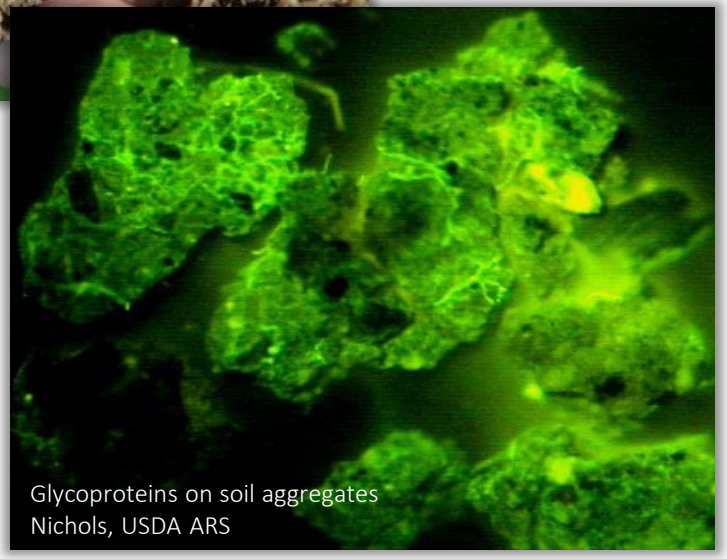
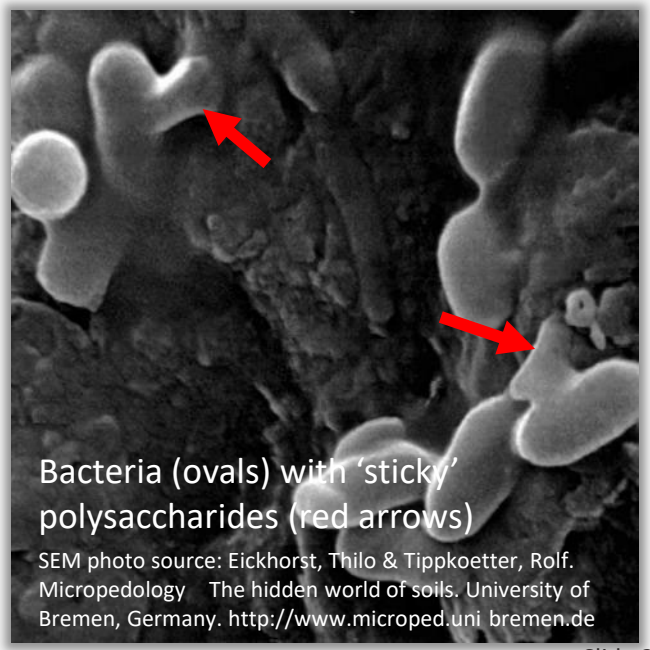
Soil Organisms Chemically Stabilize Soil Aggregates


Image source: Aaron Roth, NRCS OR

- Polysaccharides released by bacteria bind particles
- Soil proteins and other biochemicals bind soil particles

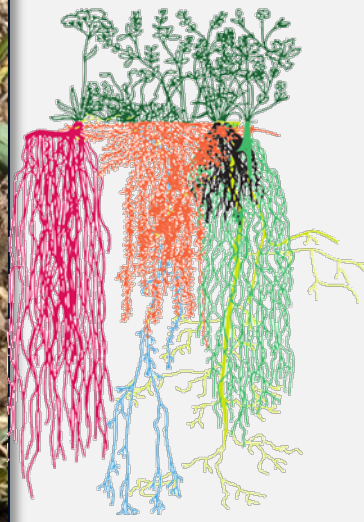

Glycoproteins on soil aggregates
Nichols, USDA ARS


Bacteria (ovals) with 'sticky' polysaccharides (red arrows)

SEM photo source: Eickhorst, Thilo & Tippkoetter, Rolf. Micropedology The hidden world of soils. University of Bremen, Germany. http://www.microped.uni bremen.de

Hot Spot For Chemical Processors & Biological Regulators - Rhizosphere

- Root exudates & chemical signals stimulates microbes & predators
  - Symbiosis
  - Protection
  - Chemical signaling
  - Nutrients
  - Resilience



Orgiazzi, Bardgett, Barrios et al., 2016. Global Soil Biodiversity Atlas.

Trends in Plant Science 2016 21, 256-265DOI:(10.1016/j.tplants.2016.01.008)

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Root Zone (Rhizosphere): Key Organisms

Bacteria

- Most numerous
- 2-5% of SOM but responsible for 90% of energy flow
- 1 g can contain 10 million bacteria and one million species.
- 0.5-3 tons per acre (Killham 1994)

Fungi

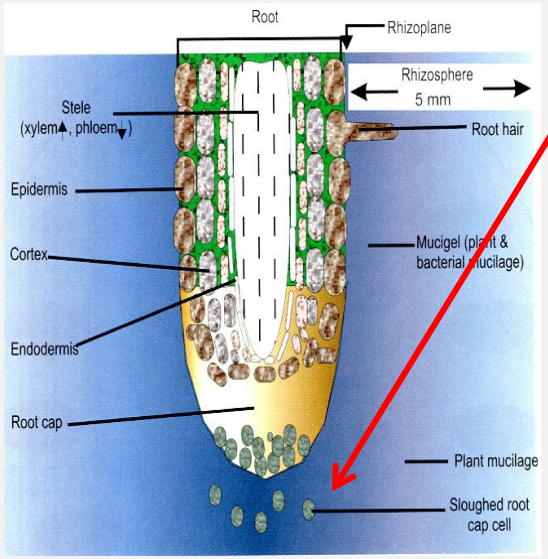
- Saprophytic
- Mycorrhizae
- Pathogenic
- Up to 5 tons per acre

Protozoa & Nematodes

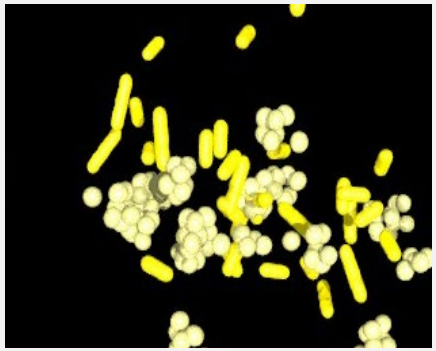
*Consume microbes and recycle nutrients to plant roots

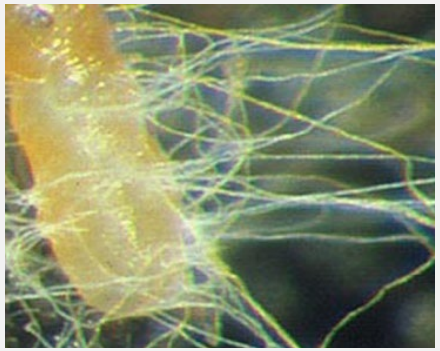
Turbe et al 2010; Coleman & Crossley 1996; Nannipieri & Badalucco 2003; Global Soil Biodiversity Atlas. 2016. Orgiazzi, Bardgett, Barrios et al.

Plant Roots Attract Microbes



Exudates: carbohydrates and proteins secreted by roots; attract bacteria which nematodes & protozoa consume, which mineralize nutrients for plants.





Bacteria and fungi are like little fertilizer bags

Nematodes and protozoa consume microbes and excrete plant available nutrients

Rhizosphere Key Organisms
Mycorrhizae

Mykós (fungus)- riza (root)

- Plants use 5-20% of C from photosynthesis to ‘feed’ fungi
- Fungi increase root surface area at least 10x
- Fungi increase nutrient uptake especially P and Zn
- Fungi suppress pests and diseases
- Fungal networks build soil aggregates

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N-Fixing Bacteria (Rhizosphere)

Bradyhizobium Japonicum
for Soybean & Cowpea

Photo: Getty Images

Rhizobum trifolii
for most Clovers


Photo: Science Source

9:56 AM

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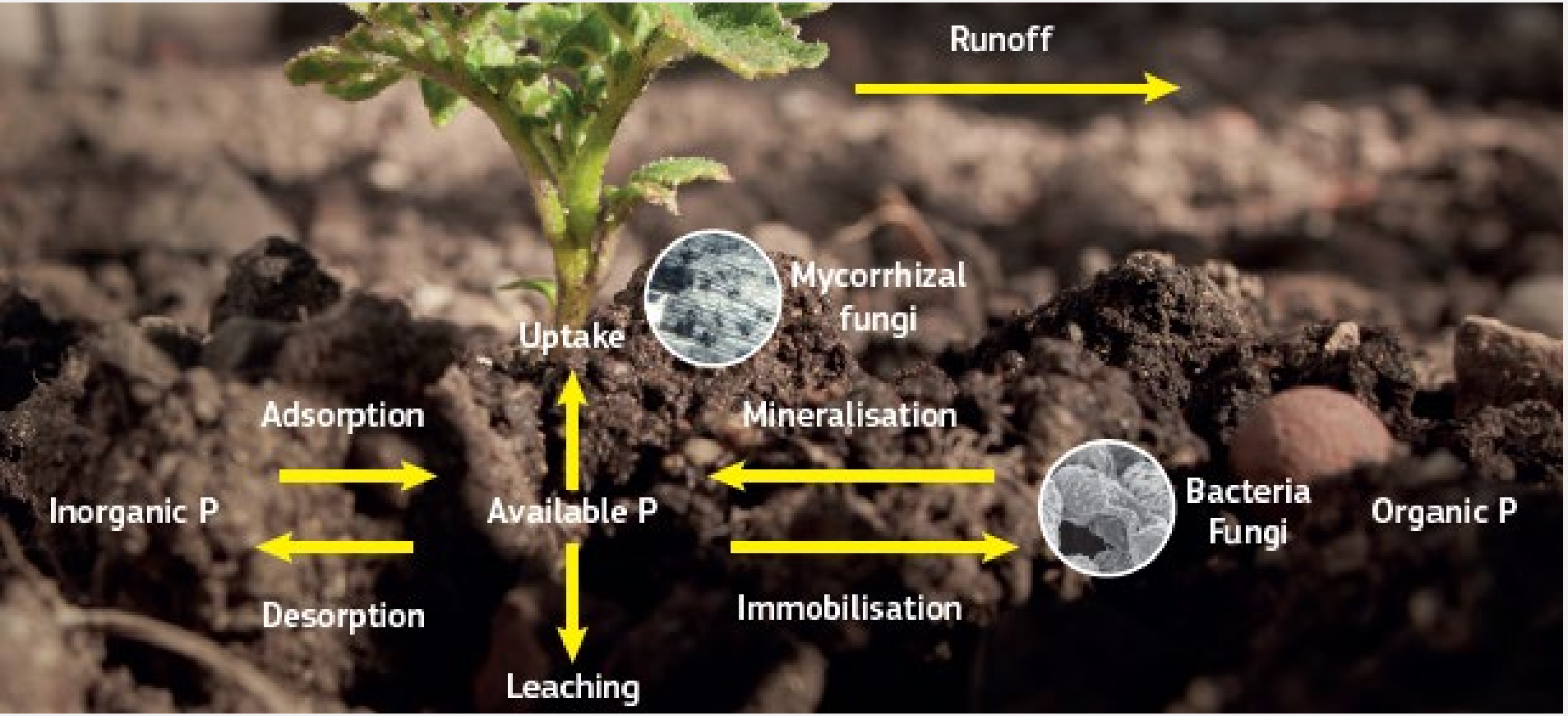
Biology and the Phosphorus Cycle:

What factors affect P movement/availability?



Top: Global Soil Biodiversity Atlas, p.105: Simplified phosphorus (P) cycle in the soil. The regulation of soil P cycling is influenced by microorganisms (e.g. bacteria and fungi). (DG, JRC)

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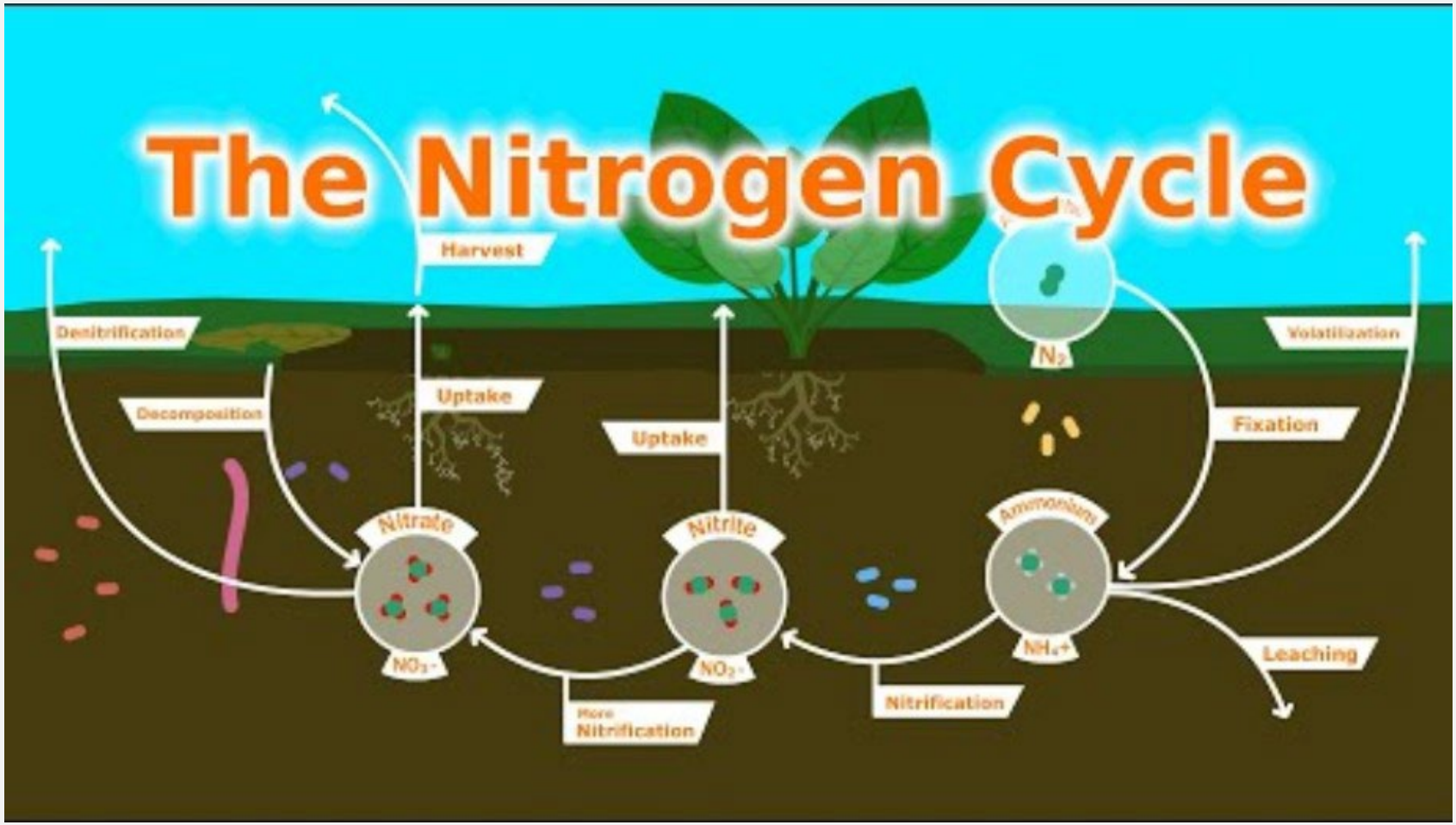
Biology and Nitrogen Cycle



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Knowledge Check - Poll Question

How many types of biological hotspots are there in the soil ecosystem?

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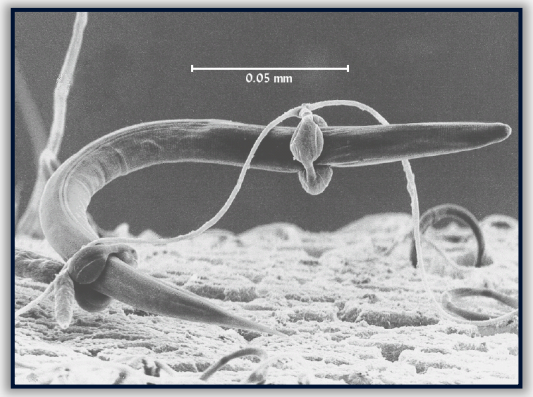
How Can the Soil Microbiome be Manipulated?

- Select different plant species, varieties, or control at various plant stages (e.g., crop rotation, cover crop selection, planting timing and termination)
- Fertilization (4 R's)
- Soil amendments, including biologicals (promise but fraught with issues)
- Manage the environment to minimize stress (e.g., pathogens, drought, temperature extremes, etc.)
  - Temperature
  - Moisture
  - Maximize presence and duration of hot spots

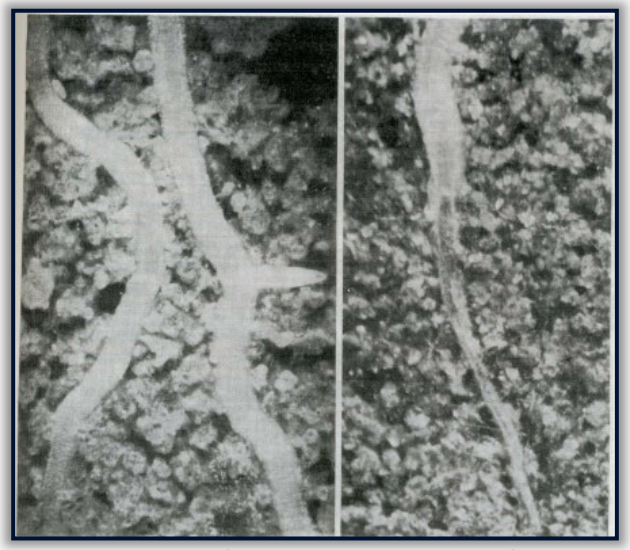
Belowground Competition

Nematode-trapping Fungi



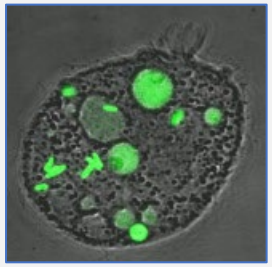
Vampyrellids (protist) eating a fungal root pathogen involved in take-all disease

Protection from *Rhizoctonia solani*



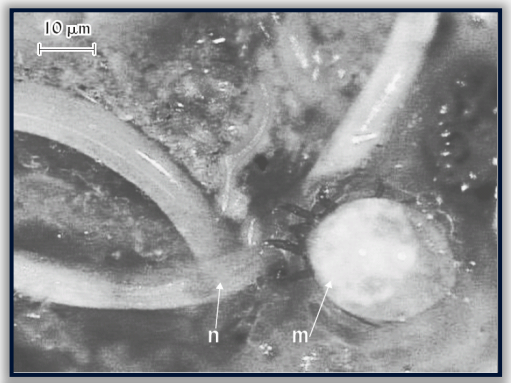
Roots with springtails

Roots without springtails



A single protozoan can eat billions of bacteria each day!

Mite preying on a nematode



Soybean cyst nematode parasitized by the fungus *Hirsutella minnesotensis*

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Summary: Managing for Soil Biology

Conventional

- Most ag soils are carbon depleted
- Disturbances destroys habitat and hyphal networks
- Bare, fallow fields provide little protection, no C
- Agrichemicals have mixed effects
- Many fertilizer concentrations too high for symbiosis

Soil Health Management System

- Manage for hot spots
- Support biology to build aggregates and create pore space
- Protect the habitat
- Feed the soil so it can feed us
- Optimize biological nutrient cycling
- Optimize plant-microbe interactions for plant defense optimization

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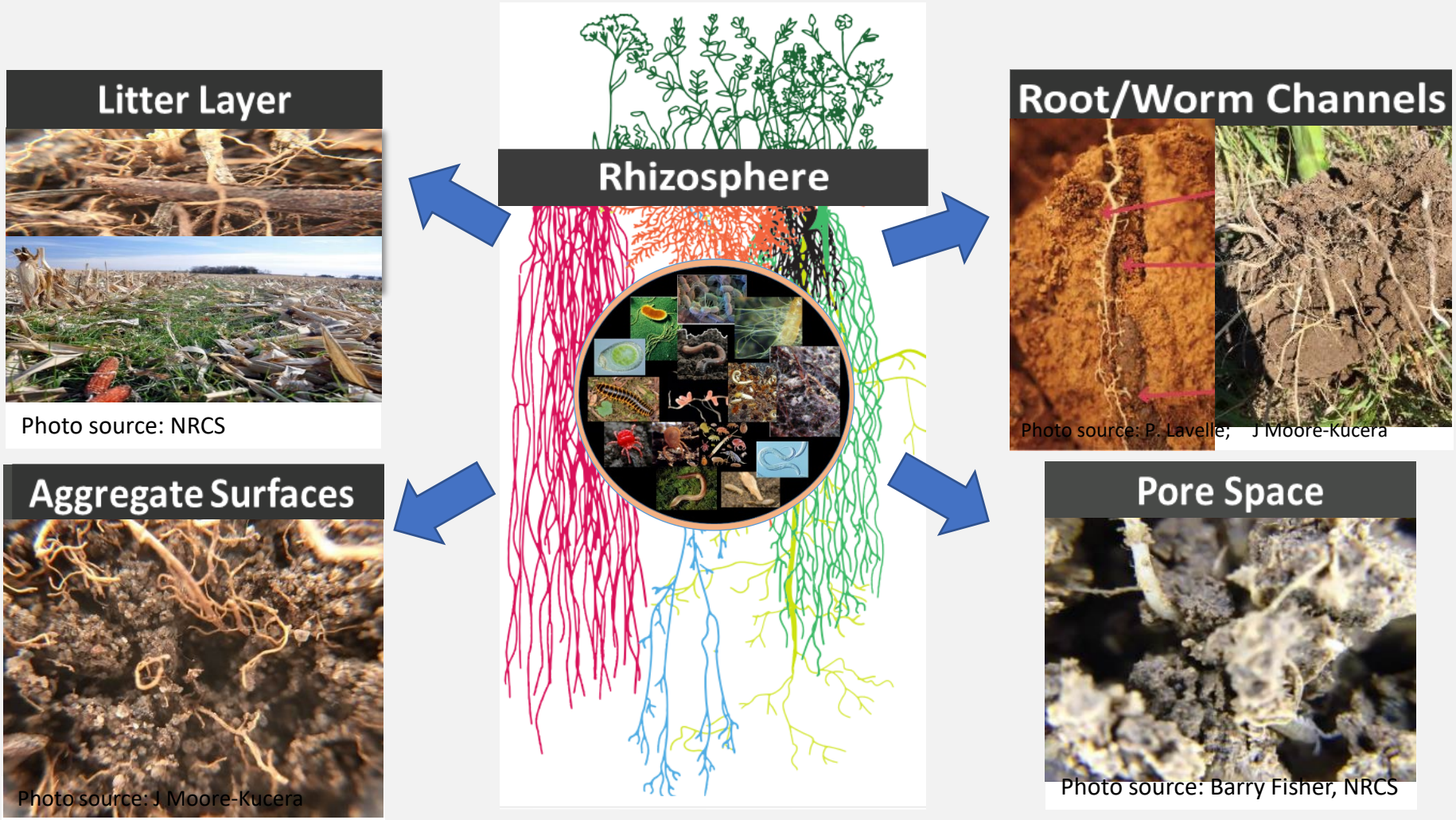
Biological Hot Spots to Optimize Function



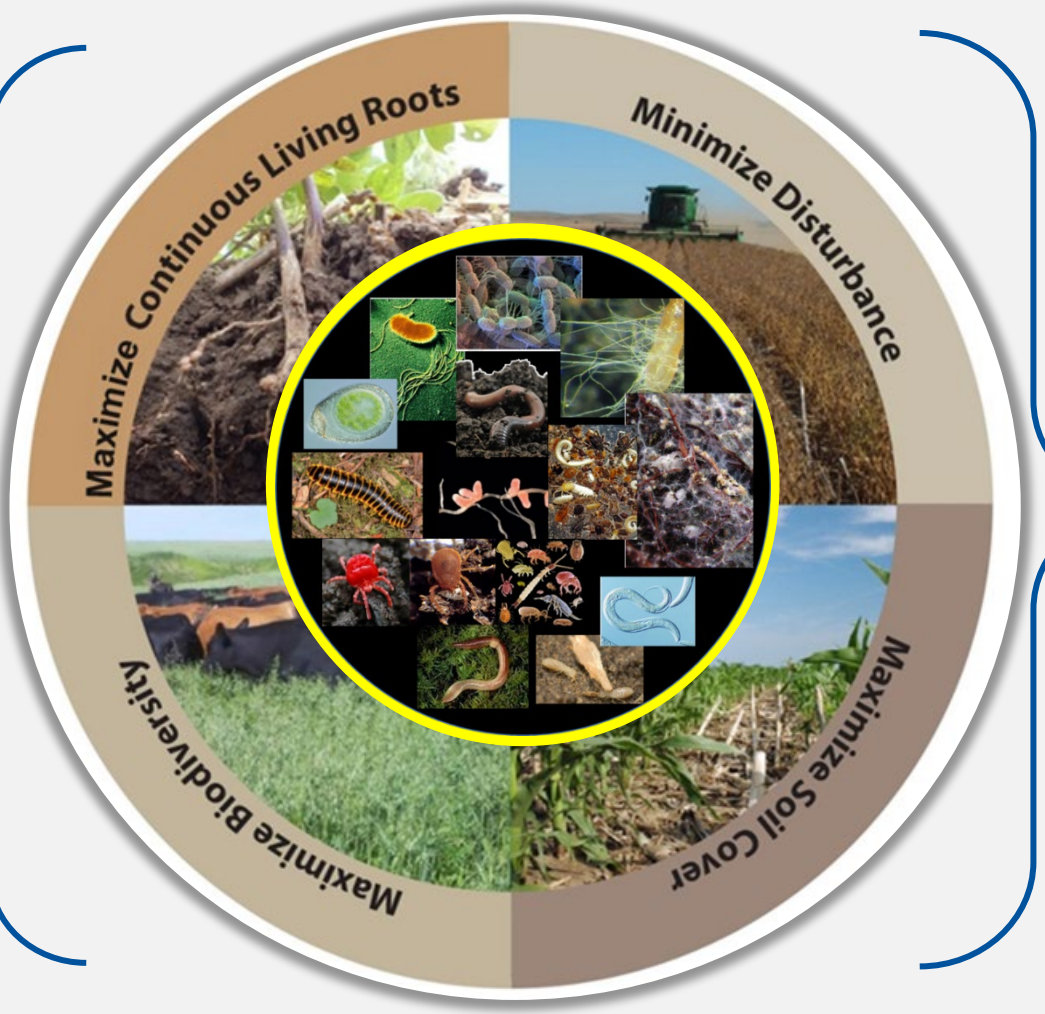
Root cartoon and organism images: Orgiazzi , Bardgett, Barrios et al. 2016. Global Soil Biodiversity Atlas.; Slide design by J Moore-Kucera

What do Soil Organisms Need?

- How can we feed belowground life?
  - Choose practices that provide diverse, near continuous inputs and build reserves (SOM)
- How can we provide & protect habitat?
  - Choose practices that minimize disturbance of habitat (aggregates) and food sources (SOM + residue)
  - Choose practices that support a stable habitat from major swings in temperature, water, & chemistry

Soil Health Principles

Feed & Fuel Soil Biology



Protect Soil Aggregates & Organic Matter

*Modified from USDA –NRCS-Principles for High Functioning Soils Factsheet

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Knowledge Check – Poll Question

Are Mycorrhizal Fungi beneficial to plants?