  
and C – Chalk et al., 2014**

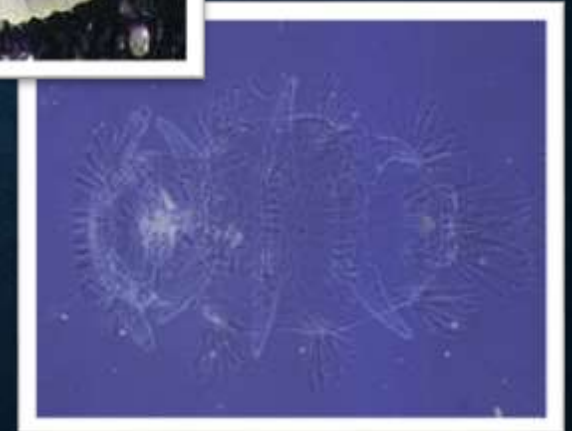
**N fixation:  $N_2$  via 32 ATP  
(needs 128 P and 320 C)**



# ARTHROPODS

## ➤ Micro

- Mites, collembola (or springtails)
- Widths range from 0.1-2 mm
- Number from about 5-20 per gram of soil
- Decompose & shred organic matter
- Tillage and pesticides are harmful
- Nitrogen cycle



# ARTHROPODS

## ➤ Micro

- Largest Diversity
- Predator-Prey
  - Weeds
  - Insects, etc
- Pollinators
- Nutrients
- Wounds – Defense Response

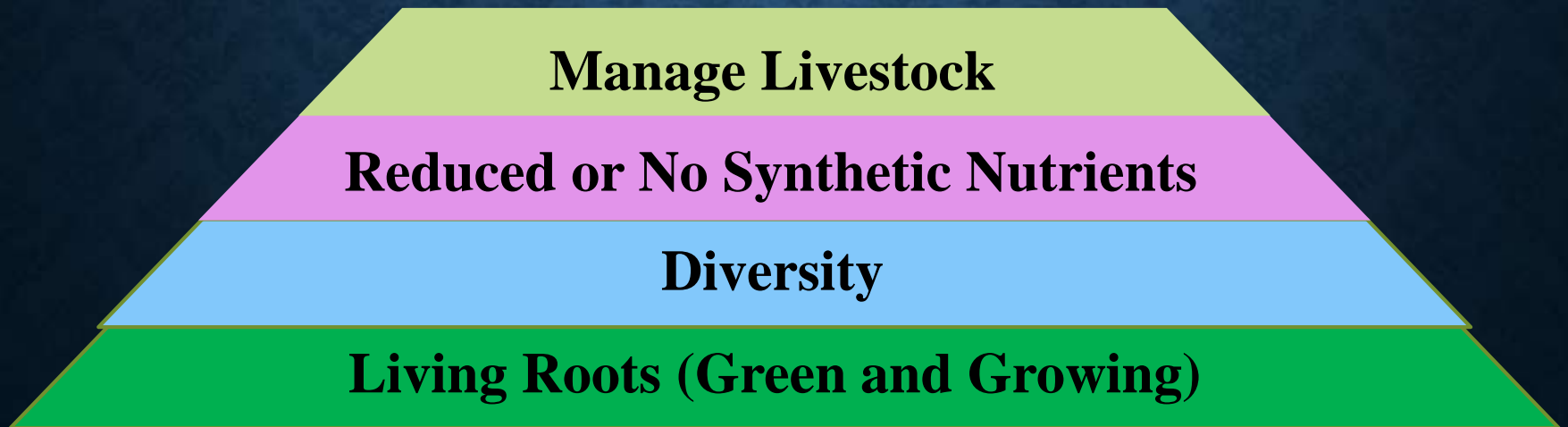
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# THE BROWN REVOLUTION

## Manage Livestock:

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



## Soil Regeneration Pyramid

# **GRAZING AND CARBONOMICS**







# 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).

# THE BROWN REVOLUTION

## Soil Armor:

1. Protection
2. Food



The diagram is a pyramid divided into five horizontal layers of different colors. From top to bottom, the layers are: orange, light green, pink, light blue, and green. Each layer contains a text label in black, bold font. The pyramid is centered on a dark blue background.

**Soil Armor**

**Manage Livestock**

**Reduced or No Synthetic Nutrients**

**Diversity**

**Living Roots (Green and Growing)**

**Soil Regeneration Pyramid**

# THE BROWN REVOLUTION

1. Habitat
2. Food

**Reduced or  
No Tillage**

**Soil Armor**

**Manage Livestock**

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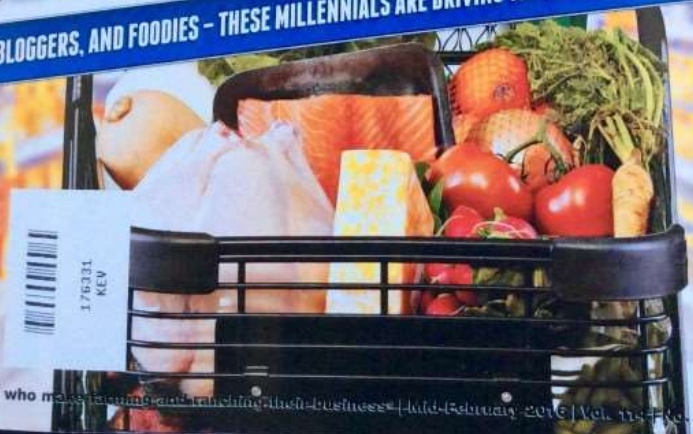
INSIDE: WHY IT'S CRITICAL THAT FARMERS SHOULD INVEST IN SOIL HEALTH. P. 4

# Successful Farming



## MEET YOUR NEW BOSS

MOMS, BLOGGERS, AND FOODIES - THESE MILLENNIALS ARE DRIVING THE NEW FOOD AND AG ECONOMY.



For families who make a living and a lifestyle from their business | Mid-February 2016 | Vol. 114 | No. 3 | Agriculture

# GLEANNINGS

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, Penn State with Colorado University and The Nielsen Company

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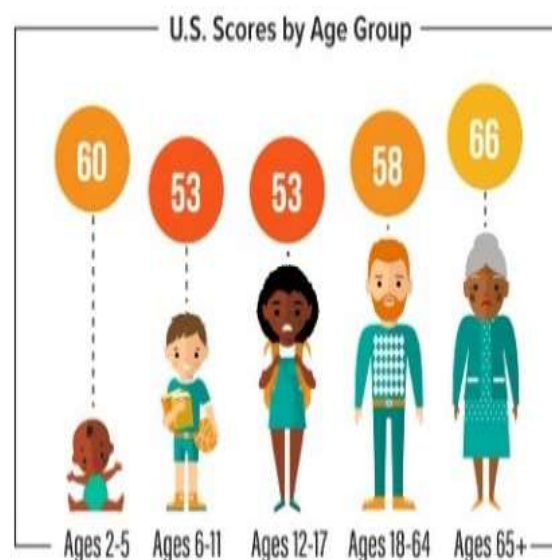
# How Healthy Is the American Diet?



59

## The Healthy Eating Index Score

shows that Americans do not align their eating choices with the Dietary Guidelines.  
(on a scale from 0-100)



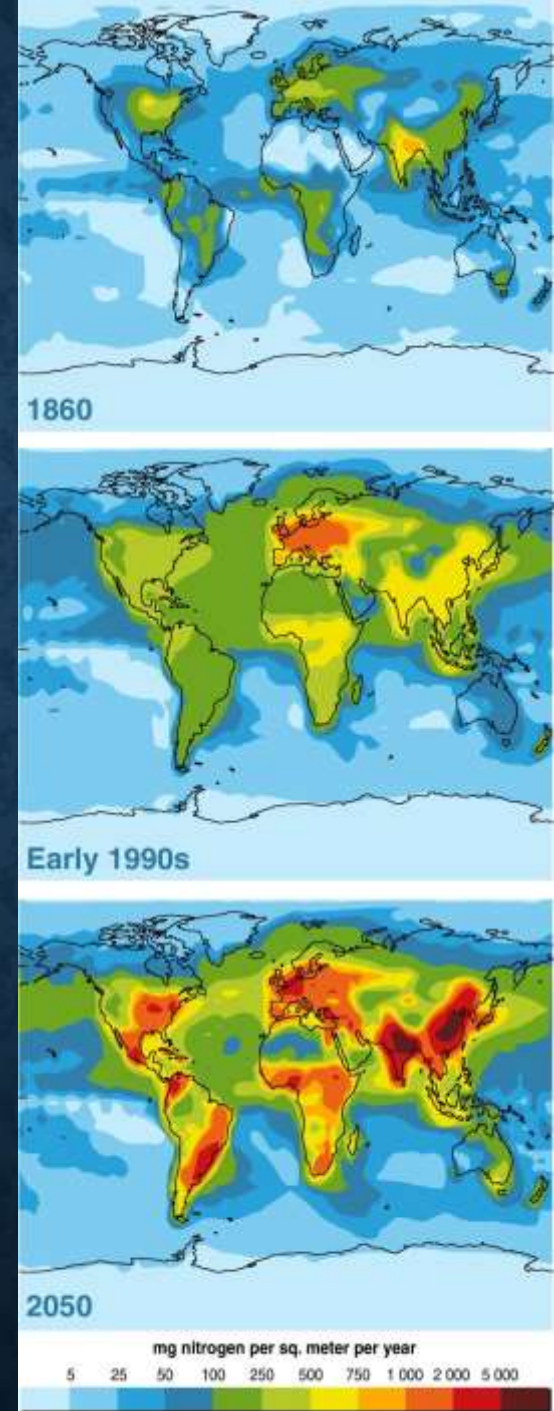
Data source for Healthy Eating Index scores: What We Eat in America, National Health and Nutrition Examination Survey (undated data are from 2013-2014).

**ABOUT 85% OF AMERICANS DO NOT CONSUME THE US FOOD AND DRUG ADMINISTRATION'S RECOMMENDED DAILY INTAKES OF THE MOST IMPORTANT VITAMINS AND MINERALS NECESSARY FOR PROPER PHYSICAL AND MENTAL DEVELOPMENT.**

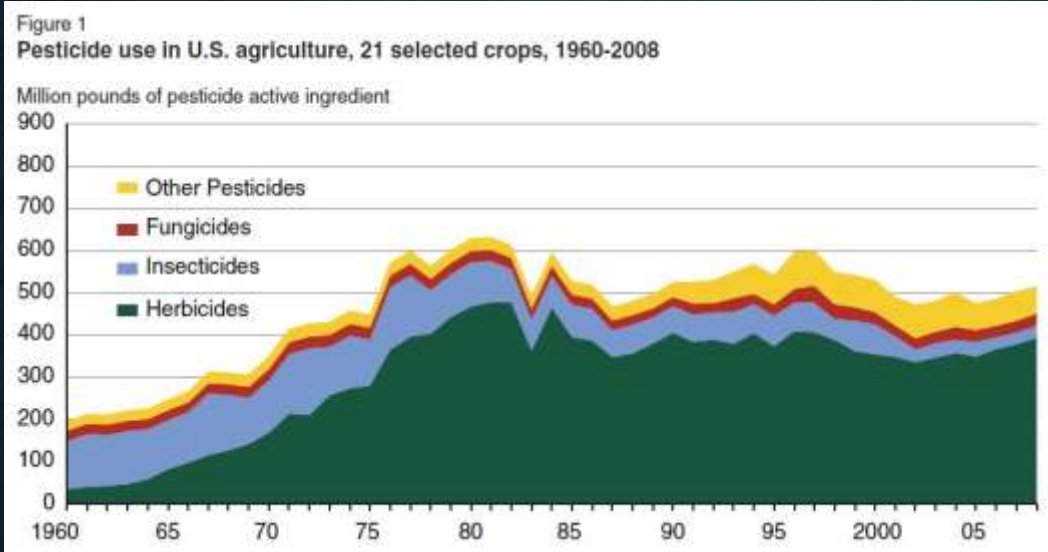
# WATER, NUTRITION, LIFE EXPECTANCY



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

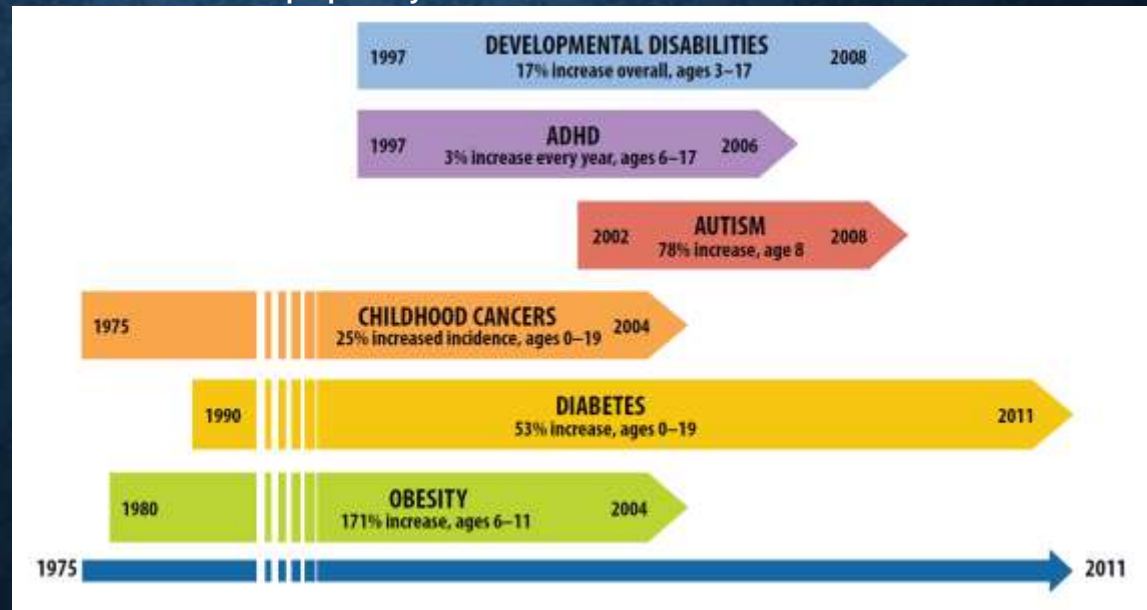


# HUMAN HEALTH



Source: Economic Research Service with USDA and proprietary data

Average person spends about 20-25% on out of pocket healthcare.



Pesticide Action Network North America 2012



## Comparison of Review Studies on Organic Versus Conventional Food

Study	Study Type	Topics	Key Results
Baranski et al., 2014	Systematic Literature Review and Meta-Analysis	<ul style="list-style-type: none"> <li>• Differences in composition of organic and conventional food i.e. nutrient concentrations and pesticide residues</li> </ul>	<ul style="list-style-type: none"> <li>• Higher antioxidants</li> <li>• Lower cadmium concentrations</li> <li>• Lower incidence of pesticide residues</li> </ul>
Smith-Spangler et al., 2012	Systematic Review	<ul style="list-style-type: none"> <li>• Nutrient density</li> <li>• Pesticide exposure</li> </ul>	<ul style="list-style-type: none"> <li>• Nutrient levels               <ul style="list-style-type: none"> <li>• Results differed within the review</li> </ul> </li> <li>• Lower pesticide residue</li> </ul>
Prescott et al., 2002	Critical Review	<ul style="list-style-type: none"> <li>• Retail purchase comparisons</li> <li>• Fertilizer treatment comparisons</li> <li>• Whole farm comparisons</li> <li>• Animal and human studies</li> <li>• Pesticide residues</li> </ul>	<ul style="list-style-type: none"> <li>• Thought to be lower in pesticide residues</li> <li>• Studies within review differ</li> <li>• Nutrient qualities differed in studies reviewed</li> </ul>

## Over Fertilization of Nitrogen Effects

Study	Study Type	Topics	Key Results
Bar-Tal et al., 2001, Njira et al., 2015	Primary research	Nutrient decline	Decrease in calcium
Follett et al., 2008	Primary research	Nutrient decline	Decrease in oil content of legumes
Prescott et al., 2002	Primary research	Nutrient decline	Decrease in dry matter, total sugar, vitamin C, essential oils, methionine, and various minerals

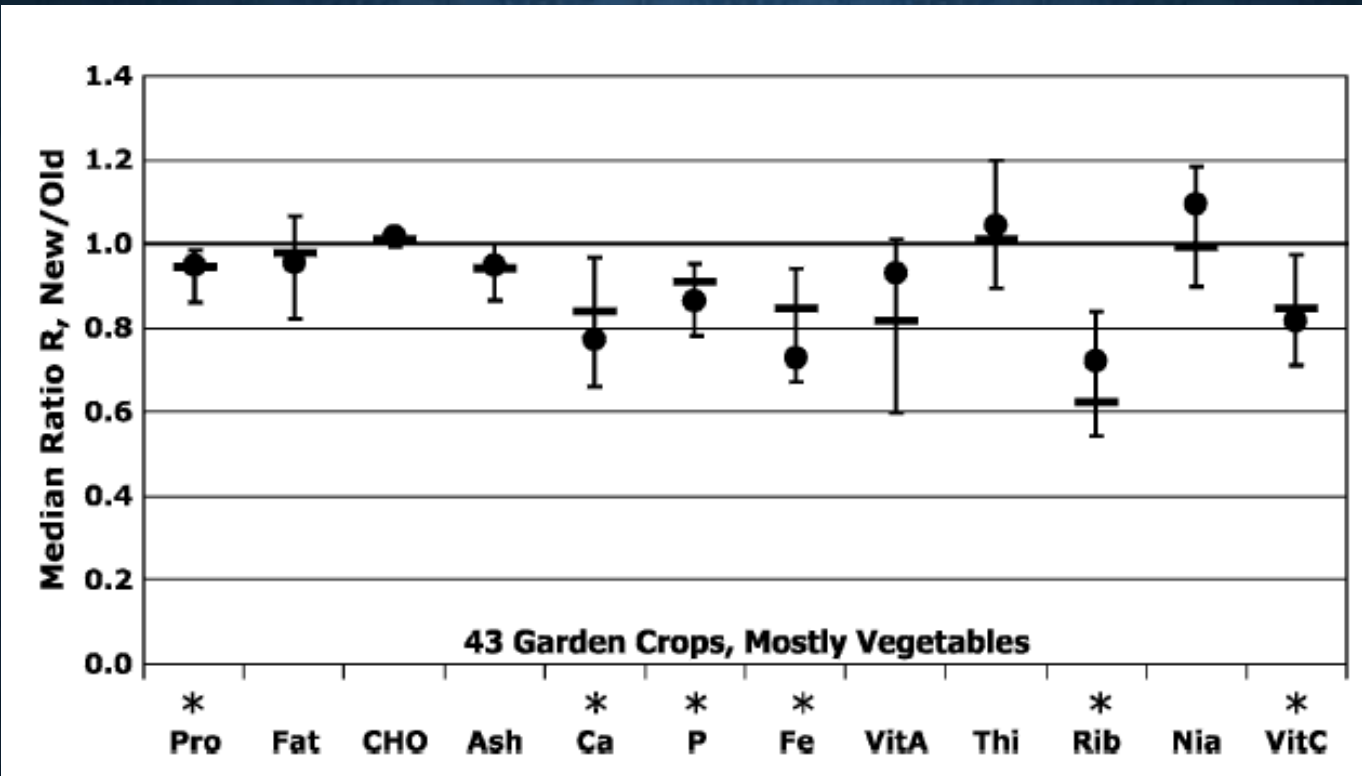
## Comparison of Review Studies on Organic Versus Conventional Food

Study	Study Type	Topics	Key Results
Davis, 2009		<ul style="list-style-type: none"><li>• Nutritional quality and human health</li><li>• Pesticides and human health</li><li>• Antibiotics and human health</li><li>• Regenerative organic</li></ul>	<ul style="list-style-type: none"><li>• Higher antioxidants</li><li>• Lower cadmium concentrations</li><li>• Lower incidence of pesticide residues</li></ul>

# SOIL HEALTH = HUMAN HEALTH

- Malnutrition is 'the cellular imbalance between the supply of nutrients and energy and the body's demand for them to ensure growth, maintenance, and specific functions'. – World Health Organization
- About 85% of Americans do not meet FDA's Daily Intakes of Necessary Vitamins and Minerals
- Nutrient density reductions in food between 5-40% (Davis, 2009)
  - Wheat and barely protein concentrations have declined by 30-50% (Davis, 2009)
  - Another study evaluated 43 garden crops and reported a median decrease in protein of 6% (Davis, 2004).

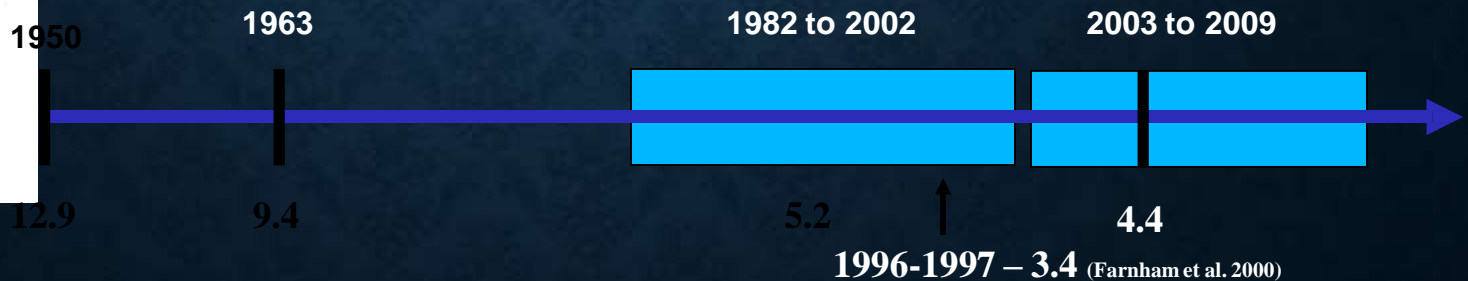
# Nutrients and Health



Davis et al. 2004, USDA data, Old-1950:New-1999, from Davis. 2009

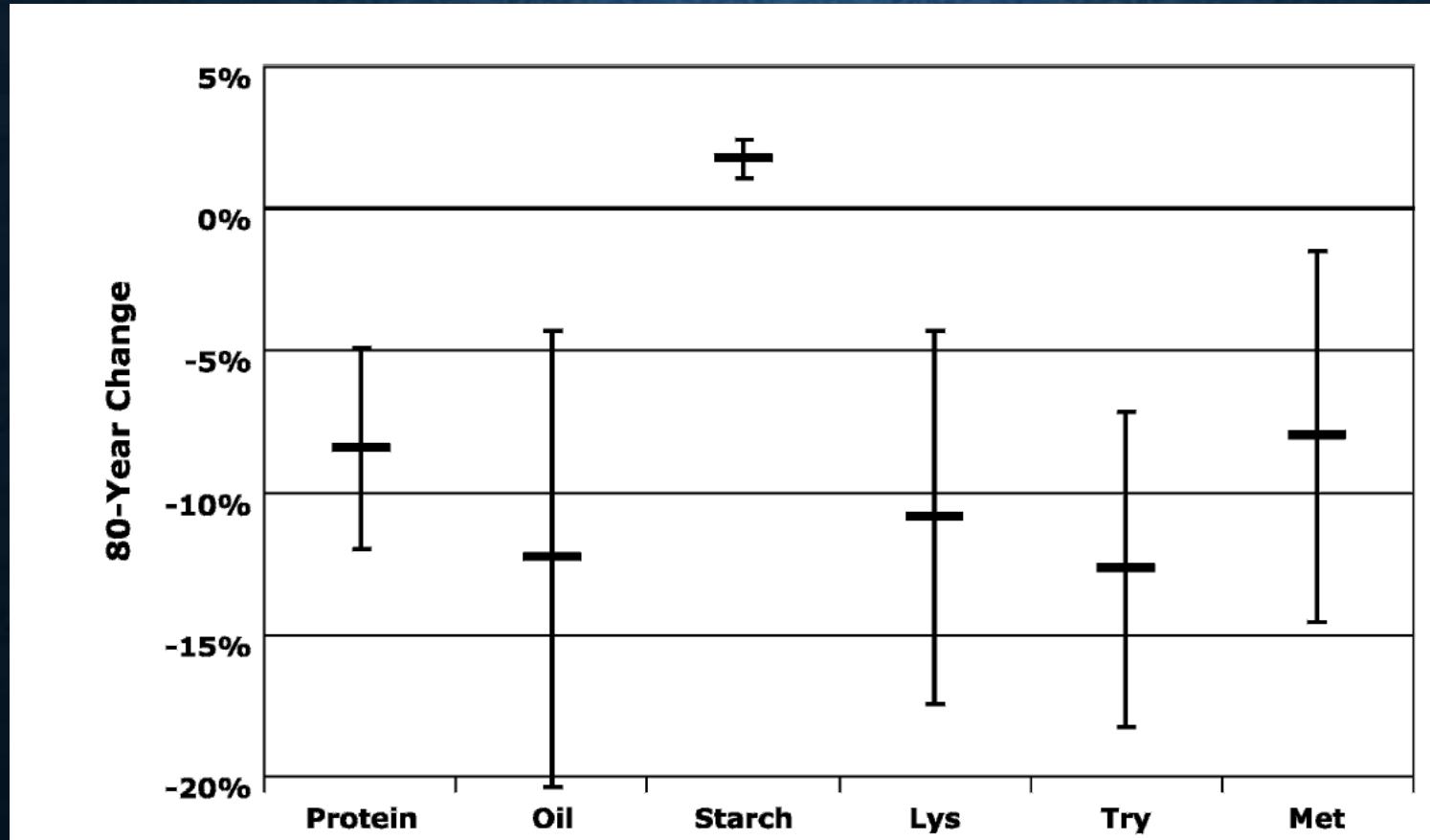


## Calcium concentrations in Broccoli (mg/g)

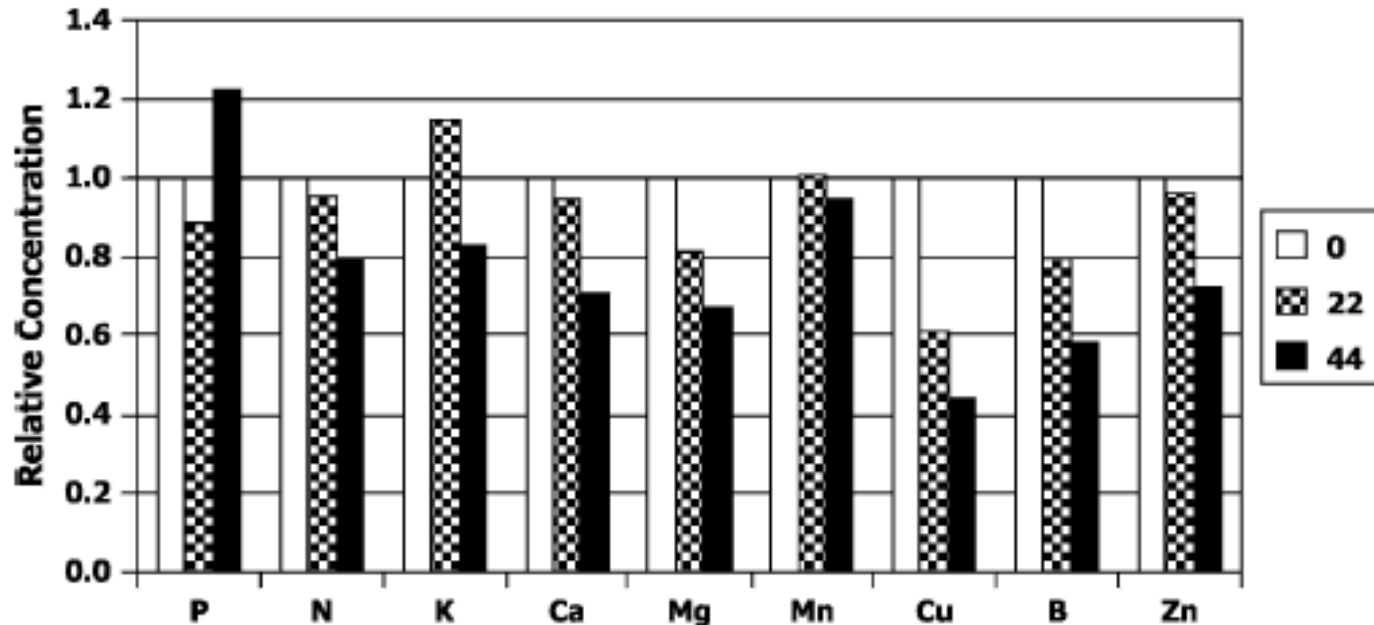


# NUTRIENTS AND HEALTH

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



# NUTRIENTS AND HEALTH



**As Phosphorus fertilizer increased, the relative concentration of most minerals declined in red raspberries.**

- **20% – 50% mineral nutrient declines**
- **37% and 119% dry matter increases**

# POLYCULTURE SYSTEM – MICROBES AND CROPS





**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 Sermon, 1967**



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