



**OHIO STATE UNIVERSITY EXTENSION**

# **ECO Farming in the 21<sup>st</sup> Century: Recycling Soil Nutrients**

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# Healthy Soil versus Sick Soil

Healthy soils have these things in common:

- 1) Live plants growing year round to absorb energy.
- 2) Healthy microbial populations. Microbes process 90% of the energy in soils.

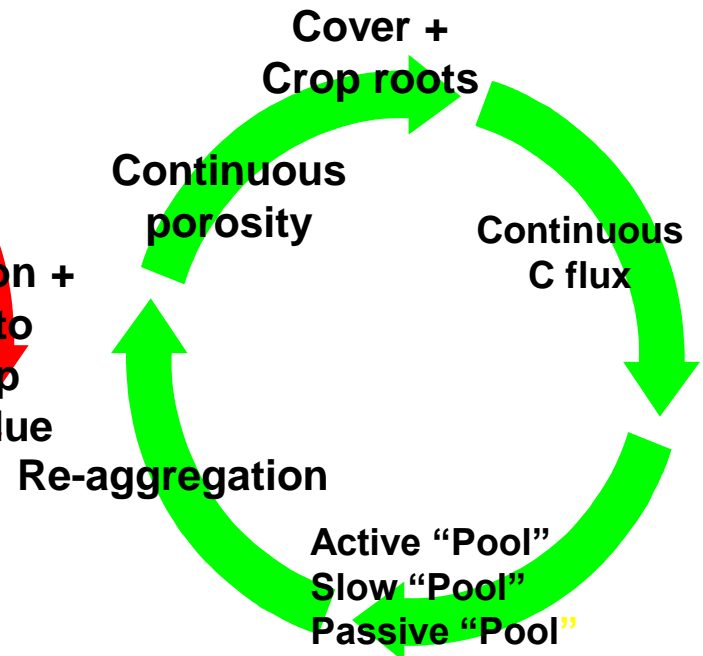
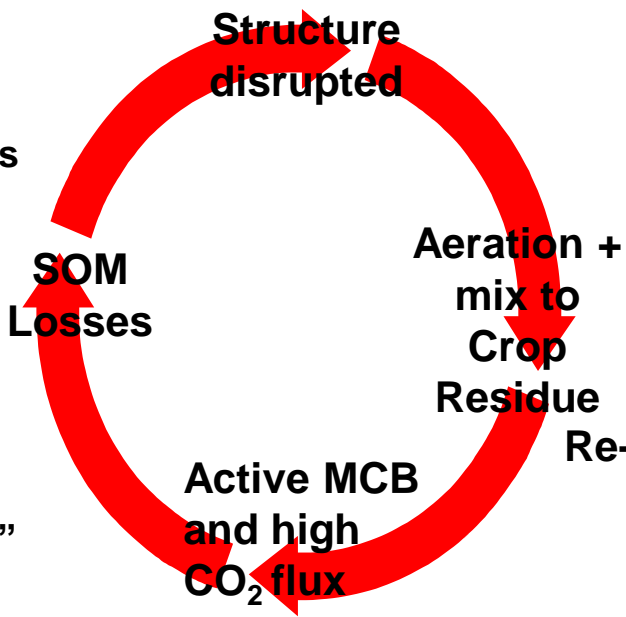
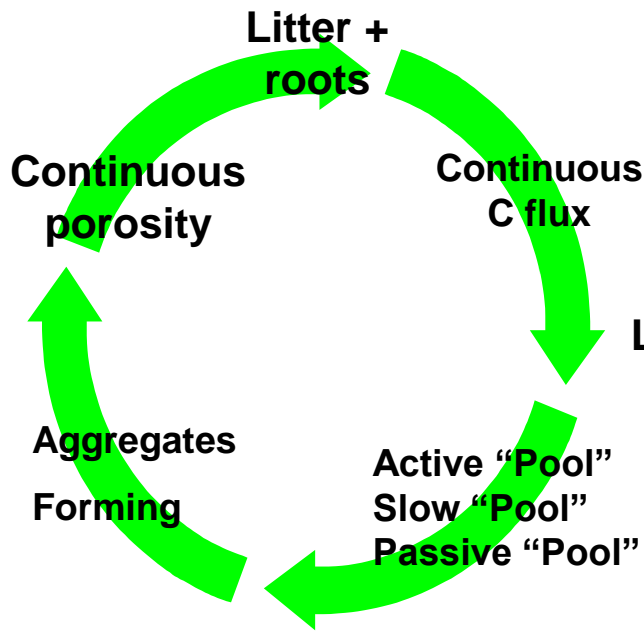
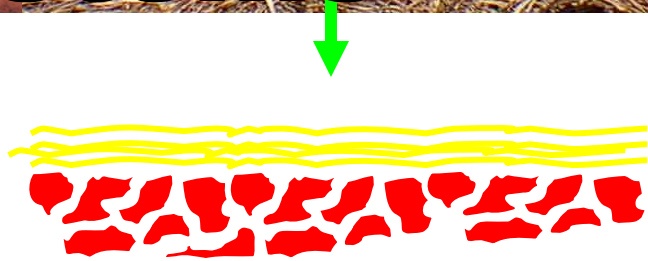
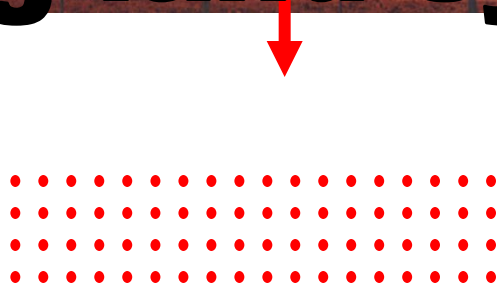
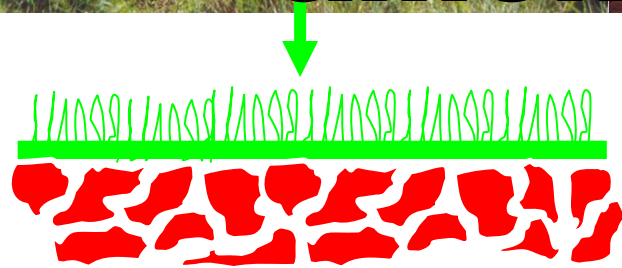
Sick soils have these things in common:

- 1) Compacted soils, high bulk density, poor water infiltration, poor water holding capacity and bare soils.
- 2) Low SOM and Nutrient Imbalances





# Basic differences among land systems



# ECO Farming

- Ecological Farming with Eternal No-till
- Continuous Living Cover
- Other Best Management Practices
  
- Economical for Farmer
- Ecologically Viable
- Environmentally Sound

ECO Farming Mimics Natural Cycles!



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# Soil Energy Comes from Plants

Conventional Tillage

No-till + Cover Crops  
“ECO Farming”



Plants 4 months out of 12 months  
Fuel & Energy = 1/3 of time



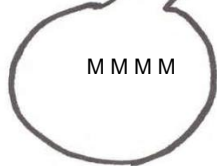
Plants 12 months out of the year  
Fuel & Energy = 100% of time

# Soil Microbes Harvest & Recycle Nutrients

## ECO Farming

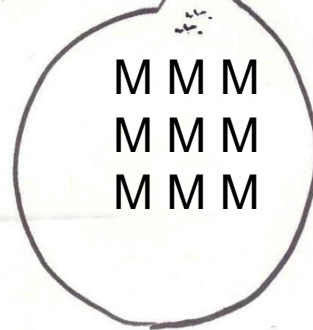


N + P  
Lost



Small Microbial  
Population

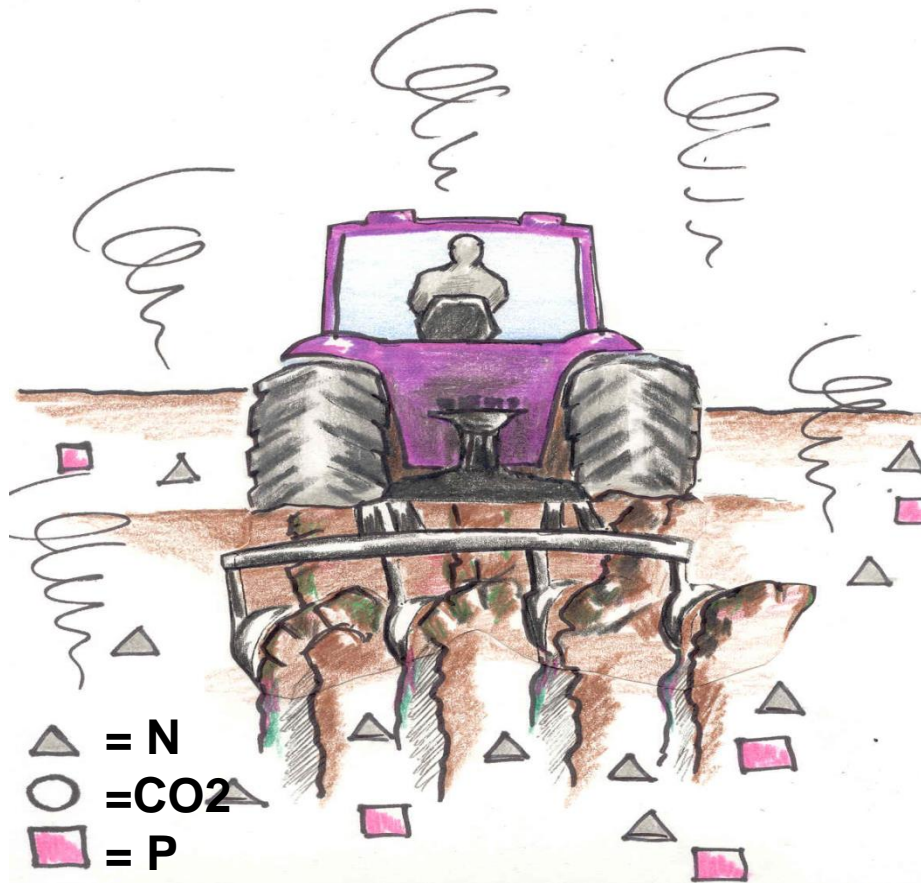
### Conventional tillage



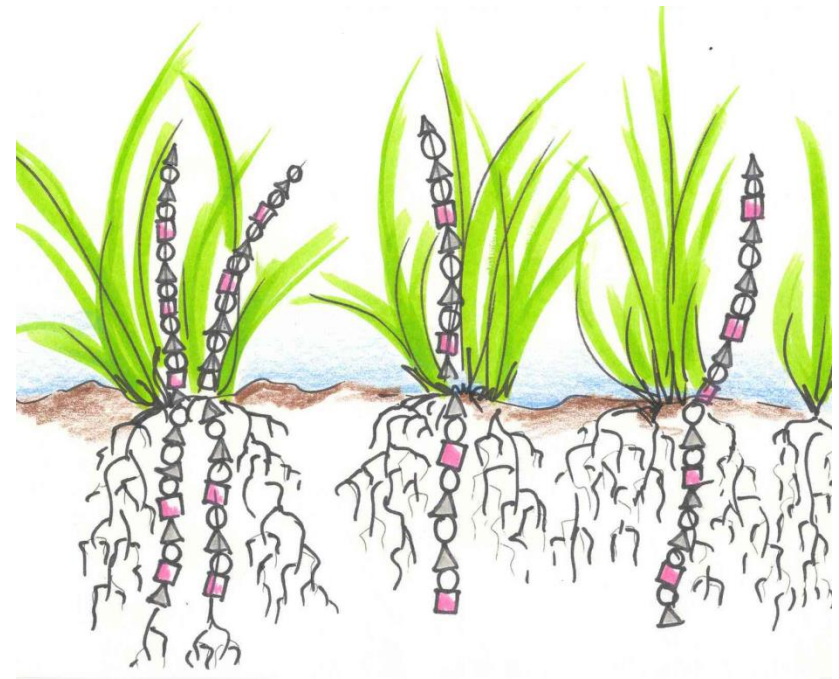
Large  
Microbial  
Population

# Tillage Burns Soil Organic Matter

## Conventional Tillage



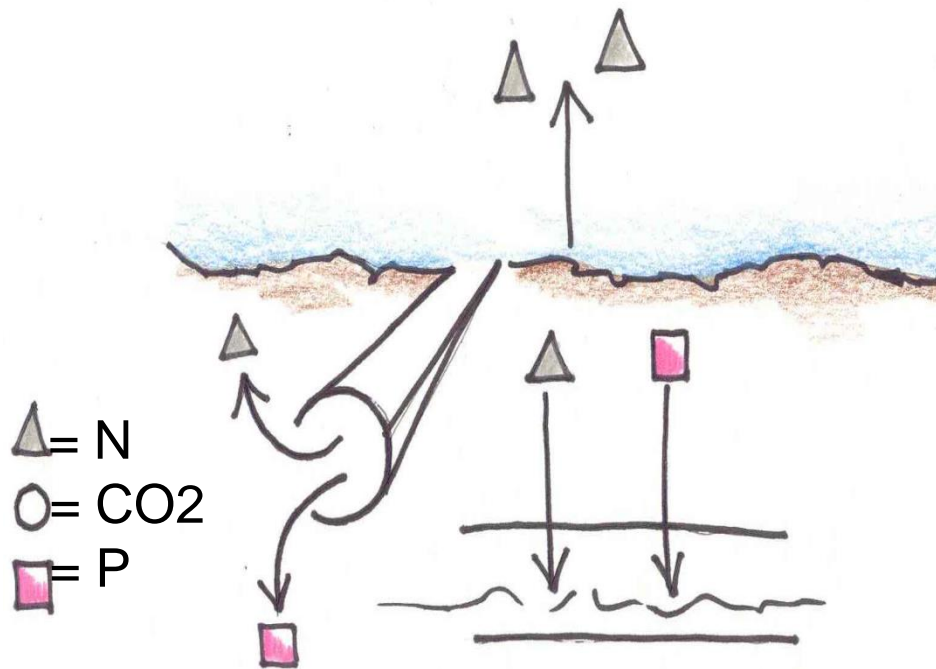
## ECO Farming



Nutrients (CO<sub>2</sub>, N, P)  
tied up in Plants.

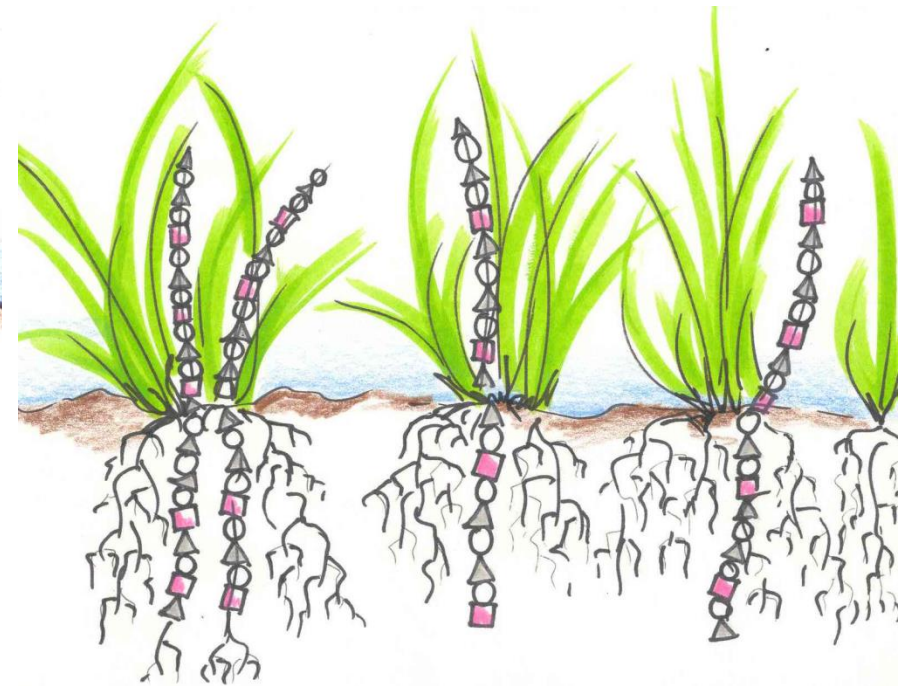
# Nutrient Fate in Winter and Spring

## Conventional Tillage



Nutrients lost to air and water because no plant roots to absorb nutrients (N, P).

## ECO Farming

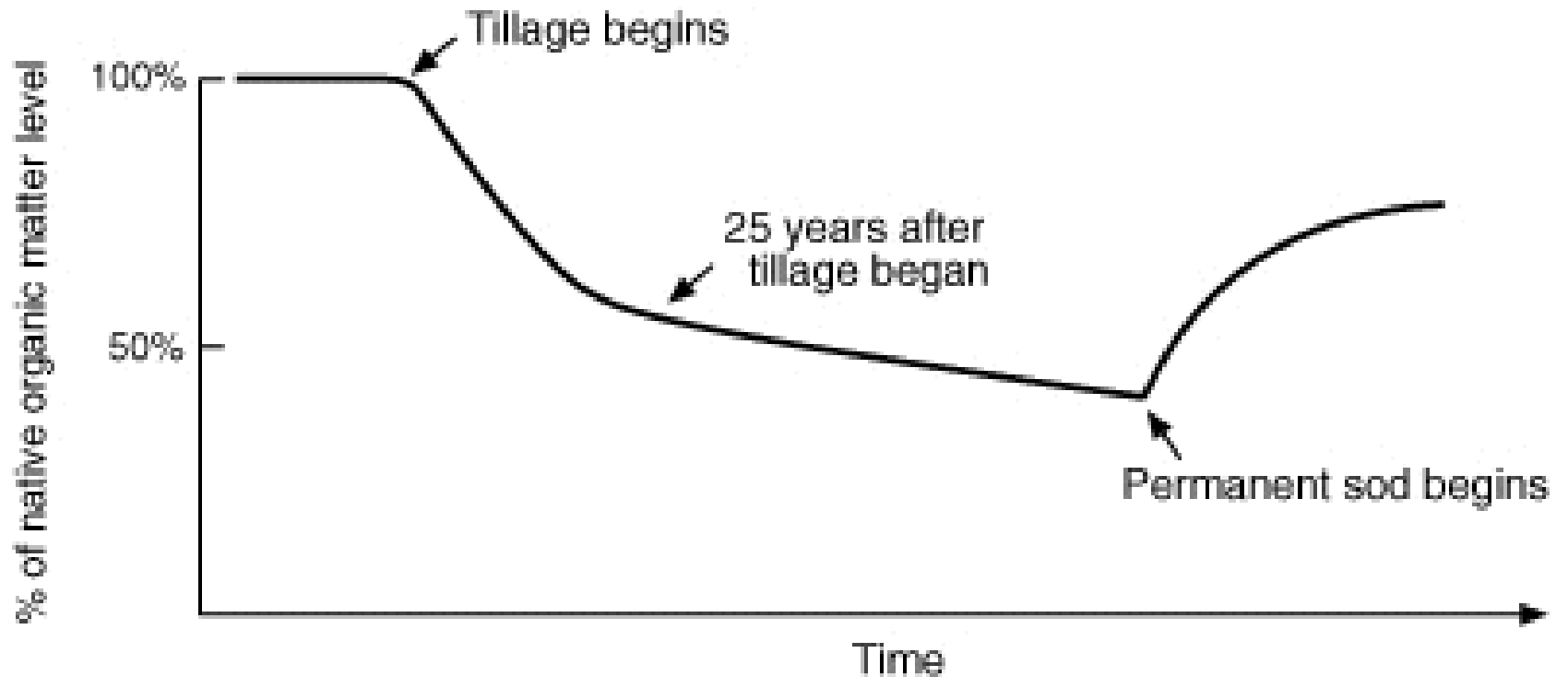


Nutrients recycled in winter & spring & carried forward to next crop.

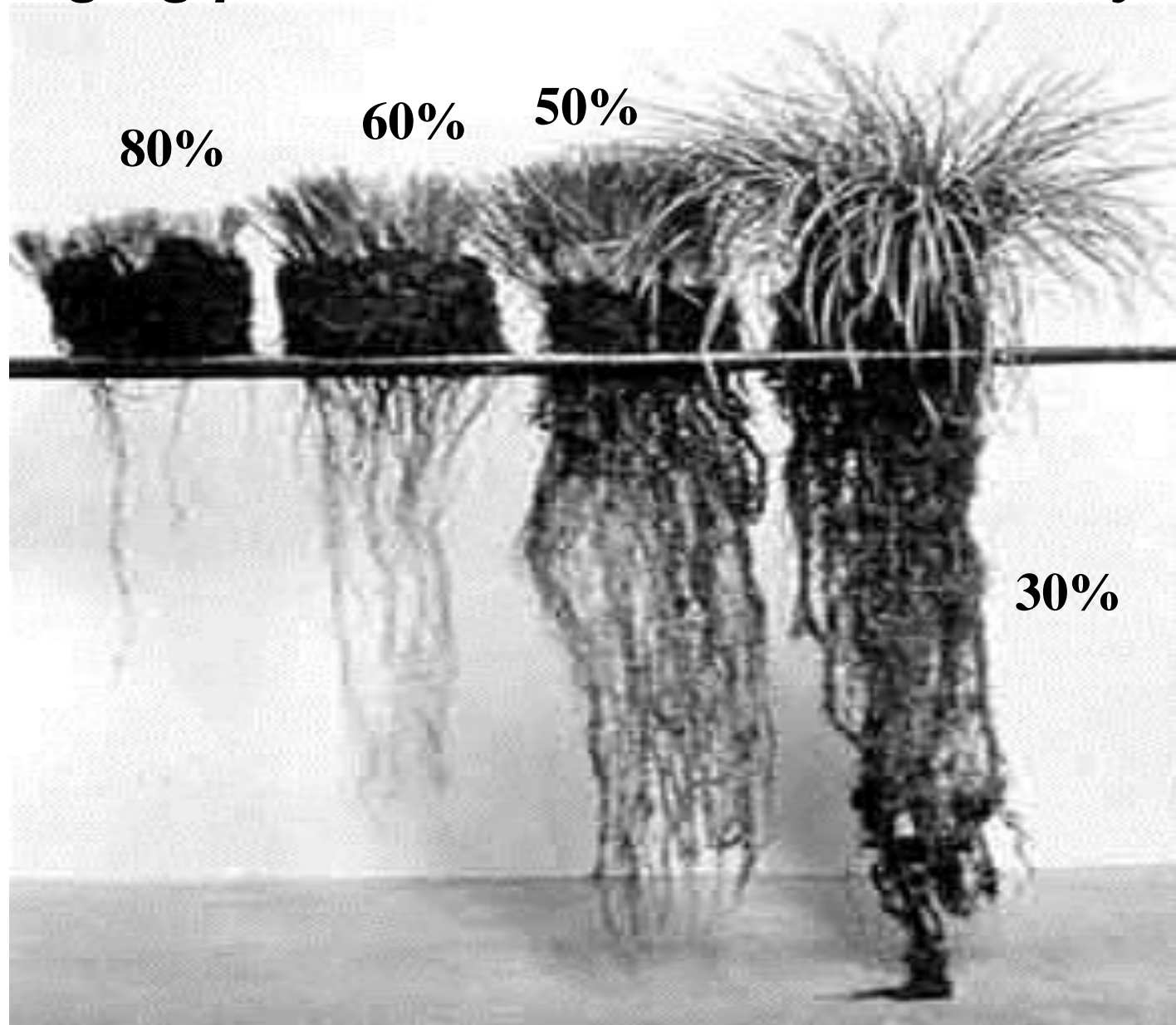


# Soil Organic Matter Loss

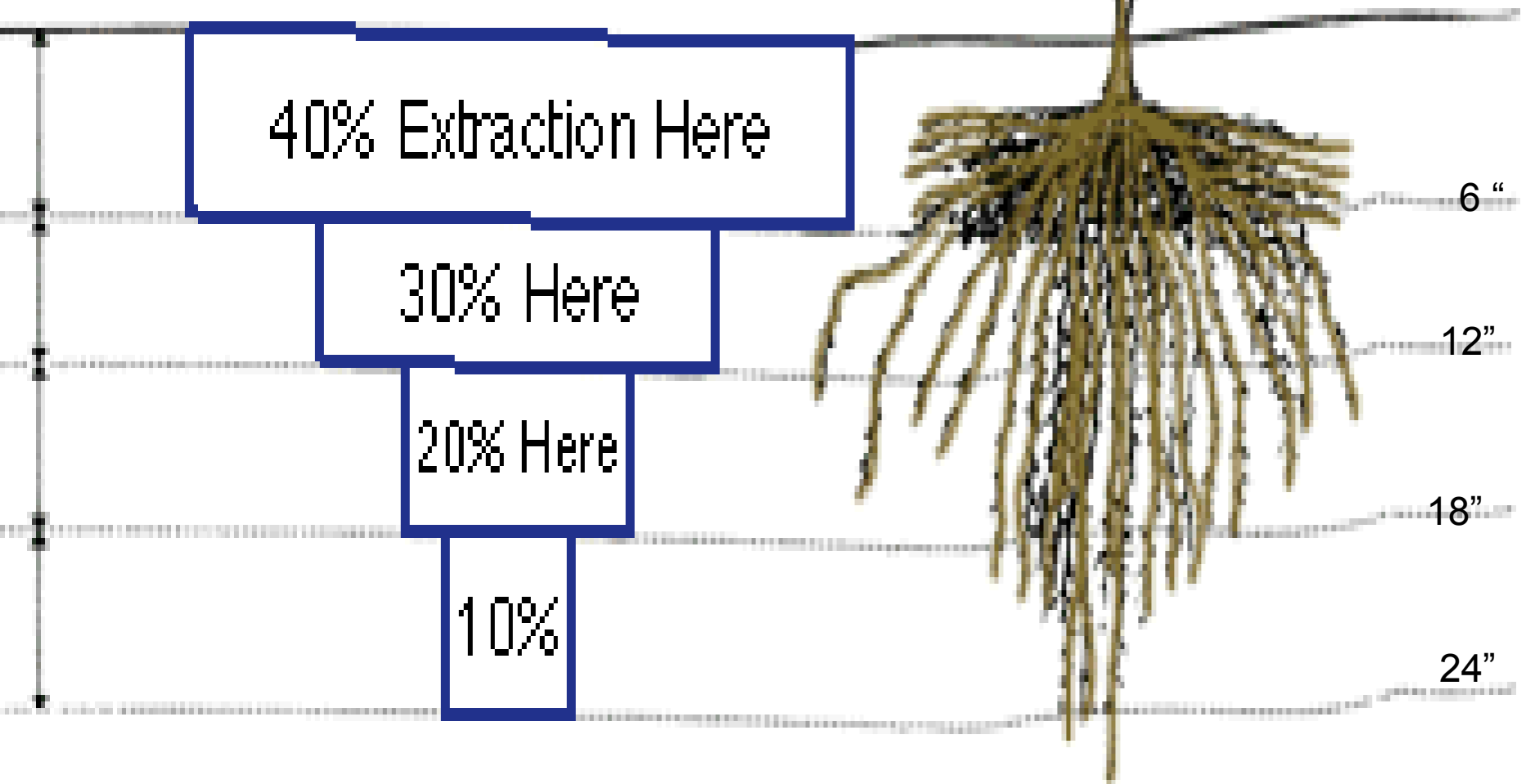
Recent research



# *Managing plant roots affects nutrient recycling*



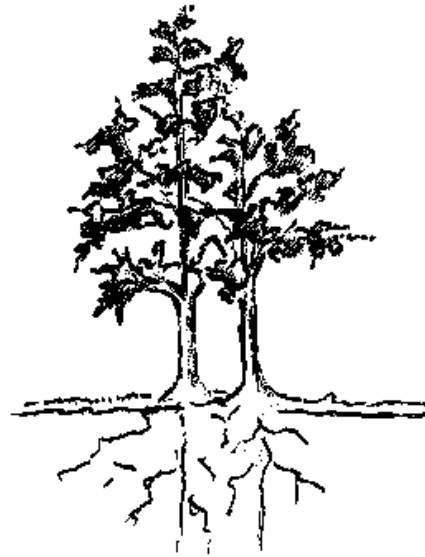
# Nutrient Extraction



# Carbon Storage West to East

## Prairie - West

Deep soils high in organic matter due to grass roots and fast root turnover



## Hardwood trees

Low organic matter levels in due to slow root turnover.

# Mimic Mother Nature

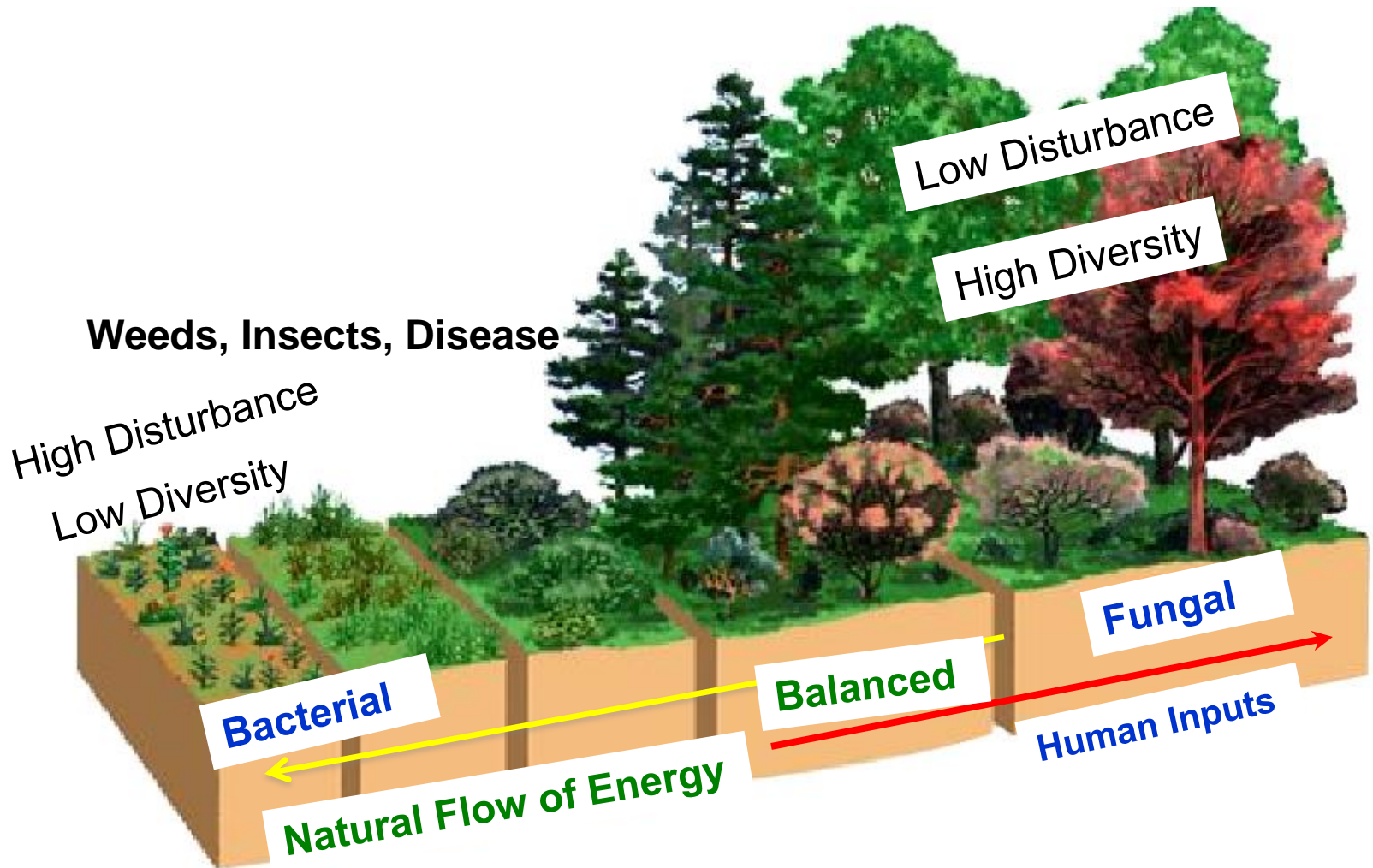


60 Million Bison  
in USA  
in early 1800's

Did they stop  
eating or  
pooping in  
winter?

Water Quality?

# Natural Succession of Plants & Soil



Impacts weeds, insects and diseases.

# Weeds

- Farmers promote weed seed by tilling the soil.
- Ways to fight weeds
  - 1) Hoe or pull them out
  - 2) Kill with herbicides
  - 3) Compete for sunlight and nutrients by growing cover crops and reduce weed seed production.
- Farmers with No-till and Cover Crops reduce herbicide cost by  $1/3 = \$7-\$12/A.$
- Early weeds reduce crop yields  $10\% * 50 \text{ bu soybeans} * \$10/A. = \$50$
- Reduced weeds: cereal rye, oilseed radish, etc.

# Value of Soil Organic Matter

Assumptions: 2,000,000 pounds soil in top 6 inches  
1% organic matter = 20,000#

## Nutrients:

Nitrogen: 1000# \* \$0.50/#N = \$500

Phosphorous: 100# \* \$0.70/#P = \$ 70

Potassium: 100# \* \$0.50/#K = \$ 50

Sulfur: 100# \* \$0.50/#S = \$ 50

Carbon: 10,000# or 5 ton \* \$?/Ton = \$ 0

Value of 1% SOM Nutrients/Acre \$670

= \$1675/Hectare



# Turmoil of Tillage = HEFT

Tillage to soil microbes is like the worst:

H = Hurricane

E = Earthquake

F = Forest Fire

T = Tornado



all wrapped into one event!

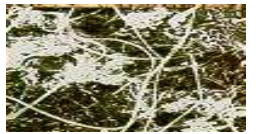
# Relative amount of microbes in handful of soil



**Bacteria** up to 50 billion



**Actinomycetes** up to 2 billion



**Fungus** up to 100 million



**Protozoa** up to 50 million



**Nematodes** 10,000



**Arthropodes** 1000



**Earthworm** 0 to 2

# Plant roots feed the Microbes!

Plant roots use 25 to 40% of their root carbohydrate supplies to feed the microbes!



Plants actively use hormones to attract and “farm” bacteria, fungus, and other organisms to help them recycle soil nutrients and water.

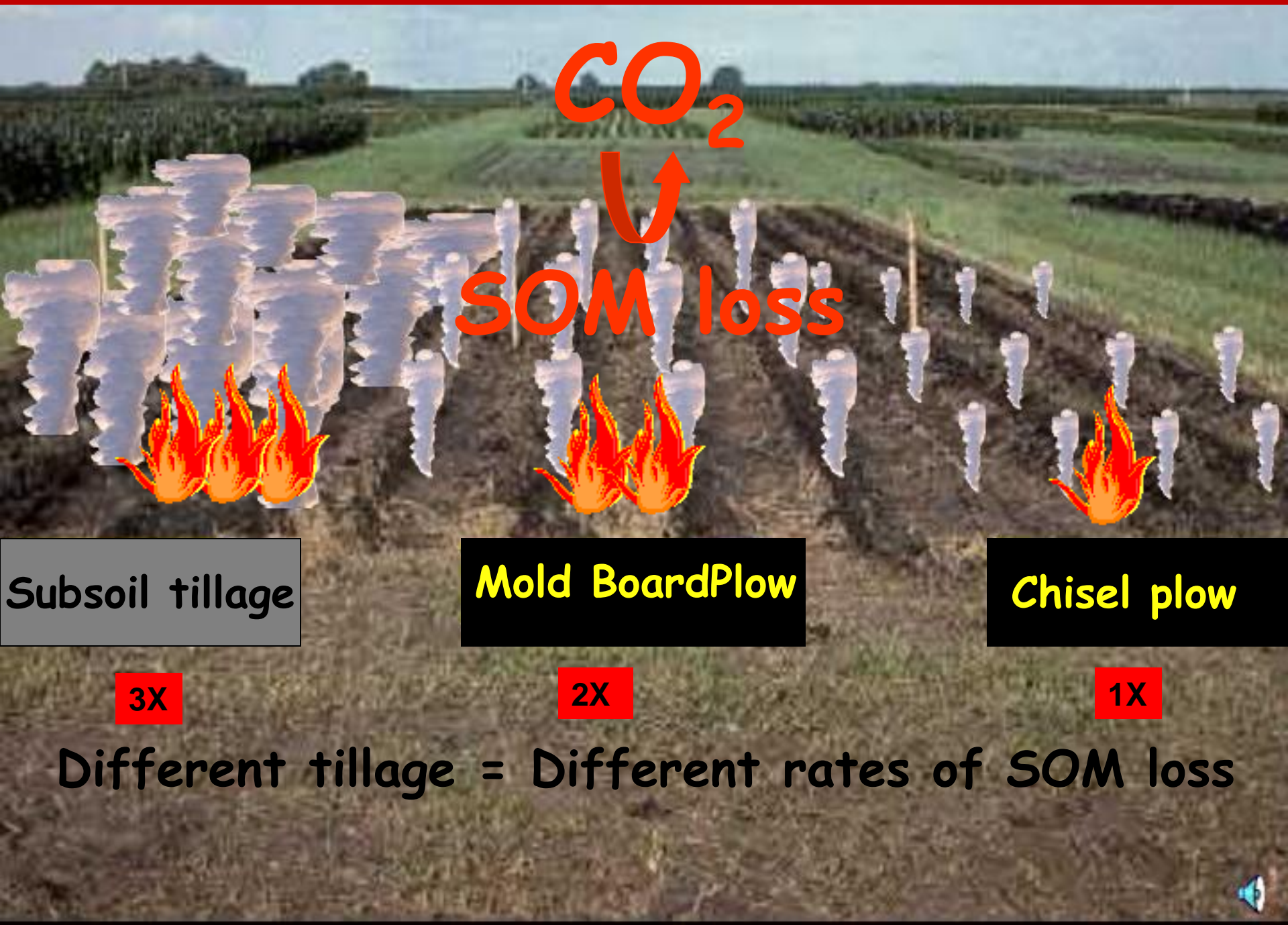
# Conventional agriculture is related to soil, air and water quality degradation

1.2 billion ton  
 $CO_2/y$  i.e. 570 M  
ton SOM loss

A 1% loss  
of SOM=  
1000 lbs N/ac  
Tilled fields  
Erode 10-100X  
Faster = 0.5% of  
All world's soils  
per year or 1"  
In 60 years.



Loss of SOM as  $CO_2$



$CO_2$



SOM loss

Subsoil tillage

Mold Board Plow

Chisel plow

3X

2X

1X

Different tillage = Different rates of SOM loss

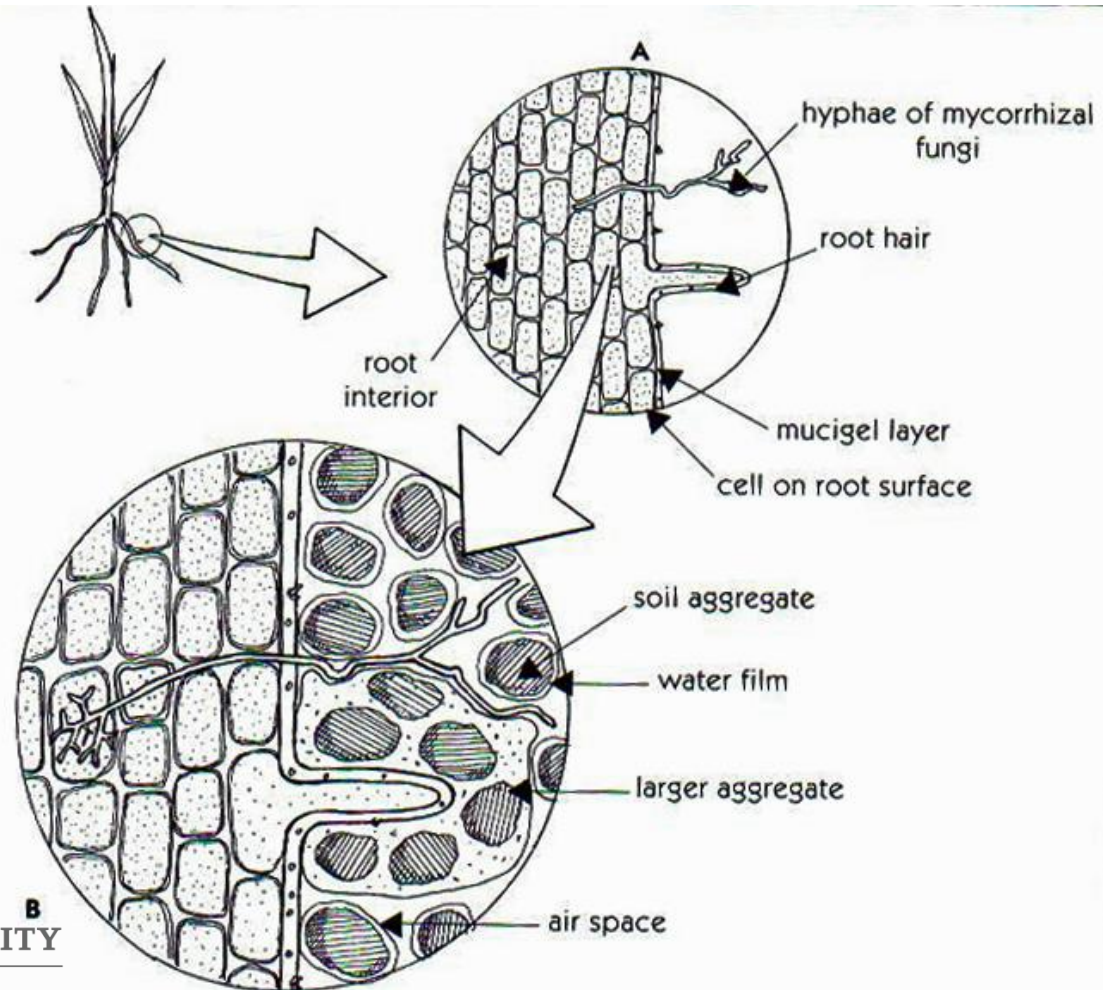


# Rhizosphere

Living roots release many types of organic materials into the rhizosphere within 50  $\mu\text{m}$  of the surface of the root. There are over 1000-2000 times more microbes associated with a live root than in the bulk soil.



# Mycorrhizal Fungus



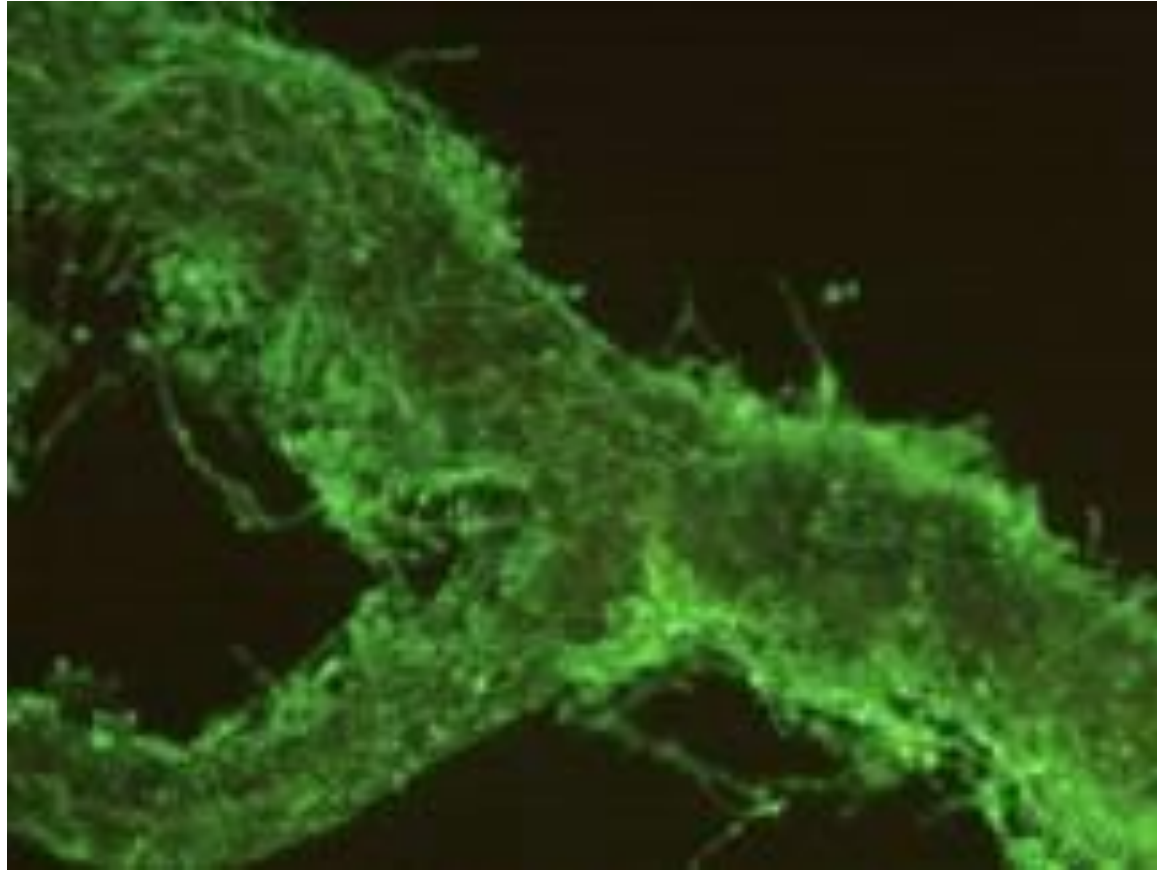
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# Mycorrhizal Fungus

- Chlorophyll content is critical for conversion of essential amino acids to vitamins. Increase plant uptake of P, Ca, Zn, Fe, B and Cu.
- Increases plant resistance to drought.
- Determines the microbial community in the rhizosphere.
- Protect plant roots from some predators.
- Are sensitive to tillage and P fertilization.
- Supply P for efficient N fixation. Hyphae take up 6x more P than root hairs, increased surface area. If AMF not active, less P released. Corn and soybeans more efficient with AMF present and require less fertilizer (Clapperton, 2013).





**Sticky substance, glomalin, surrounding root heavily infected with mycorrhizal fungi. Fungi help roots explore up to 20% of the soil volume. A root by itself can only explore 1% of the soil volume. Photo by Sara Wright.**