Principles of Soil Health and Nutrient Management

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United States Department of Agriculture (USDA)
Natural Resources Conservation Service (NRCS)

Pierceton, IN - - February 7, 2019

Helping People Help the Land.

TOPICS:

- What is *Soil Health?*
- The principles of *Soil Health*
- Importance of healthy soil
- Improve nutrient use efficiency
- Importance of biology on nutrient use

What is *Soil Health*?

- **Soil Health Key Indicators =**
  - Increas**ing** organic matter
  - Improv**ing** aggregate stability
  - Increas**ing** water infiltration
  - Increas**ing** water-holding capacity
  - Improv**ing** nutrient cycling
  - Enhanc**ing** and diversify**ing** soil biology

Soil Health is not a destination...it's a journey!

Soil Health Principles

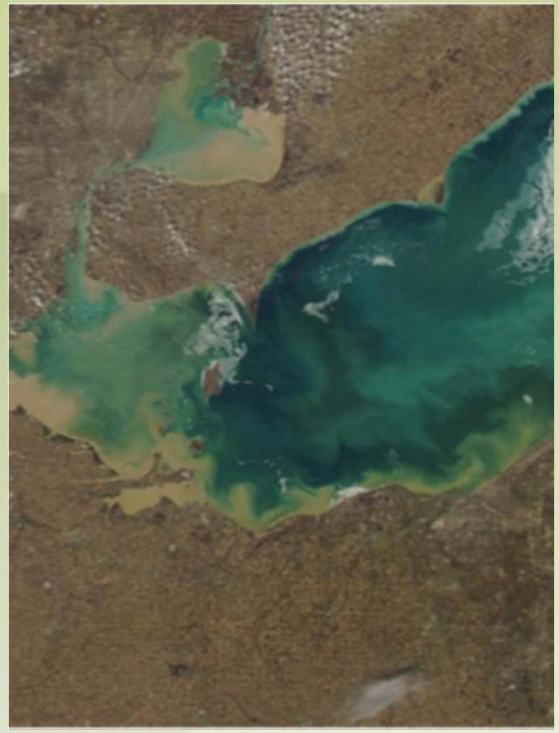
Achieving soil health takes a <u>system</u> that will:

SOIL HEALTH:

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

Why is *Soil Health* Important?

Incomplete System = sediment and nutrient loss



October, 2011

Lake Erie = sediment and algae plumes

SOLUTION = Conservation Cropping Systems

Water Quality

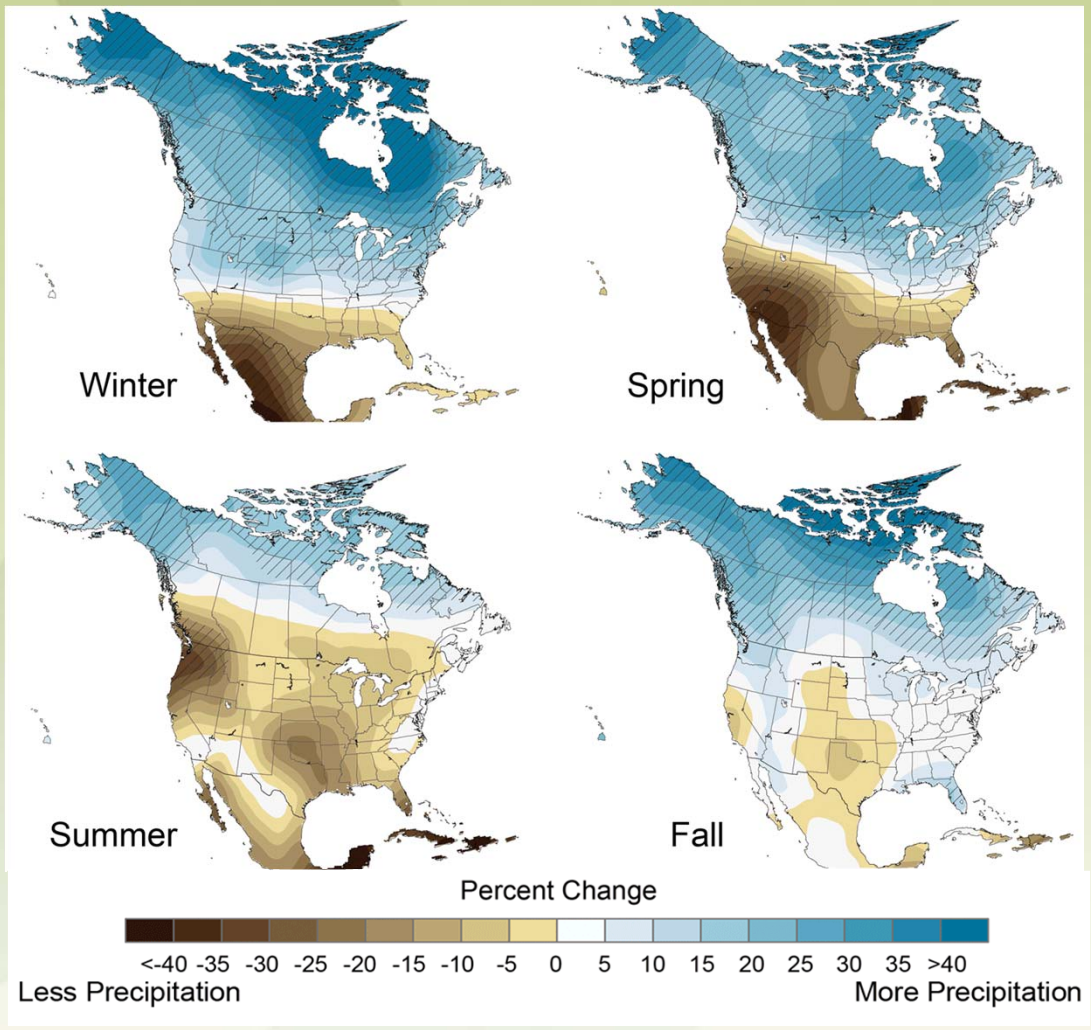
Why is *Soil Health* Important?

Soil Erosion and Runoff

Western Lake Erie Basin
Steve Davis, NRCS

Agricultural soils do not have a water erosion/runoff problem, they have a water infiltration problem.

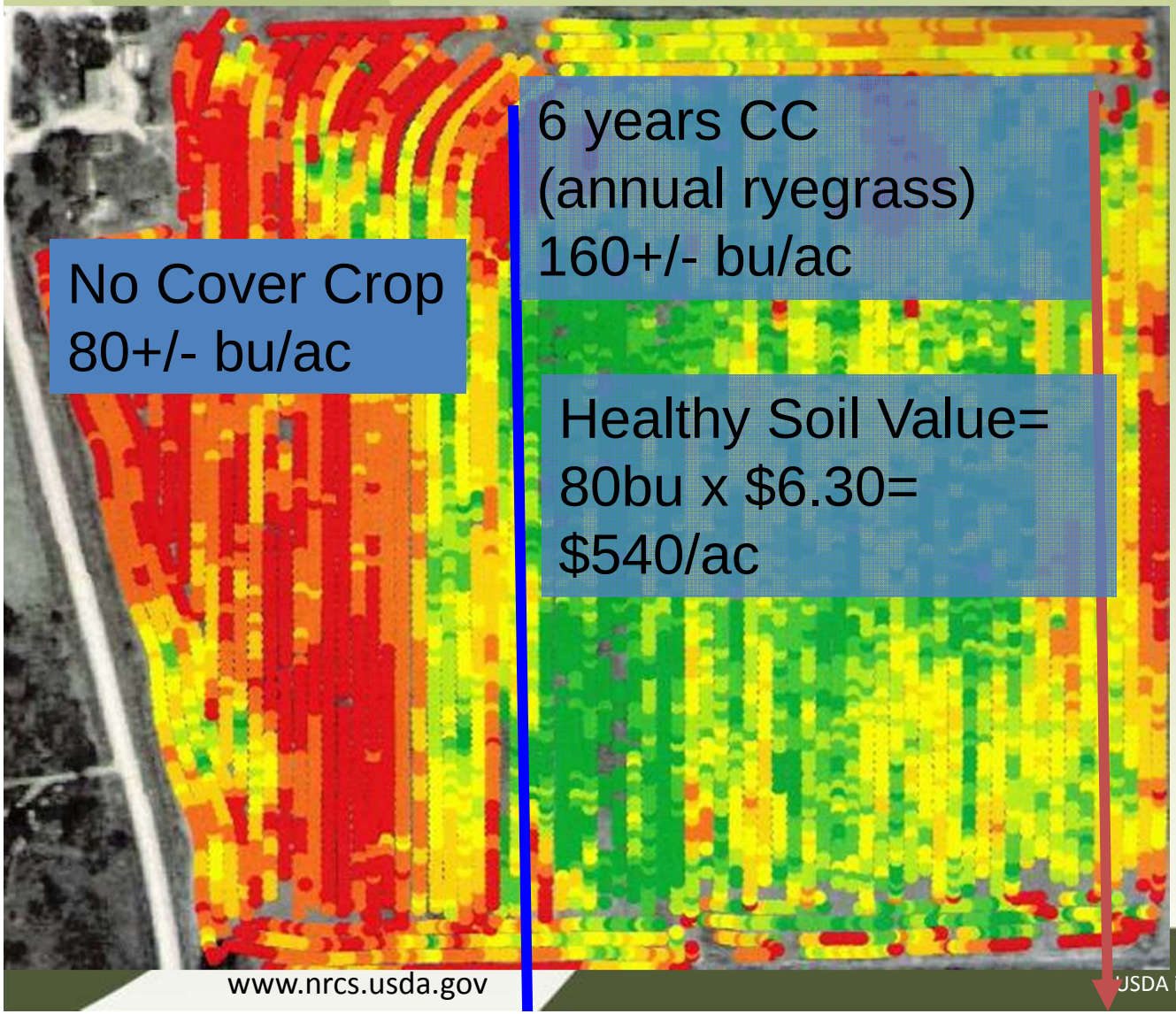
Why is *Soil Health* Important? (Resilience)

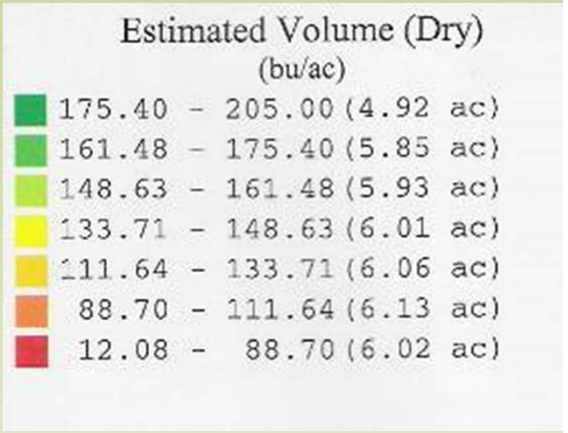


Jerry Hatfield, ARS

Effects of NT & Cover Crop = Resilience!

2012





Mike Plumer's long term no till with annual ryegrass CC

We need to start building soil life….ASAP!

Soil response… aggregation after <u>ONE</u> season

Soil Properties- Through the Lens of Soil Functions

Biological Soil Properties

Organic Matter

Roots

Biological Activity

Macro and Micro Fauna

Microorganisms

Store Carbon

Physical Soil Properties

Aggregate Stability

Soil Structure

Soil Pores and Porosity

Water Movement

Capture, filter, drain and store water

Compaction

Surface sealing

Chemical Soil Properties

Nutrient Cycling and Recycling

Nutrient Holding Capacity

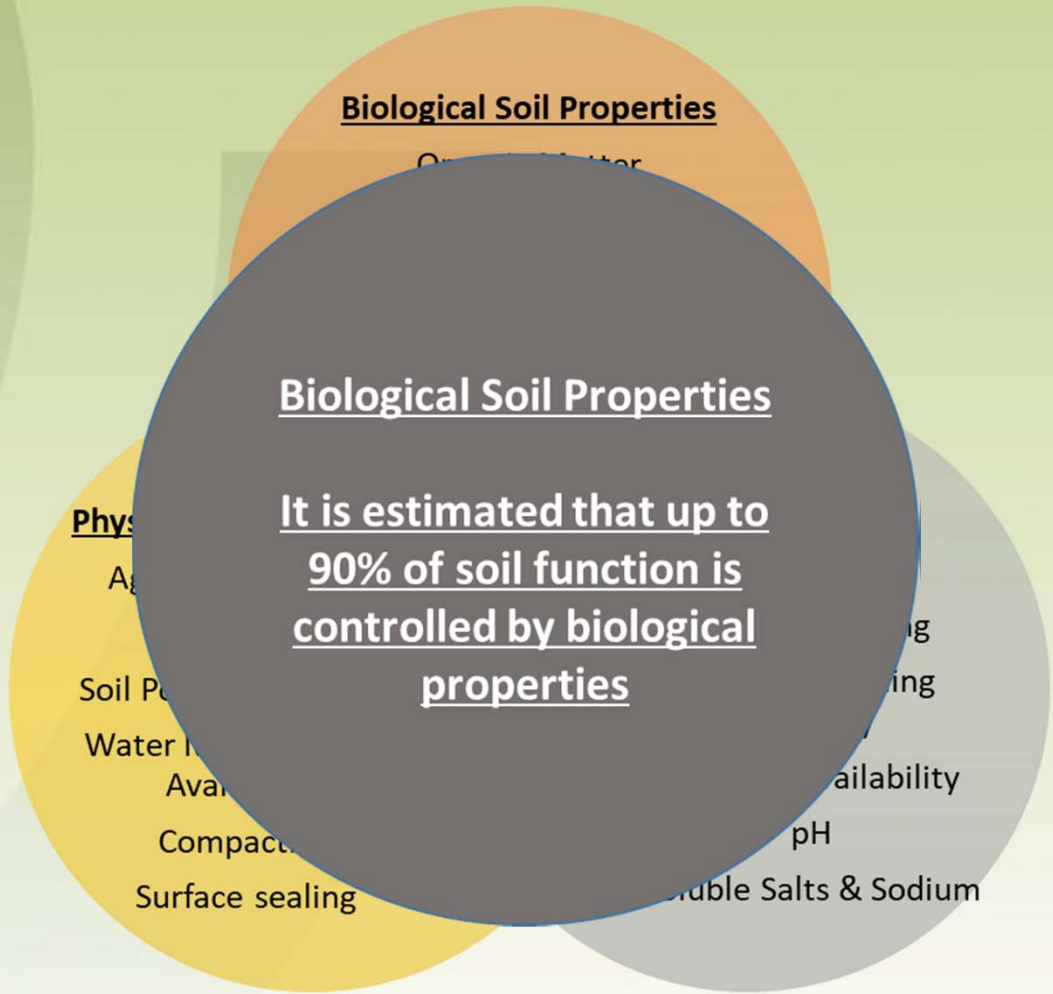
Nutrient Availability

pH

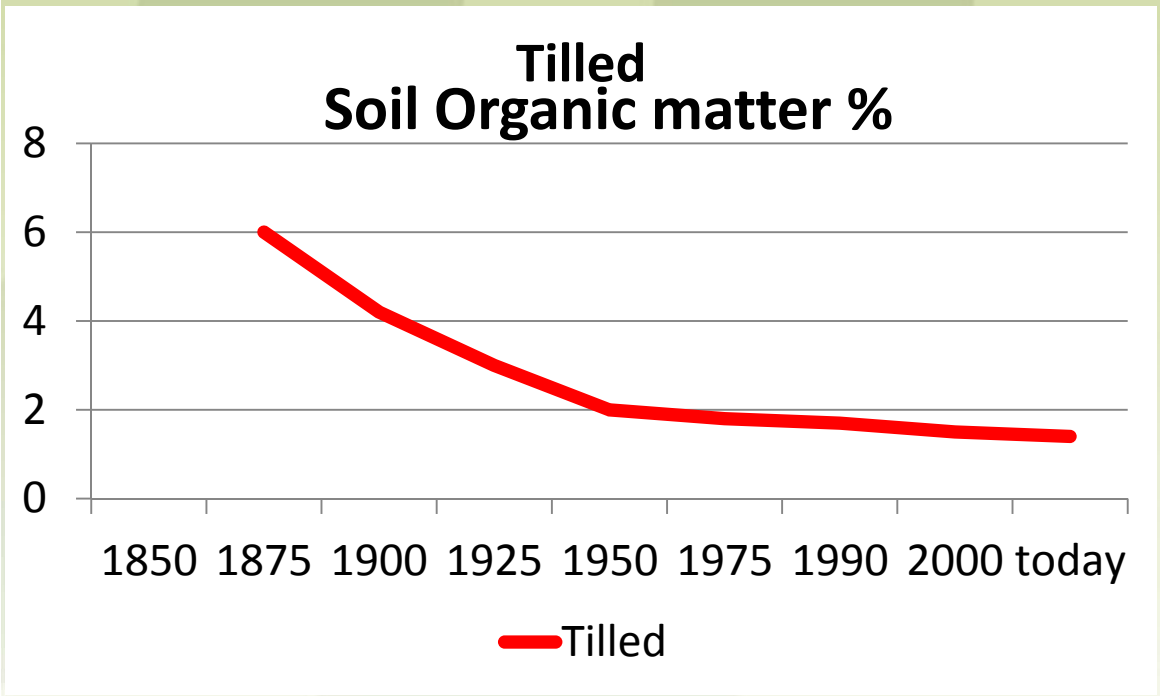
Detoxify Pollutants

Soluble Salts & Sodium

Are All Properties Equal?



Mining Organic Matter Is Not An Option!



Morrow plots, Champaign, IL

Each 1% of O.M. contains:

10,000 lbs. of C

1000 lbs. of N

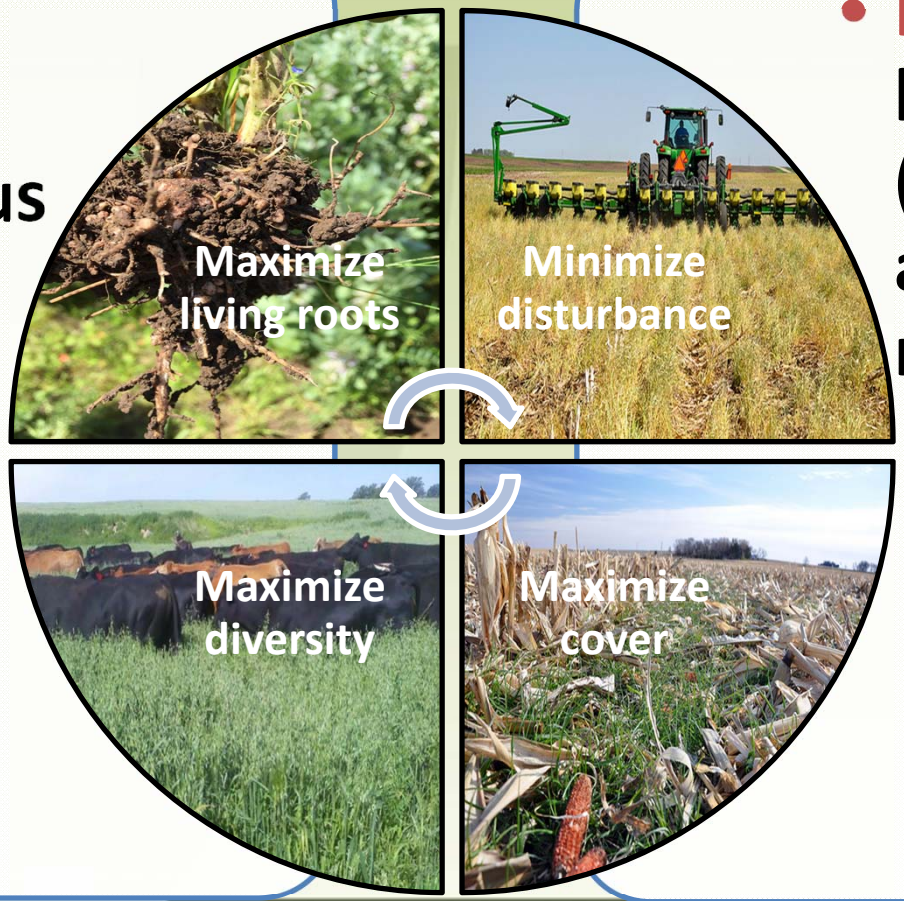
100 lbs. of P

100 lbs. of S

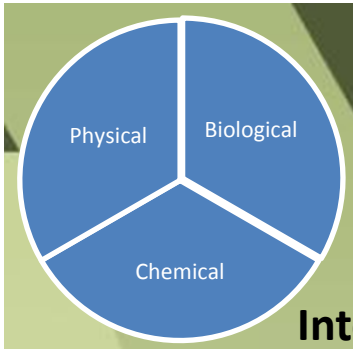
14,000 gallons of H_2O

Soil Health Principles To Support High Functioning Soils

- **Feed** diverse, continuous inputs (C sources, energy)



- **Protect** habitat (aggregates and organic matter)



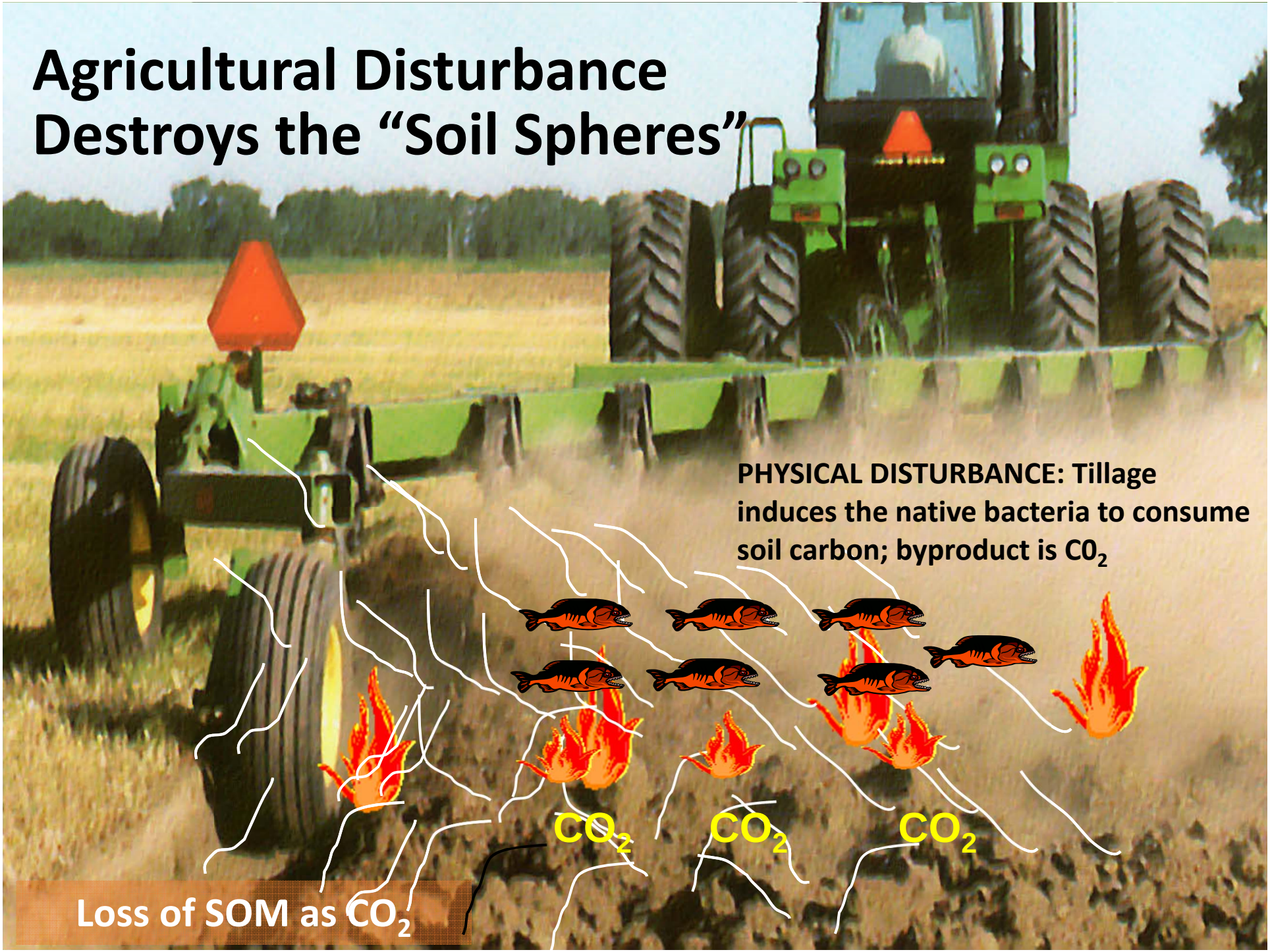
What Does Tillage do to the Soil?

Intensive tillage "butchers the biology" in the soil. It cuts, slices, and dices the soil and blend's, mixes, and inverts the soil creating havoc for the soil biology (fauna).

- Destroys aggregates
- Exposes organic matter to decomposition
- Compacts the soil
- Damages soil fungi
- Reduces habitat for the Soil Food Web
- Disrupts soil pore continuity
- Increases salinity at the soil surface

Bet
Pri
Till

Mike Kucera, NRCS


Agricultural Disturbance
Destroys the "Soil Spheres"
PHYSICAL DISTURBANCE: Tillage induces the native bacteria to consume soil carbon; byproduct is CO_2
CO_2
CO_2
CO_2
Loss of SOM as CO_2

Maximize Soil Cover

- Many crops provide little biomass or cover
- Prevents erosion
- Further moderates soil temperatures
- Reduces evaporation
- Reduces compaction from machines and livestock
- More food for microbes
- Fuels the nutrient cycle

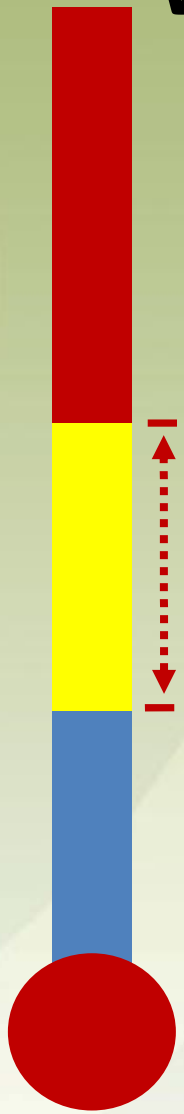
Carbon mat: feeds soil, keeps it cool, suppresses weeds, and protects from rain drop

Break It Down – Soil Temperature

92 Degrees Sunny Day June 24	Soil Temp 2" Depth	Infiltration Rate In/Hr
Forest	73	82
Stand Alone No-Till Soybeans	102.6	2
18 Inch Cover Terminated Soybeans	94.1	5
48 Inch Crimped Biomass Soybeans	85	7
Conventional Tillage Soybeans	110.5	<1
Stand Alone No-Till Corn	91	2
24 Inch Cover Terminated Corn	84	4
48 Inch Crimped Biomass Corn	82.6	9
Conventional Tillage Corn	113	<1

Adam Daugherty, NRCS Coffee County TN

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% 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

Grow Living Roots…Throughout the Year

- Increases soil microbe activity
- Increases plant nutrient recoverability
- Increases biodiversity and biomass of soil organisms
- Improves physical, chemical and biological properties of soils
- Sequesters nutrients
- Increases OM

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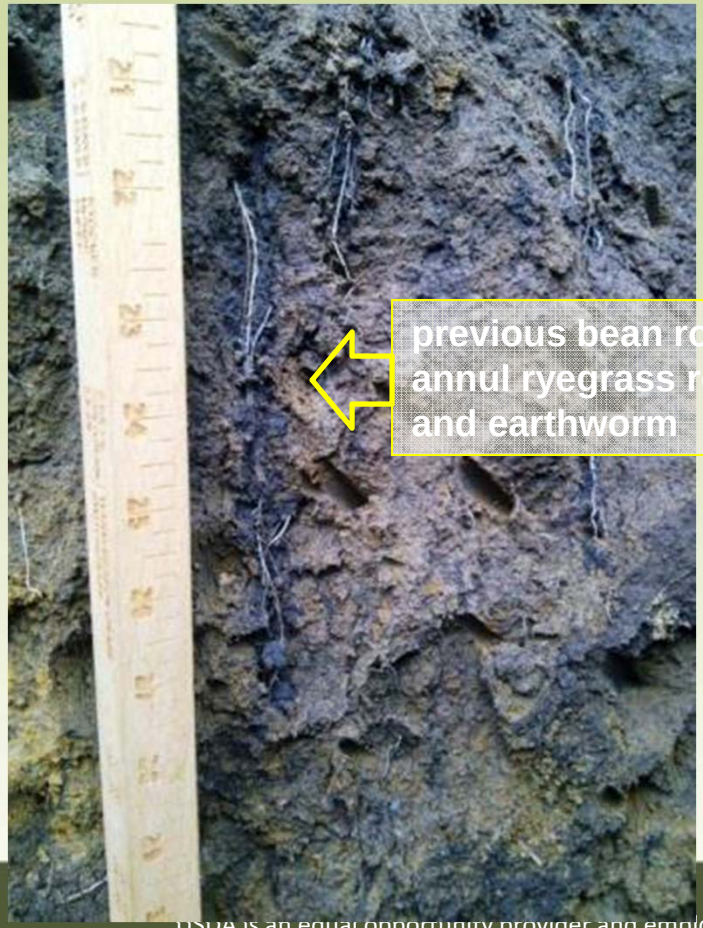
Build Organic Matter…
Active Carbon?

Most occurs 0”- 4”

…maybe it occurs deeper as well



Add Diversity with Cover Crops and Crop Rotations

- Supports other soil health principles (year round living roots, surface residue)
- Adds diversity during non-cropping part of the year
- Offers functions for specific objectives not provided by cash crops
- Mixes mitigates any negative affects of single species
- Increases and diversifies the soil food web
- Mixes provides cover crop insurance


Crop
Rotations

The more diverse the better!

2 way mix –
for <u>new</u> Covercroppers

12 way mix –
for <u>experienced</u> Covercroppers

Achieving soil health takes a *SYSTEMS* approach

- A Quality No-till (Never-Till) System
- Diverse and Strategic Cover Crops
- Adapted Nutrient Management
- Integrated Weed & Pest Management
- Diverse Crop Rotations
- Precision Farming Technology
- Prescriptive Buffers and other edge of field practices

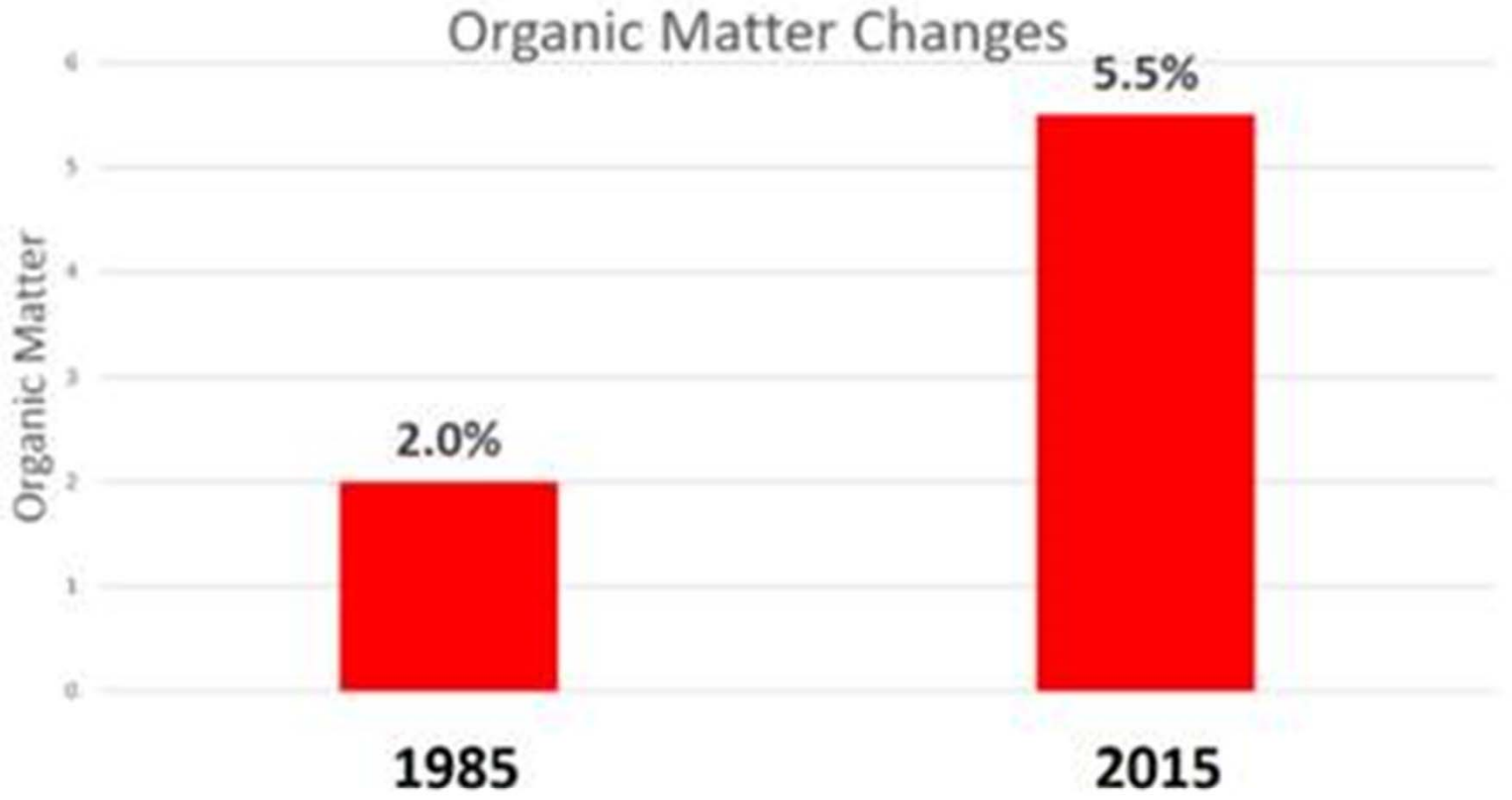
Healthy soil is not a destination...it's a journey!

Improve Nutrient Use Efficiency (NUE)

Nitrogen Management

- **Carbon cycling**
  - **Starter = 20-60 lbs/A in a 2x2 band (closer to 50 lbs/A).**
  - **Inject at least half of the N below surface residues – if side-dressing, apply as early and with as little disturbance as possible.**

The Past 30 Years...



...at Cedar Meadow Farm

Cover Crop Coaching

Cover Crop Innovators

Strategically…

Planning the system

First and Foremost - P applications should **ONLY** take place if a soil test supports the need for more P.

Only if Soil Test P is <40 ppm.

Joern/Tri-State/Other, 20xx

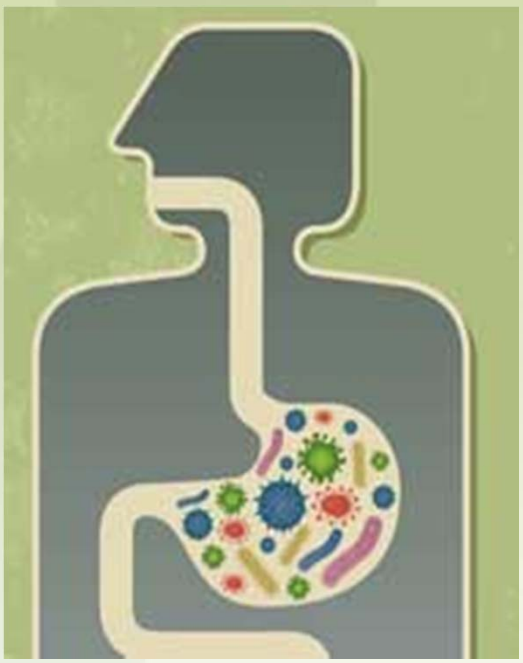
Strategically…

Planning the system

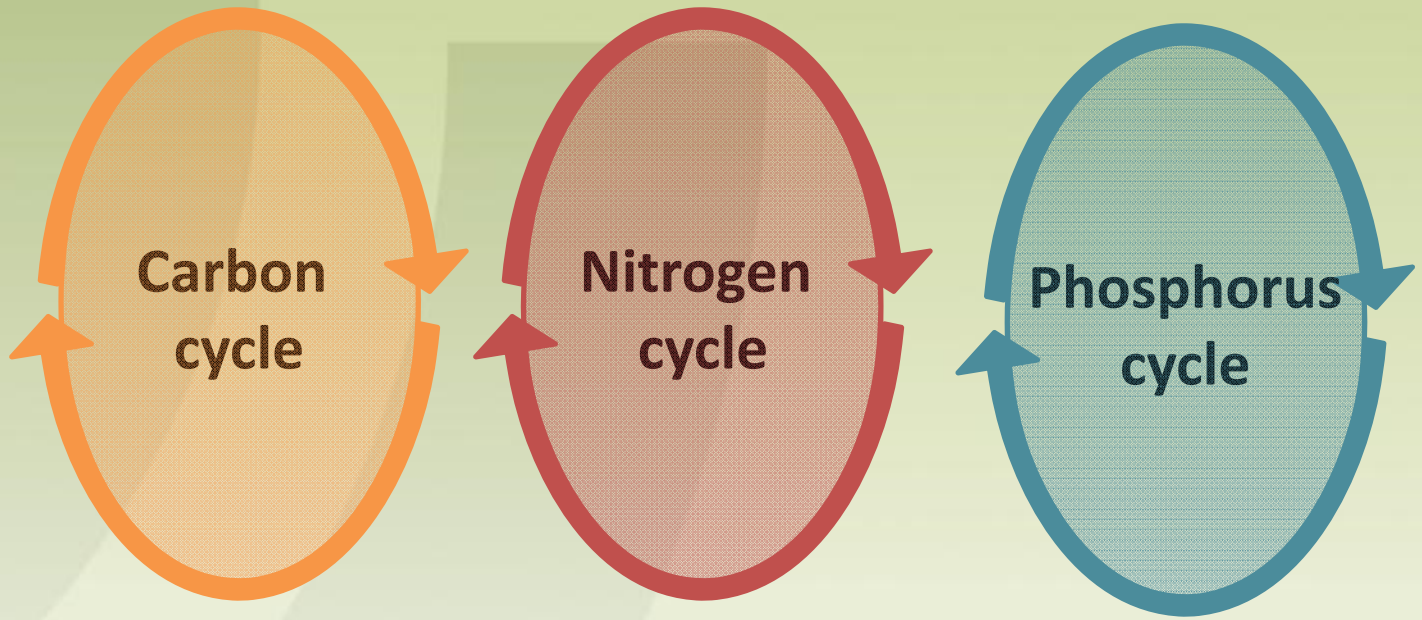
P Applications:

- Use VRT to apply P only where needed,
- If possible, apply P as starter (2x2) = less is lost if injected below ground.
- If runoff potential is high, only apply 1 year of phosphorus.
- If applying in the fall, strip-till injector will place P below the surface = less loss.
- Apply P to corn residue instead of soybean residue = less runoff.

Soil Serves as the "Gut" for Plants



Soil Health and Nutrient Cycling



C Cycling, Mineral Nutrient Release & SOM Formation

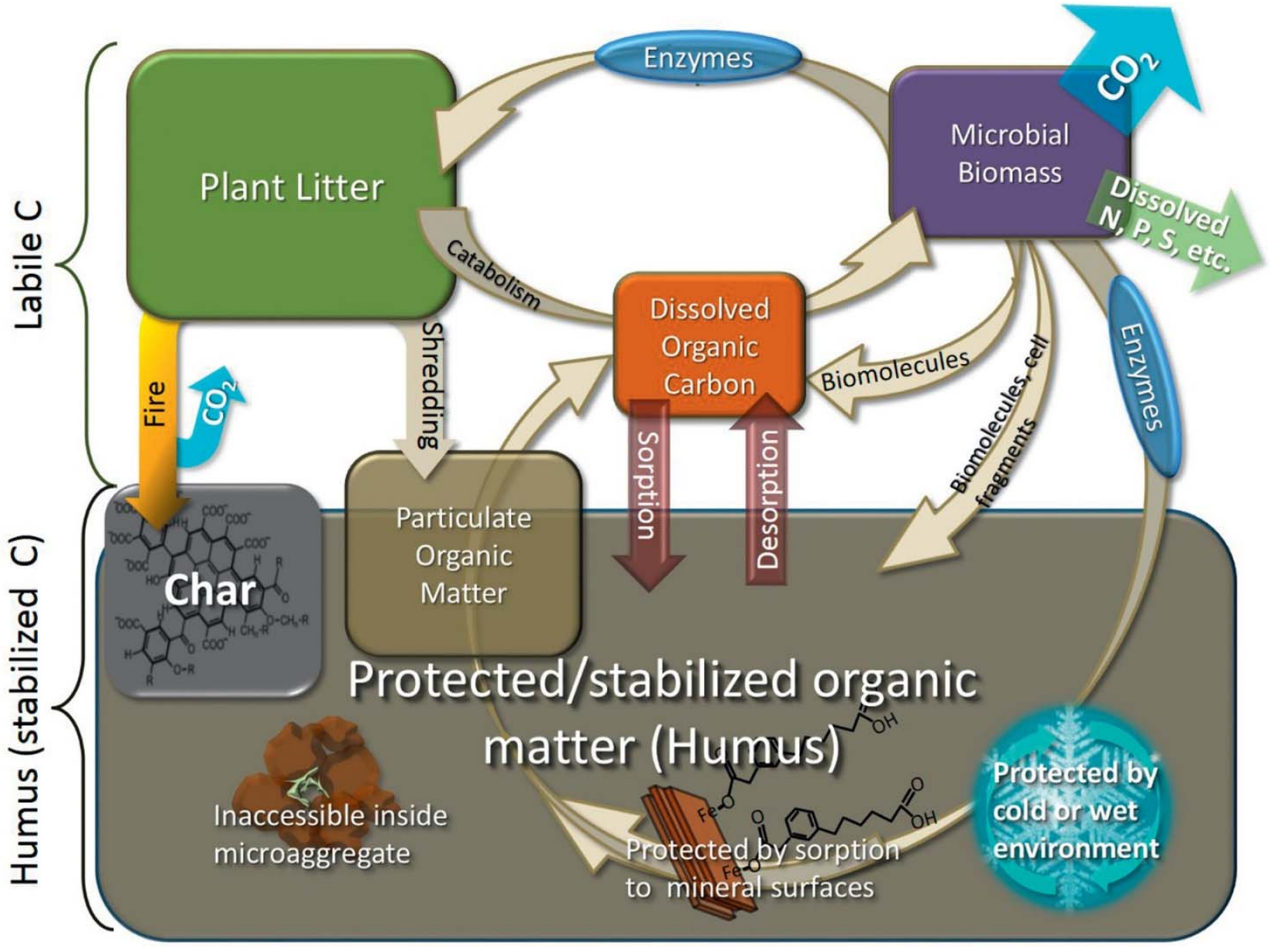
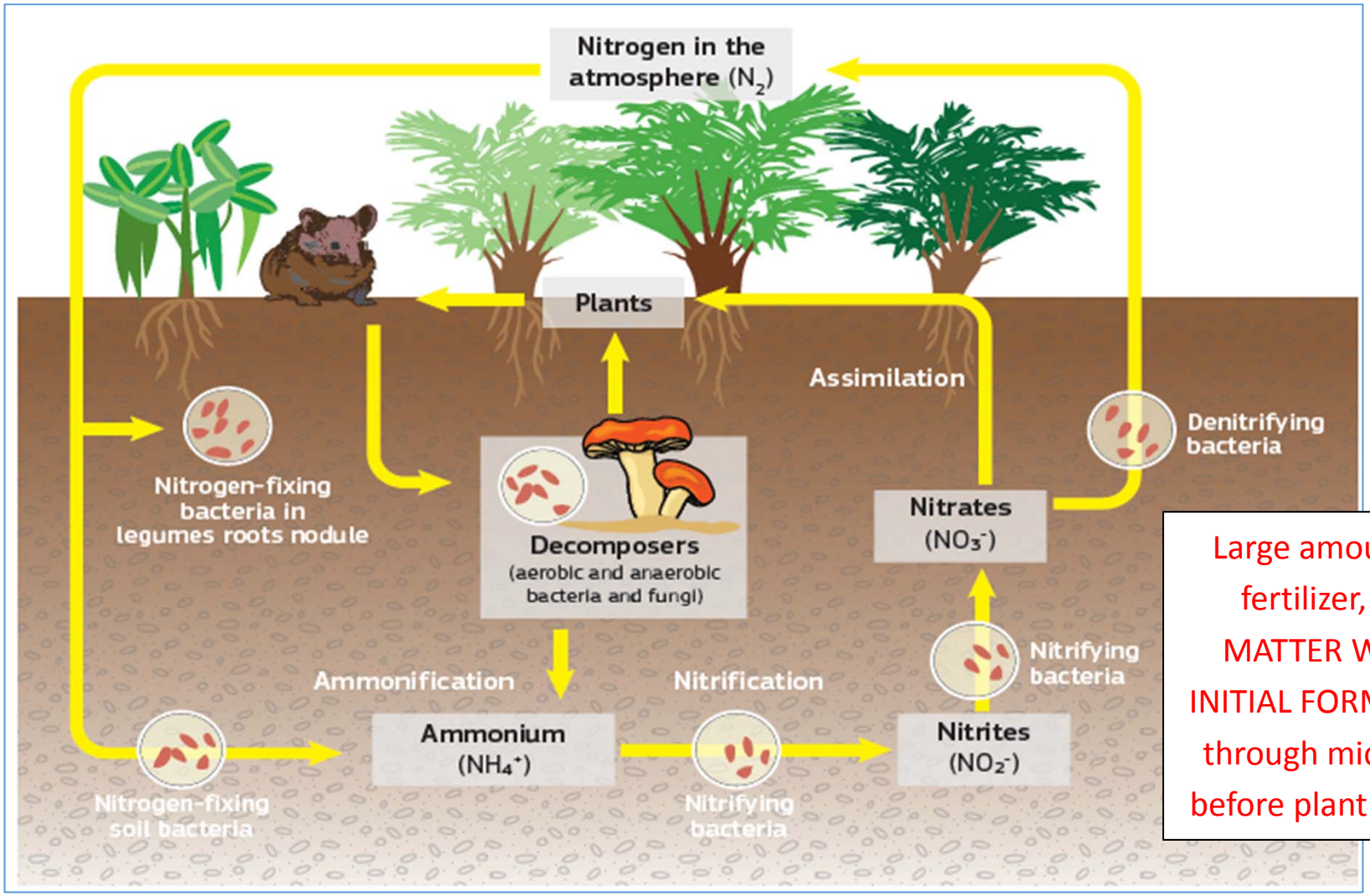


Image source: The Nature and Properties of Soils, 15e, Weil and Brady

Nutrient Cycling: Managing the N Cycle Means Managing Soil Biology



Large amount of fertilizer, NO MATTER WHAT INITIAL FORM, goes through microbes before plant gets it.

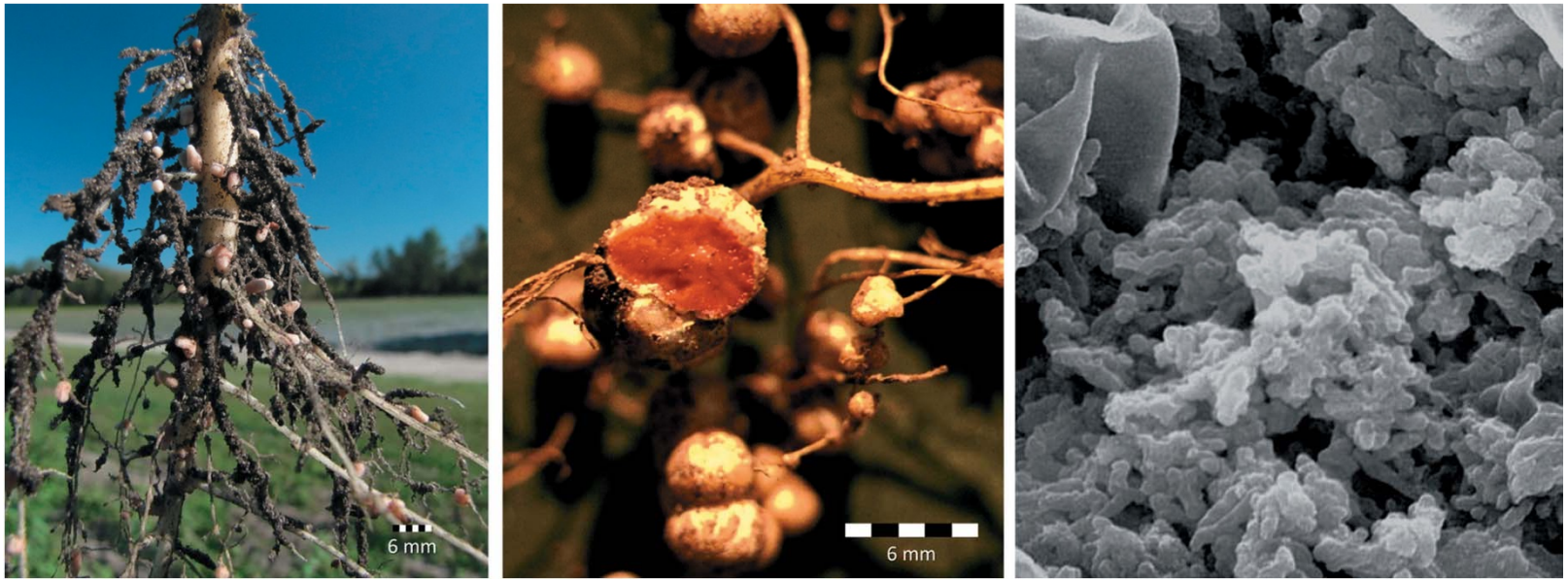
Schematic representation of the main flows of nitrogen (N) through the terrestrial environment. The importance of soil bacteria and fungi in the cycle is immediately recognized as being a key element, providing different forms of N compounds assimilable by higher organisms, such as plants. (JJB, FVI, NLA, NRCS)

Only 30-55% of Inorganic Fertilizer is Directly Used by Plants

Fertilizer N applied (lb/ac)	Corn grain yield (Bu/ac)	Total N in corn plant (lb/ac)	Fertilizer-derived N in corn (lb/ac)	Soil-derived N in corn (lb/ac)	Fertilizer-derived N in corn as % of total N in corn
45	62	76	25	54	33
89	73	130	49	81	38
178	88	140	77	63	55

Calculated from Reddy and Reddy, 1993 and modified from Weil & Brady, The Nature and Properties of Soils, 15th ed.

Biological N Fixation



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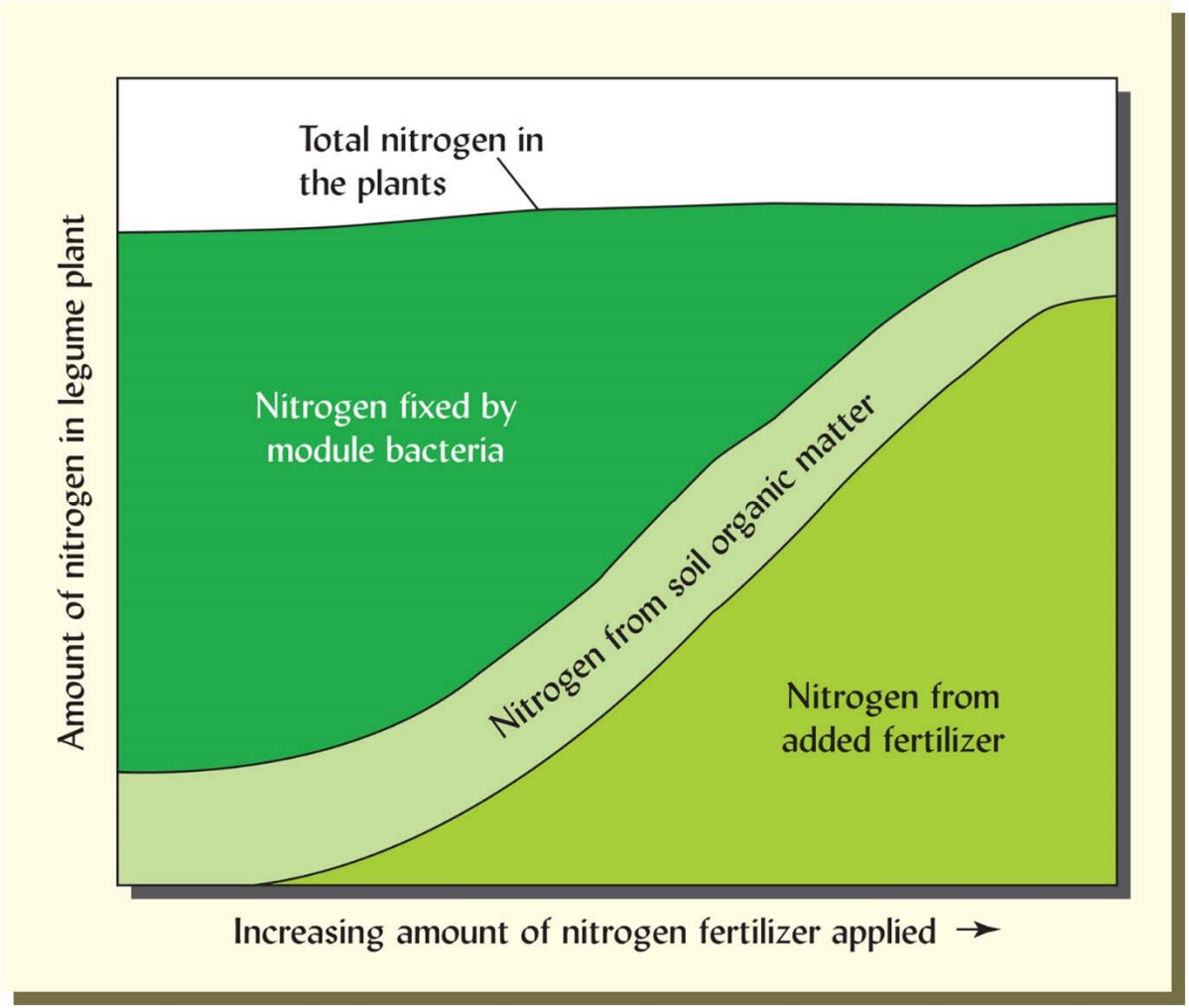
Increasing N Fertilizer Decreases N Fixation



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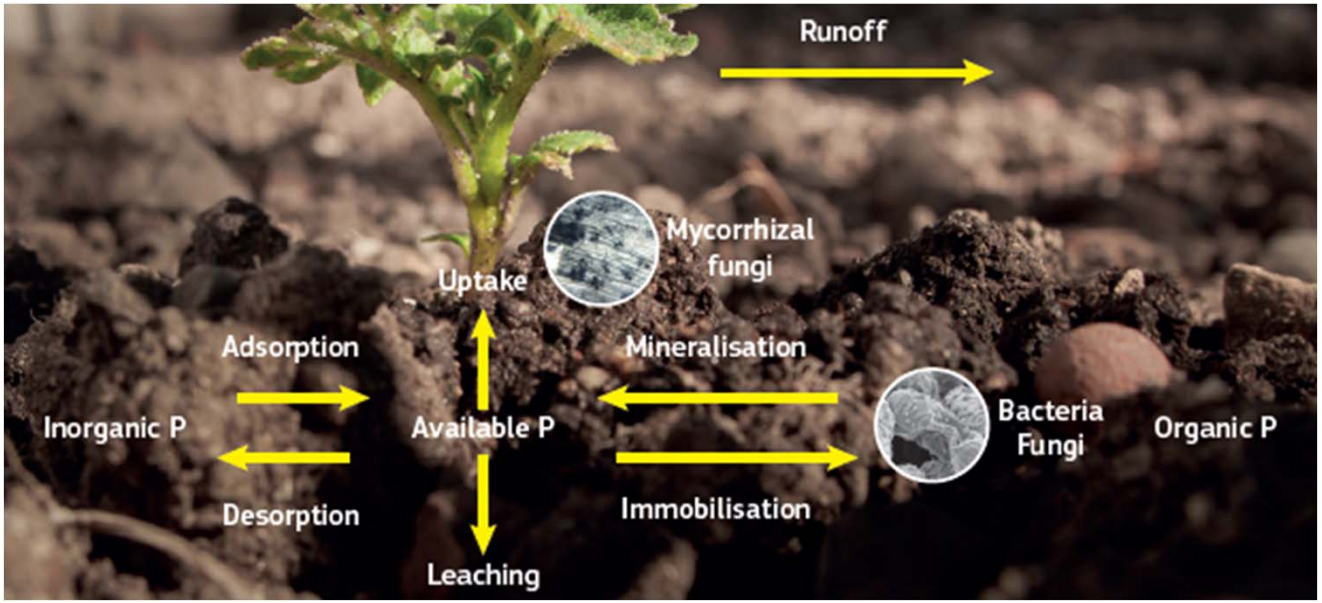
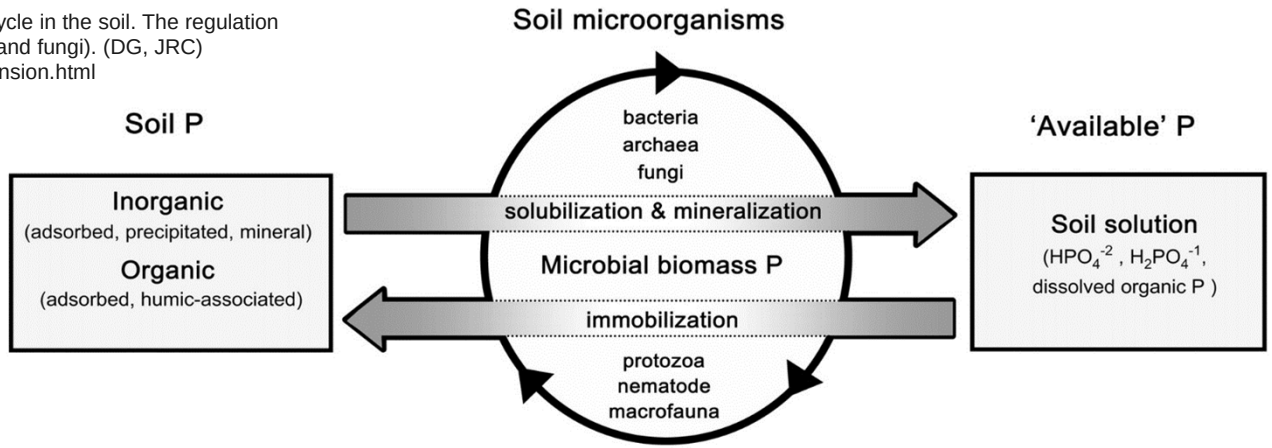
Nutrient Cycling: Managing the P Cycle Means Managing Biology

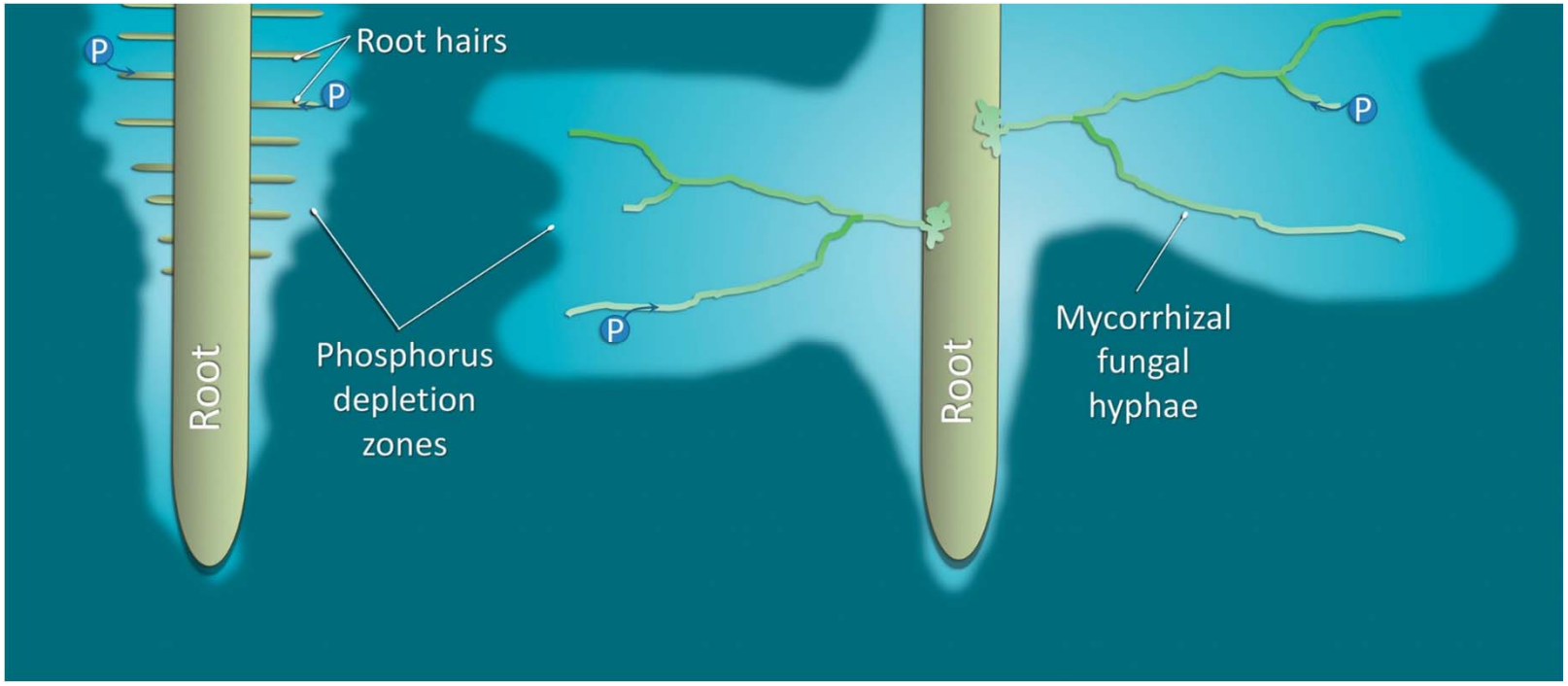


- P sources mainly from ancient rocks and deposits
- Soil pH and minerals affect availability
- Plant-microbe interactions release stored org-P and mineral-P

Top: Global Soil Biodiversity Atlas: Simplified phosphorus (P) cycle in the soil. The regulation of soil P cycling is influenced by microorganisms (e.g. bacteria and fungi). (DG, JRC)
Bottom: http://www.plantphysiol.org/content/156/3/989/F1.expansion.html



Mycorrhizal Root Colonization and Effective Root Volume



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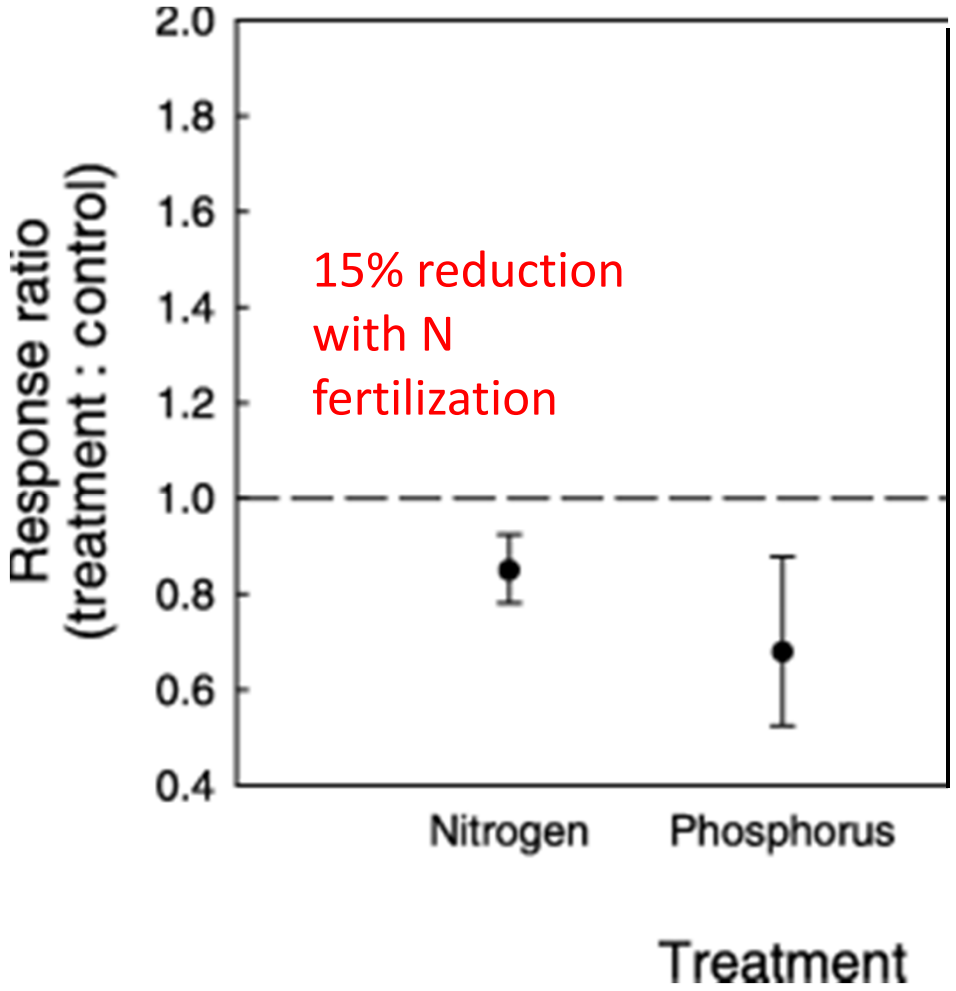
Fertilization Reduces Mycorrhizal Fungi



Modified from Treseder (2004),
New Phytologist, 164: 347–355

Early transition(s)…to SHMS

- Combine – spread residue full width
- Utilize cover crops
- Less tillage:
  - Not as deep,
  - Not so aggressive (3° instead of 6°, 0° instead of 3°),
  - Slow down,
  - One less pass.
- Change nitrogen timing

Healthy soil is not a destination…it's a journey!

Later transition(s)…to SHMS (continued)

- Crop rotation
- Complex cover crop mixes
- Apply manure (appropriately)
- Controlled Traffic Farming
- Judicious use of inputs
  - Pesticides
  - Fertilizer types and rates

Healthy soil is not a destination…it's a journey!

Soil Health Is Understanding How the Soil is Designed to Function and Managing it Accordingly

Thank you!

- **Stephanie McLain**
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- **Tony Bailey**
  - **State Conservation Agronomist**
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