HOW COVER CROPS BENEFIT SOIL HEALTH

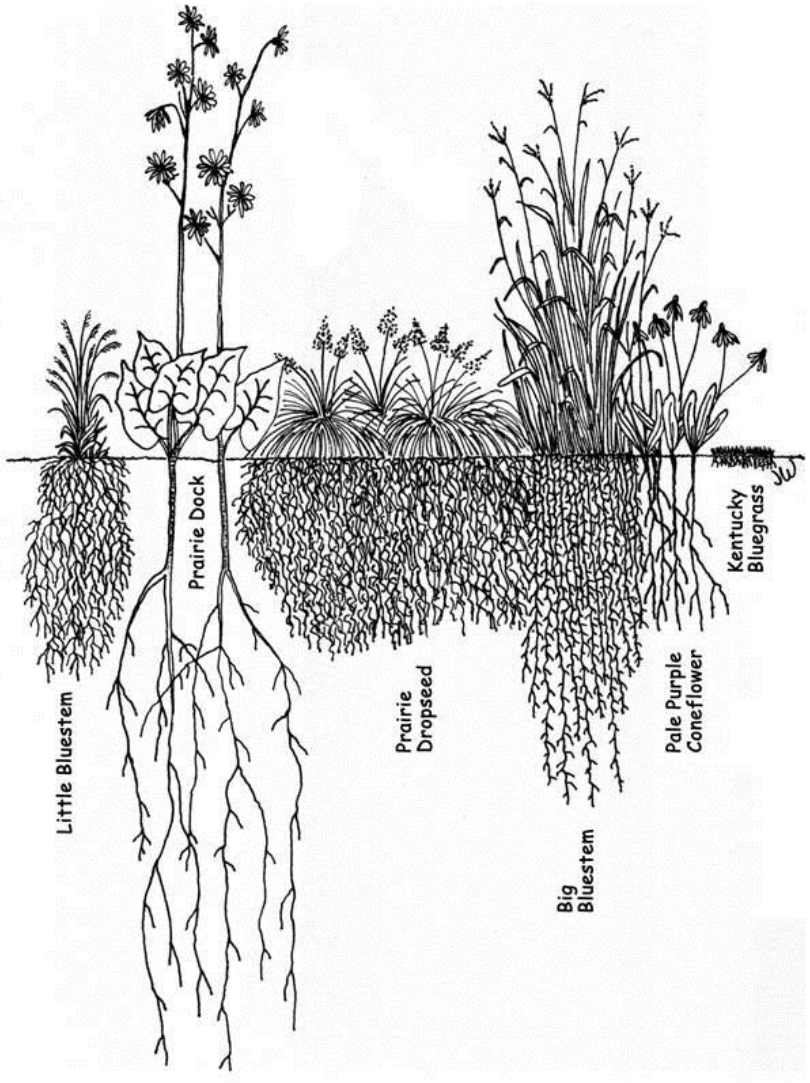
Emily Reiss, Cornell University

Outline

- The impact of plants on soil function
- Collaboration of plants and microbes for soil health
- The importance of soil nitrogen pools for plant yield
- How cover crops contribute to OM and soil health

Plants are the engine of the soil

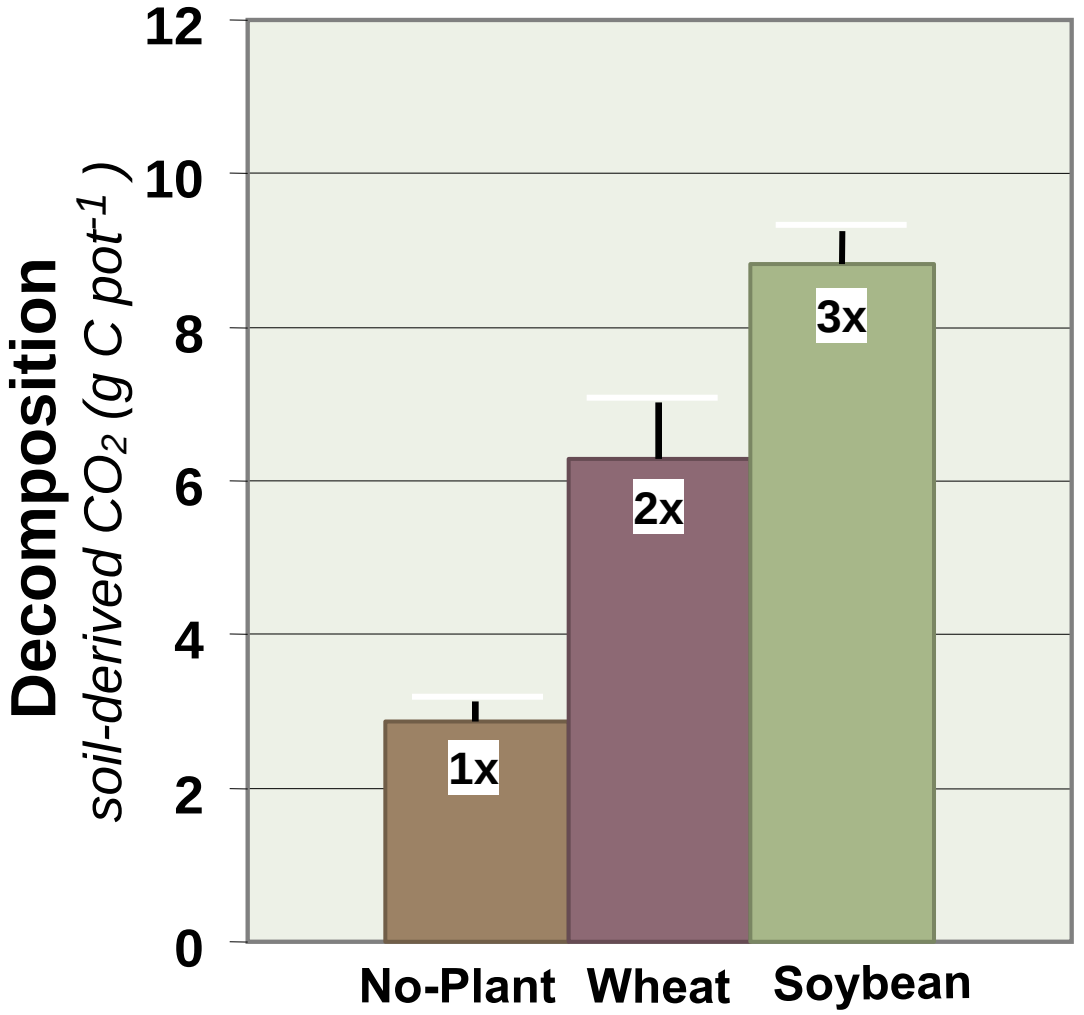
First start with the belowground impact



Then talk about increasing the aboveground contribution

Plants prime the soil for decomposition

Wheat doubled and soybean tripled decomposition rates of soil organic matter (SOM).



Cheng, W., SSSA 2002.

Plants and microbes collaborate in the rhizosphere

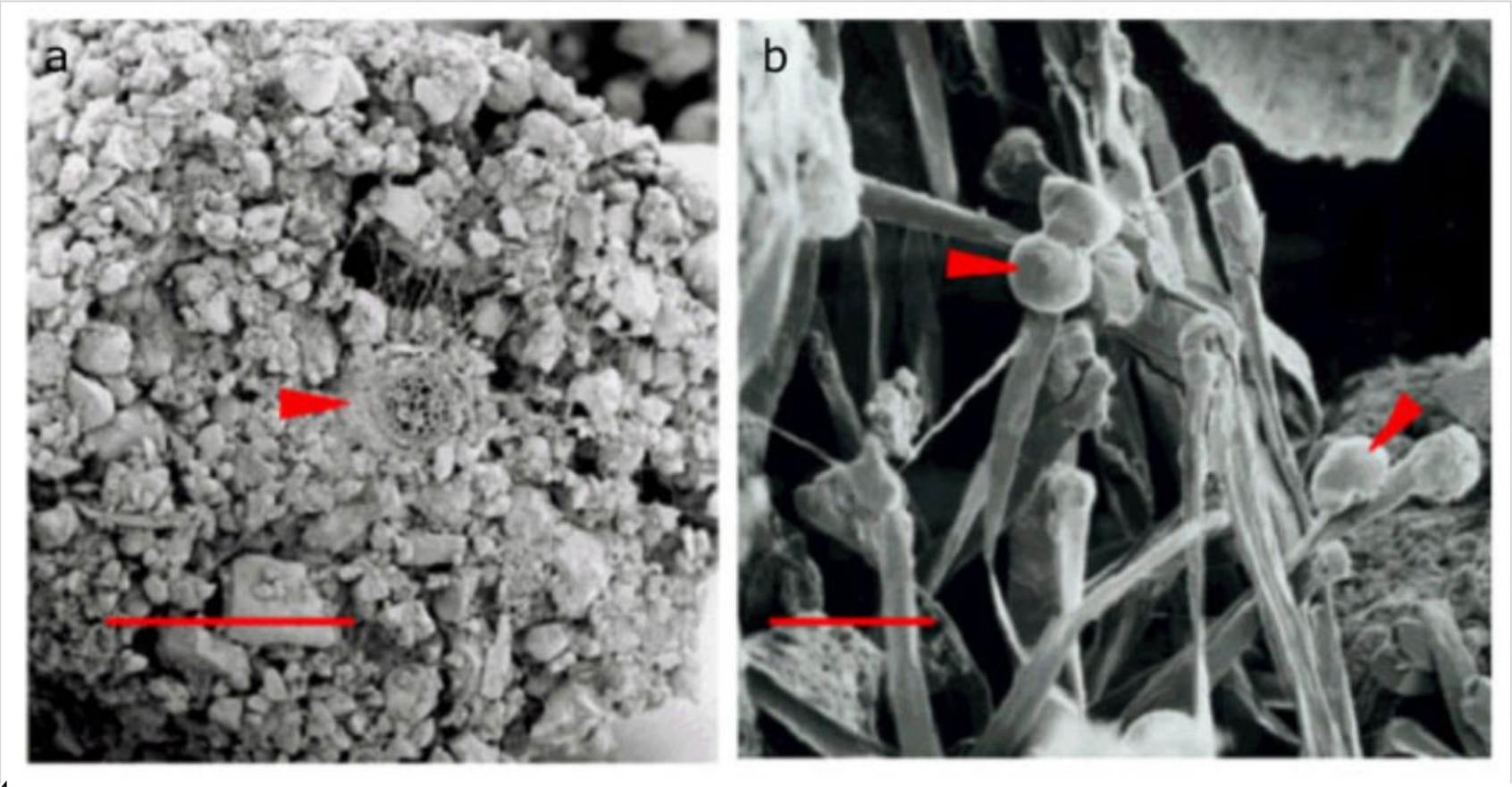
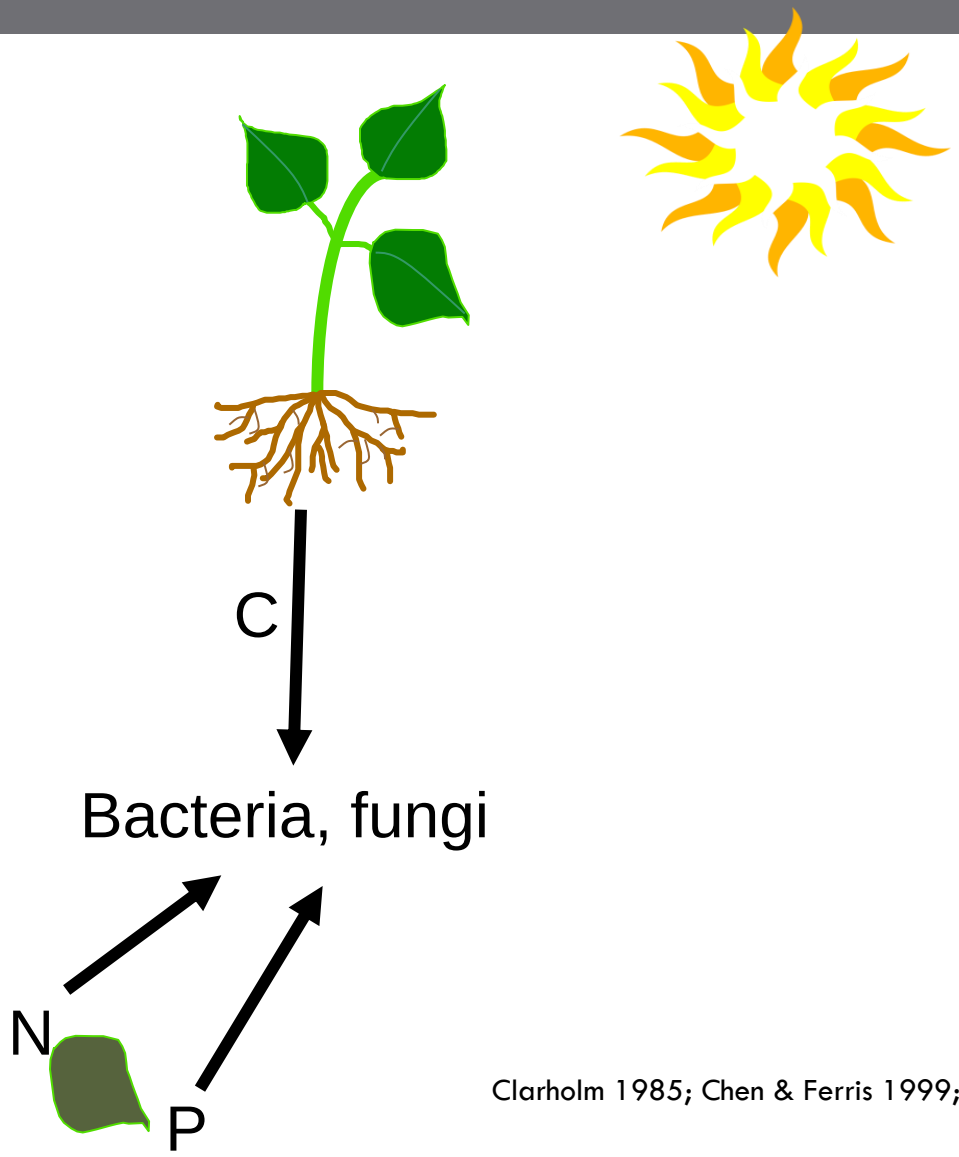


Figure 4
A branch root (red arrow) of buckwheat (Fagopyron esculentum) frozen together with its surrounding soil and then imaged using scanning electron microscopy to reveal the intimate contact between the root and soil. Note the root hairs extending out and exploring the surrounding soil. Bar = 600 µm. b) Red arrows point to droplets of root exudates released from the tips of root hairs on the surface of broom corn (Sorghum sp.). Bar = 50 µm.

Plants and microbes collaborate to cycle nutrients



Clarholm 1985; Chen & Ferris 1999; Hamilton & Frank 2001; Schimel & Bennett 2004; Dijkstra & Cheng 2007; Fontaine et al. 2011

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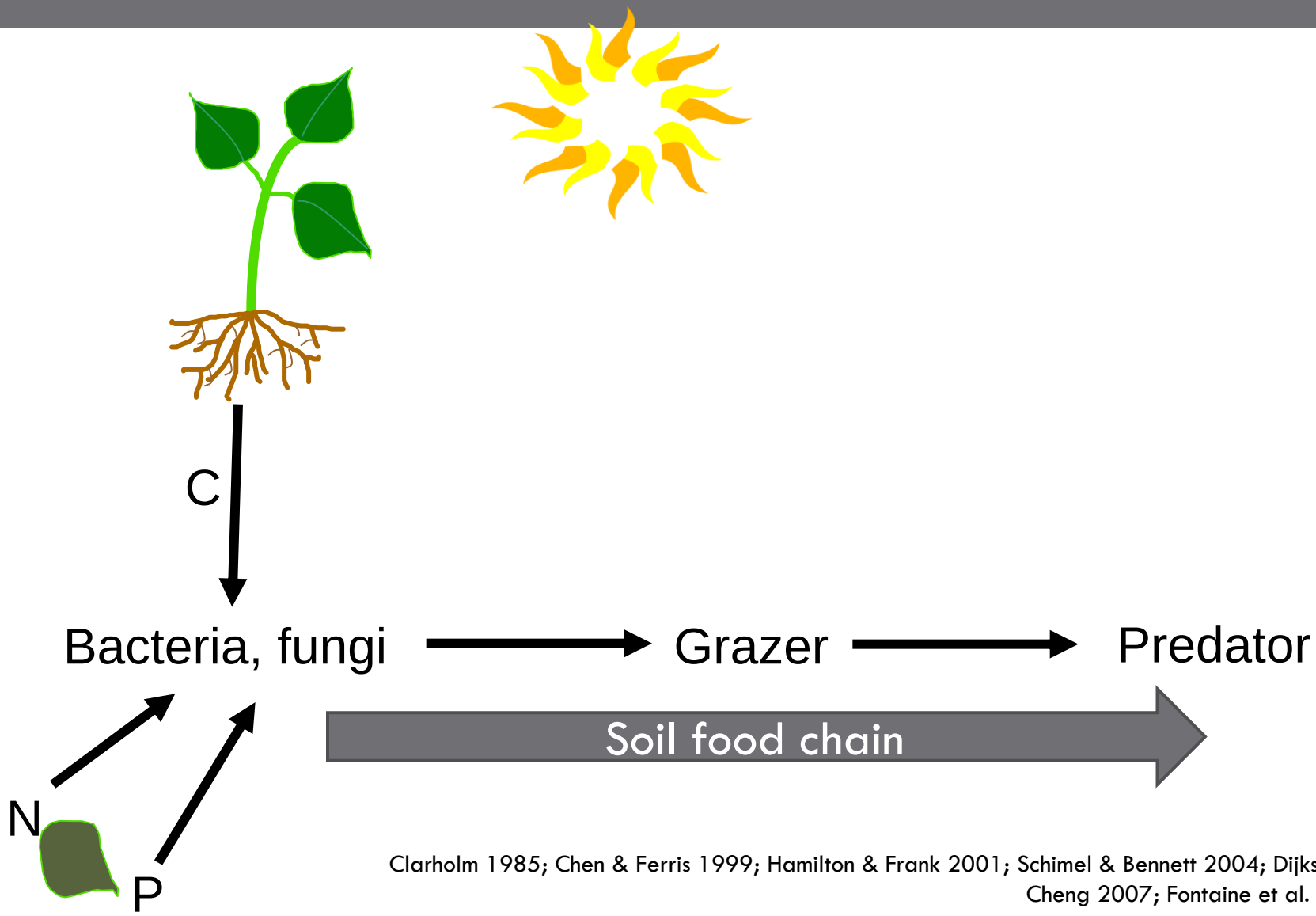

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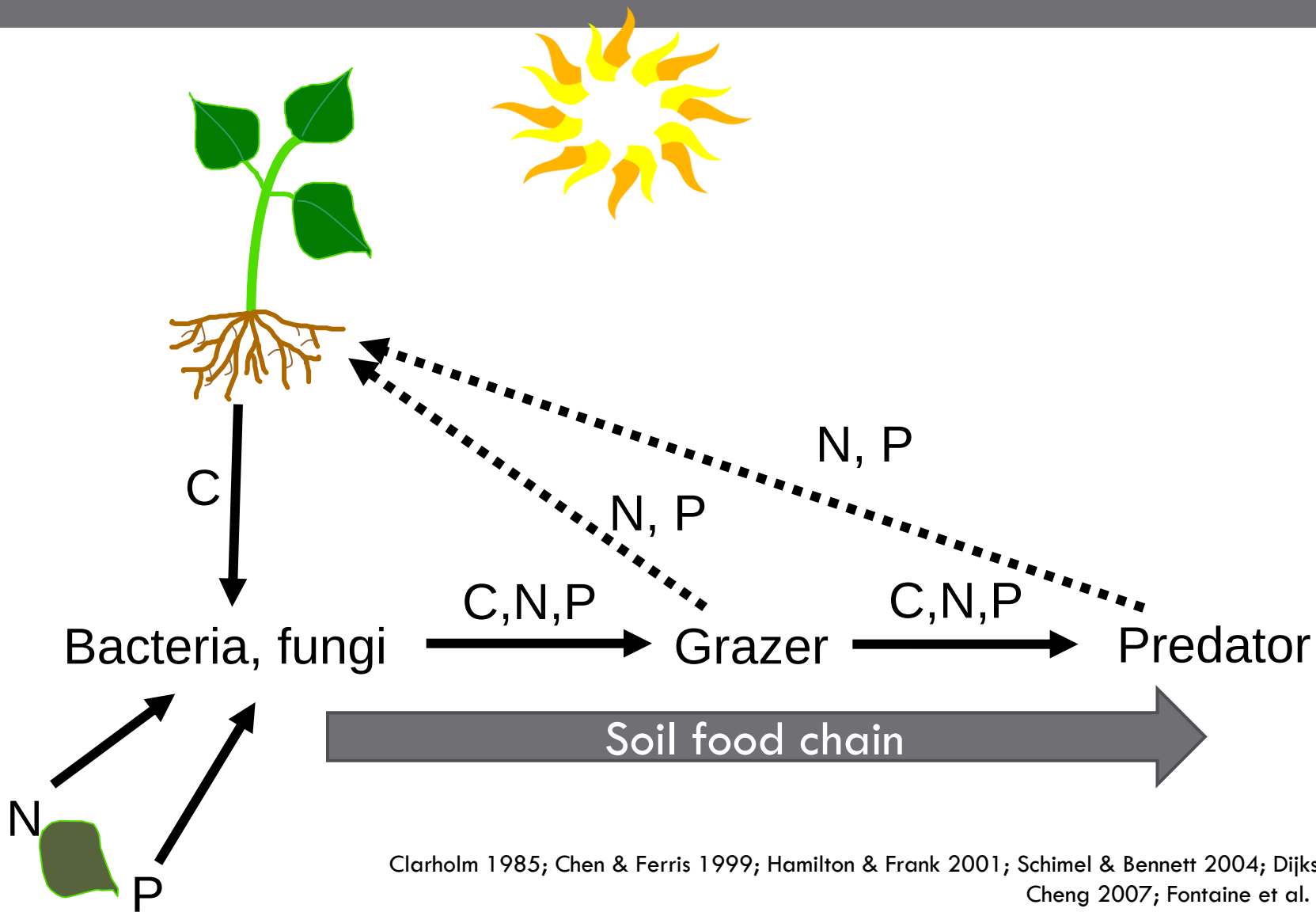

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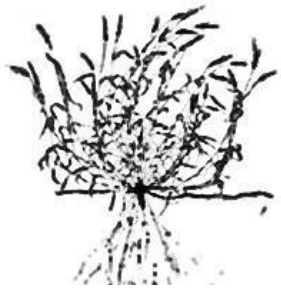
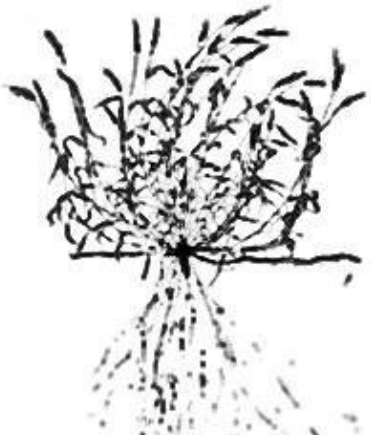
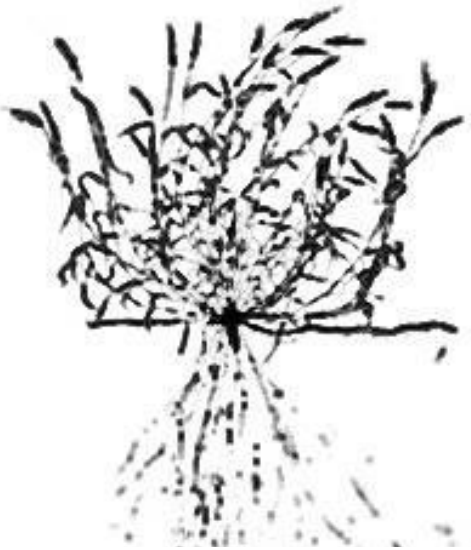


Sterile soil



Sterile soil
+ bacteria



Sterile soil
+ bacteria
+ grazers

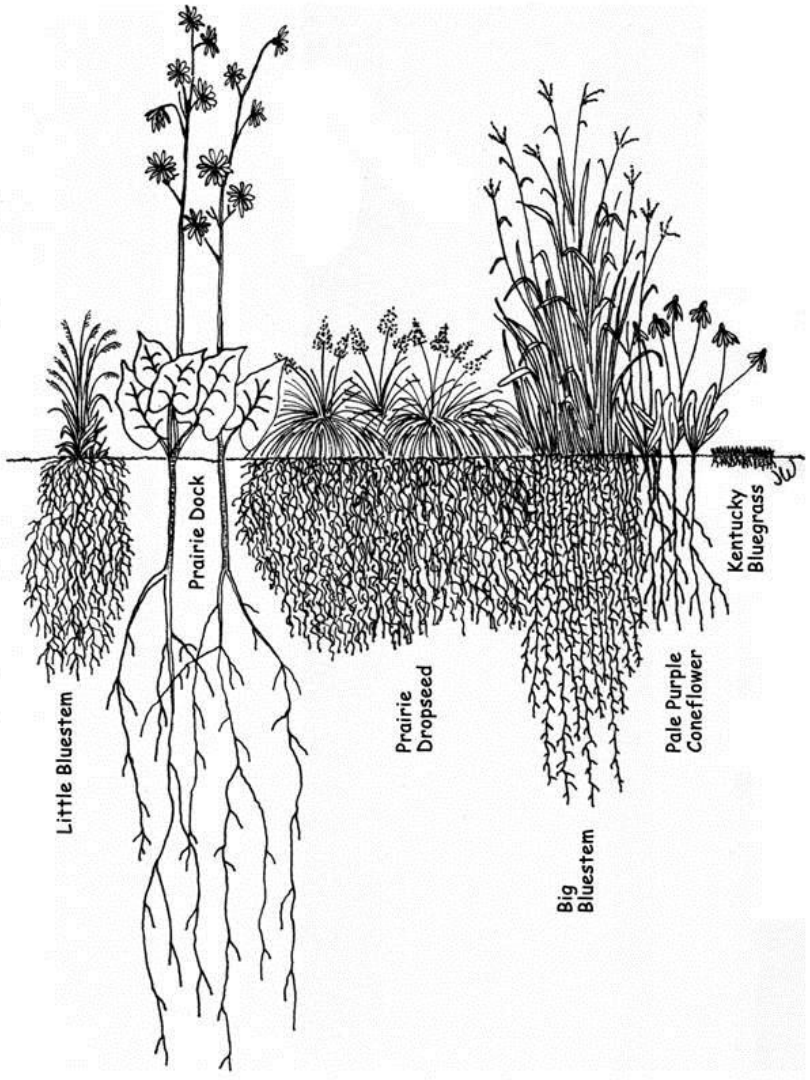
Clarholm et al. 1986

Cover the soil whenever possible

Most common rotations

Rotation with a cover crop

Why is this nutrient cycling so important?



Soil nitrogen accounts for more than half of the nitrogen a crop takes up

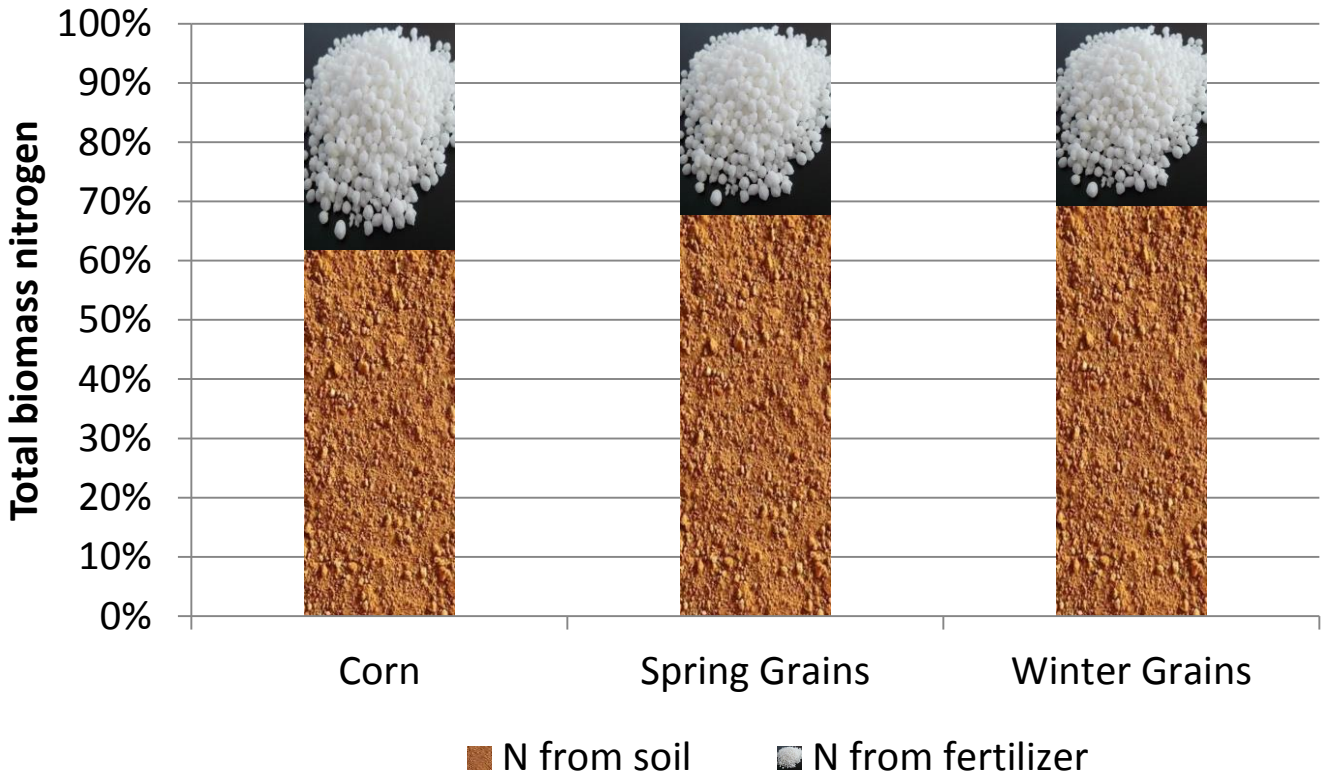


FIG. 8. The percentage of total plant biomass N from fertilizer and soil for corn, spring small grains, and winter small grains, for studies in the meta-analysis database. In aggregate, the 15N literature confirmed the generalization that the majority of crop N comes from soil pools. From Gardner and Drinkwater 2009.

Legume-based cropping systems can provide high nitrogen organic matter

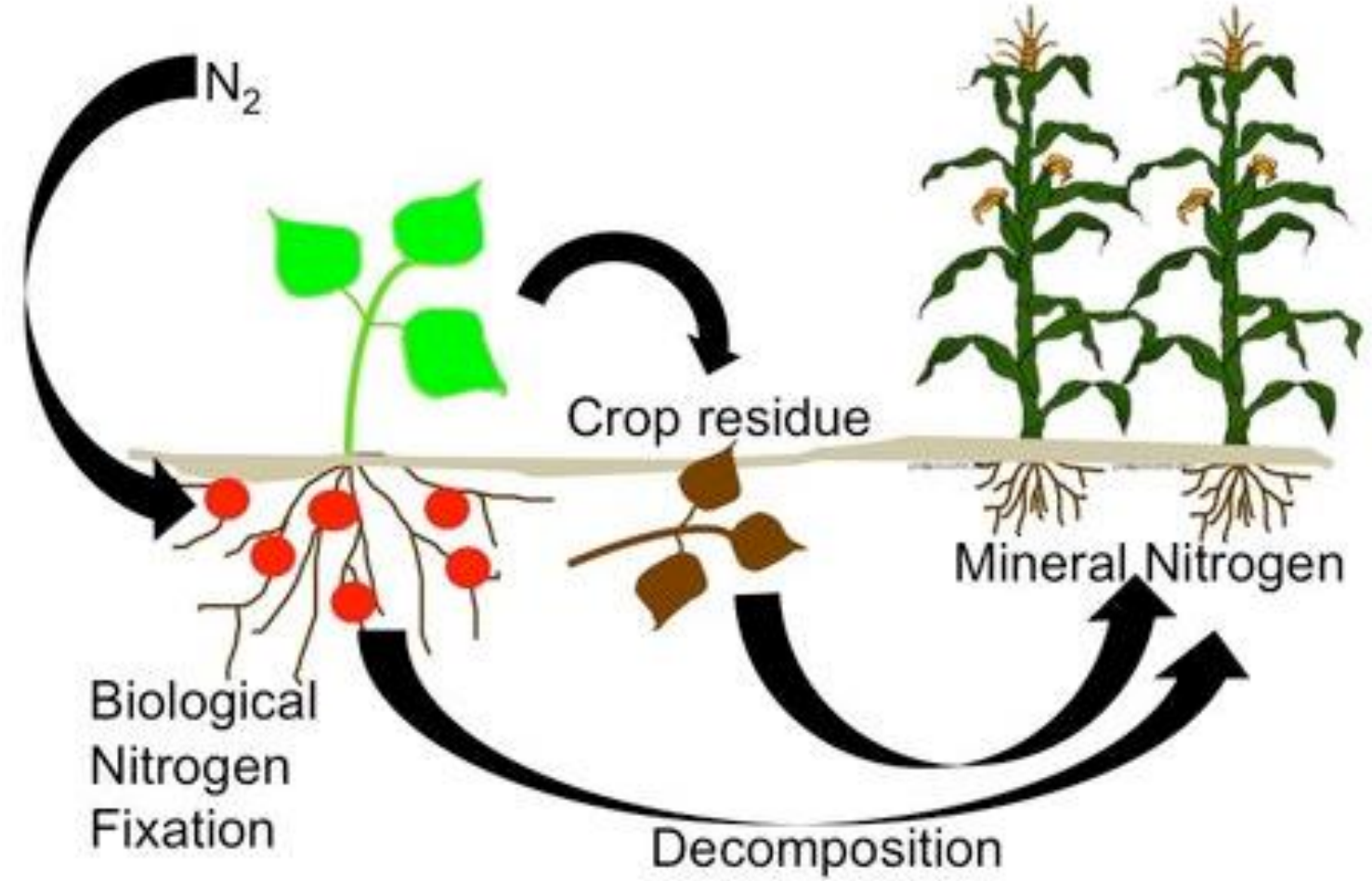


Figure credit: Nape Mothapo, North Carolina State University

Bigger impact on OM% from a diverse crop rotation with cover crops, than without

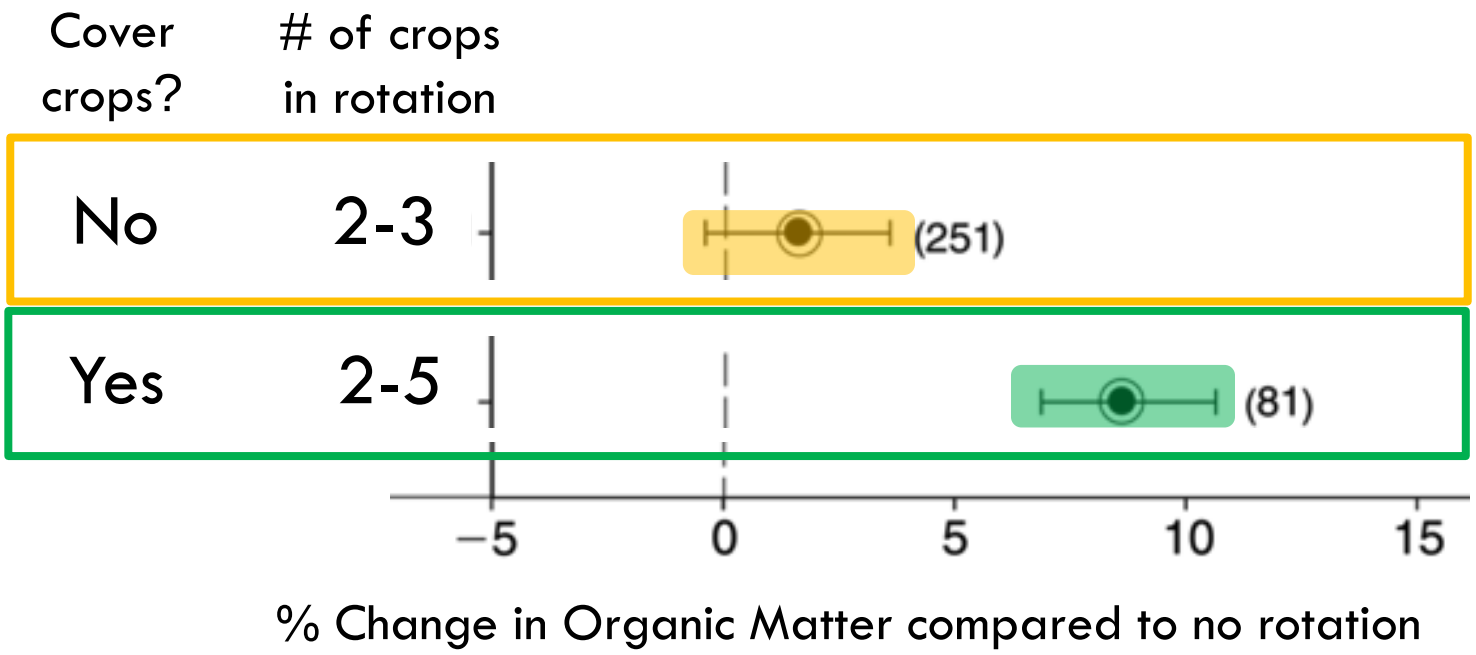
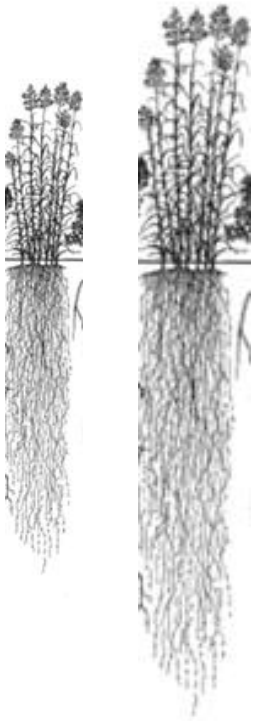


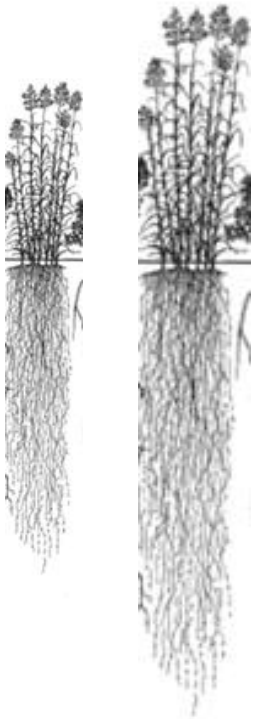
Fig. 5. Mean changes in soil total C by whether one or more of the crops included in the rotation was a cover crop and number of crops in rotation. The number of observations for each crop is shown in parentheses. "Overall" (outlined circles) is the mean change when the different number of crops are pooled. Error bars are 95% bias-corrected confidence intervals. *(McDaniel et al. 2014)*

Organic matter diversity

Organic matter diversity



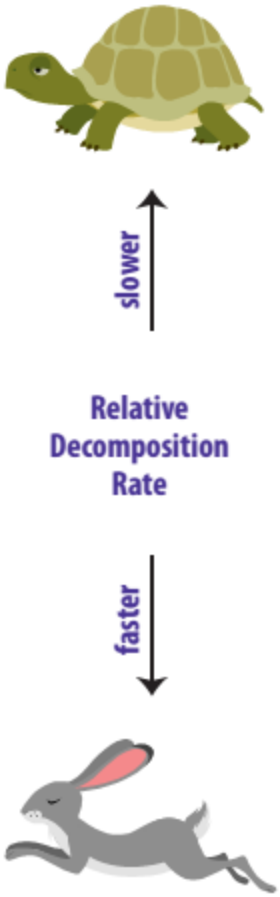
Organic matter diversity



C:N
30:1

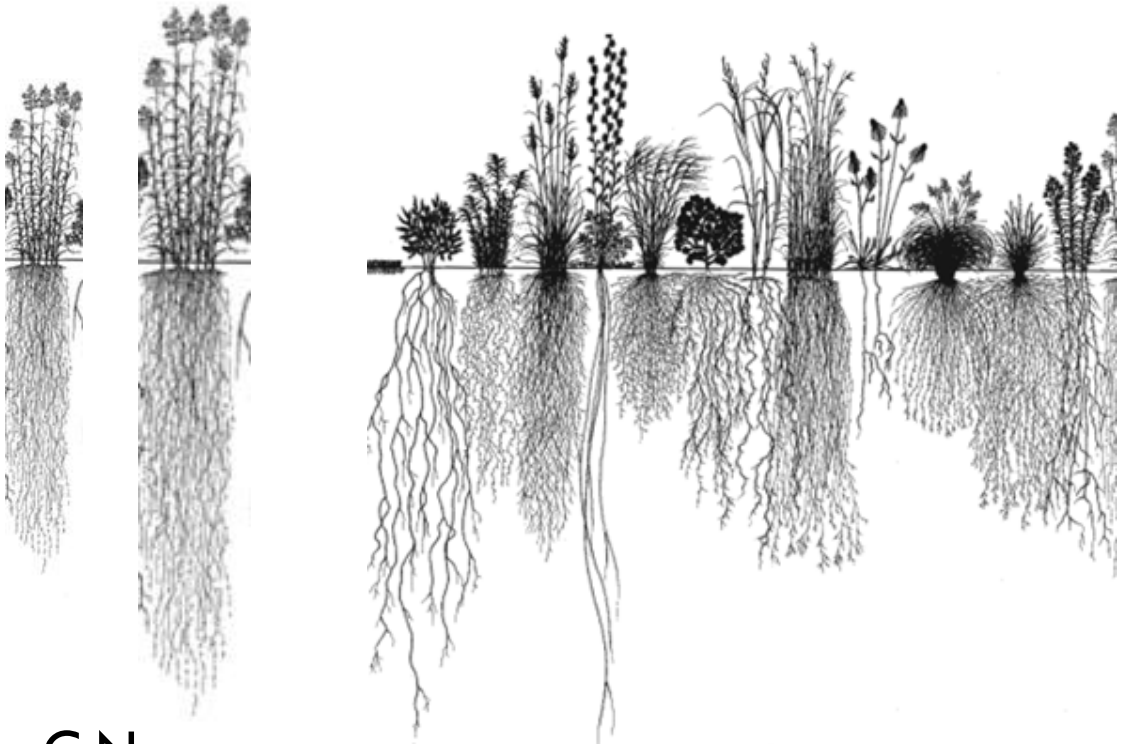
Table 1. Carbon to nitrogen ratios of crop residues and other organic materials

Material	C:N Ratio
rye straw	82:1
wheat straw	80:1
oat straw	70:1
corn stover	57:1
rye cover crop (anthesis)	37:1
pea straw	29:1
rye cover crop (vegetative)	26:1
mature alfalfa hay	25:1
Ideal Microbial Diet	**24:1**
rotted barnyard manure	20:1
legume hay	17:1
beef manure	17:1
young alfalfa hay	13:1
hairy vetch cover crop	11:1
soil microbes (average)	8:1



USDA NRCS East National Technology Support Center, Greensboro, NC, in cooperation with North Dakota NRCS

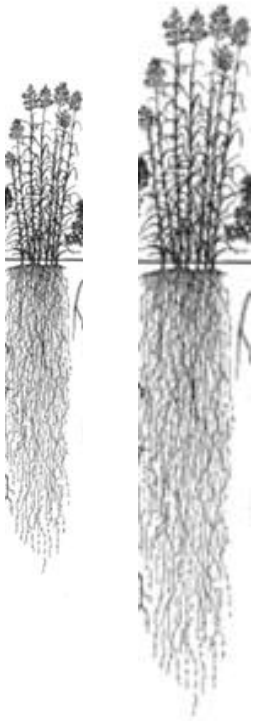
Organic matter diversity



C:N
30:1

12:1 60:1 24:1 37:1 42:1

Organic matter diversity



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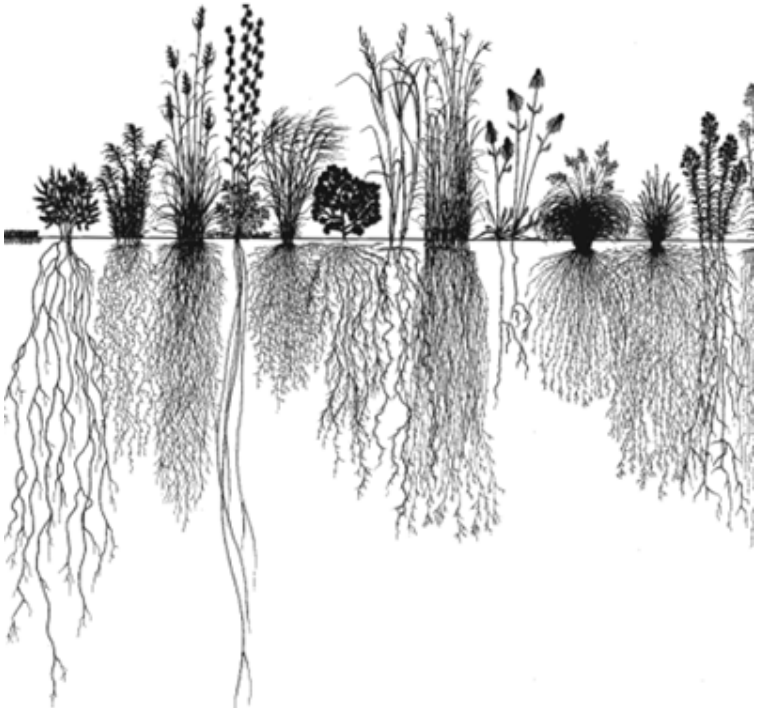

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Diversity in agricultural systems

Diversity in agricultural systems

- **Temporal diversity: rotations**

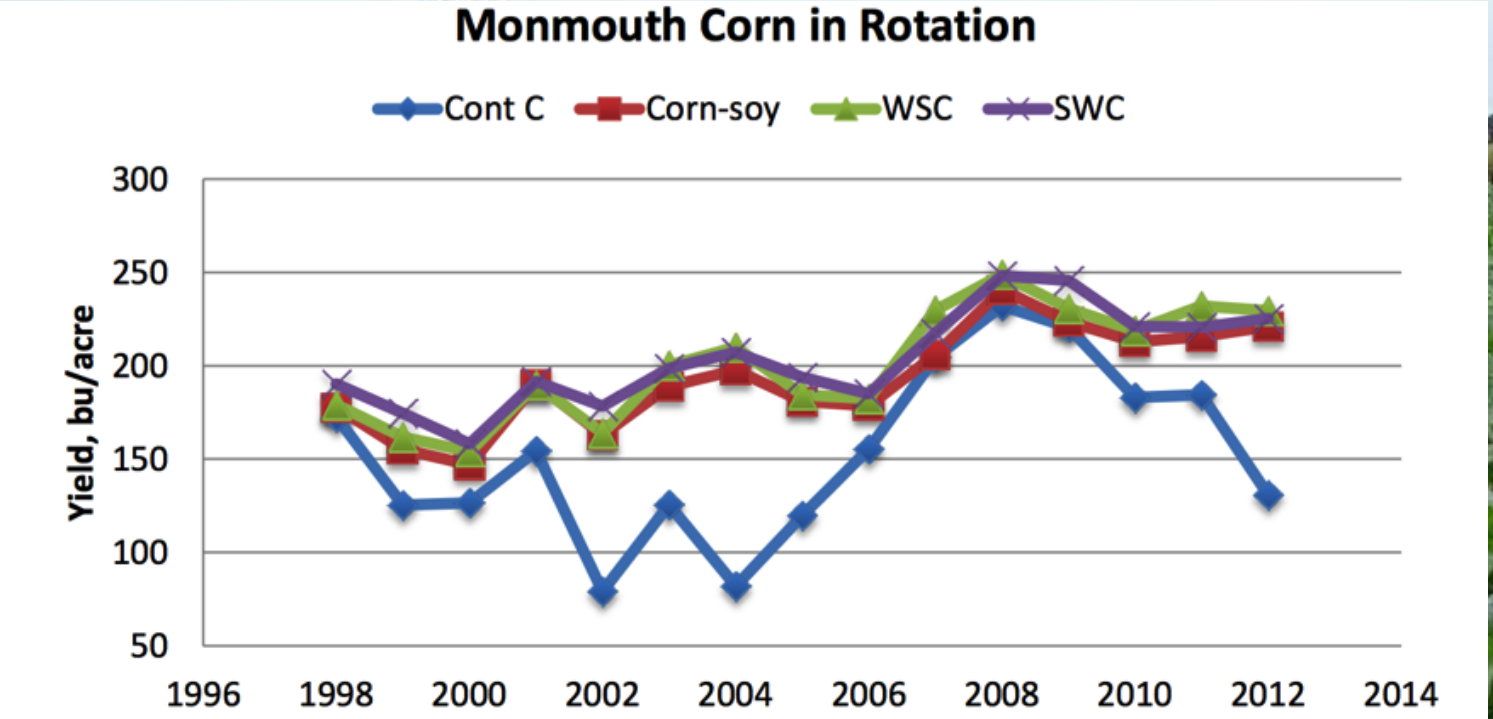


Figure 1. The effect of crop rotation on corn yield at the NWIARDC in Monmouth, IL between 1998 and 2012. *https://web.extension.illinois.edu/nwiardc/downloads/48185.pdf*

http://s0.geograph.org.uk/geophotos/01/95/63/1956379_7757be12.jpg

Cover crop mixtures

Why might you be interested in mixtures of cover crops?

Why might you be interested in mixtures of cover crops?

- Looking for multiple benefits that one species can't deliver
- The C:N ratio of just legumes or non-legumes isn't appropriate
- Want to incorporate plant families that aren't in main crop rotation
- Synergy from combining cultivars, species or functional groups

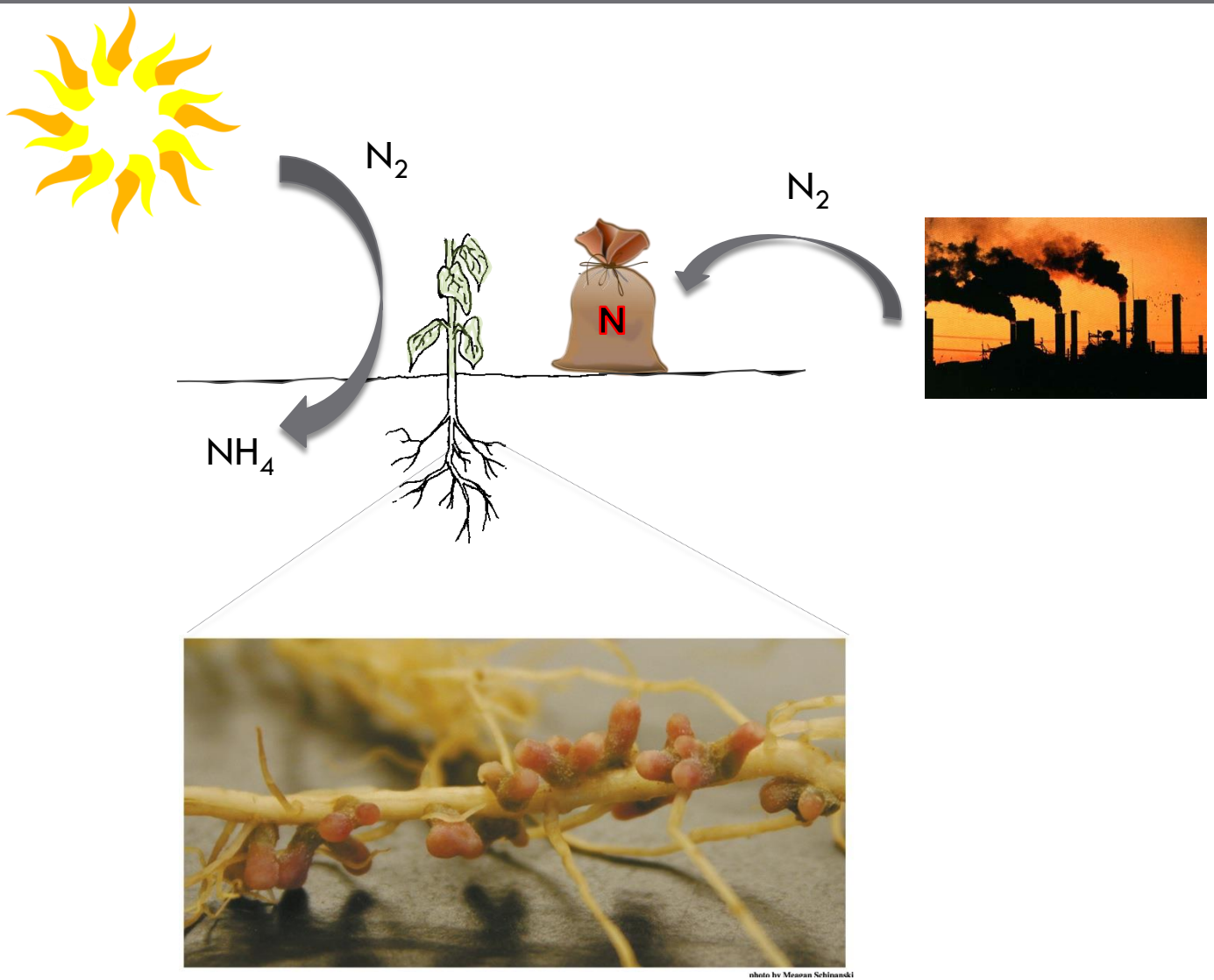
Common example of a mixture: Legumes and grasses

Fixed nitrogen from legumes

Weed suppression from grasses

Together, lower C:N ratio than grass alone, consistent weed suppression, increased nitrogen fixation

Nitrogen is fixed by rhizobia symbiosis with legumes



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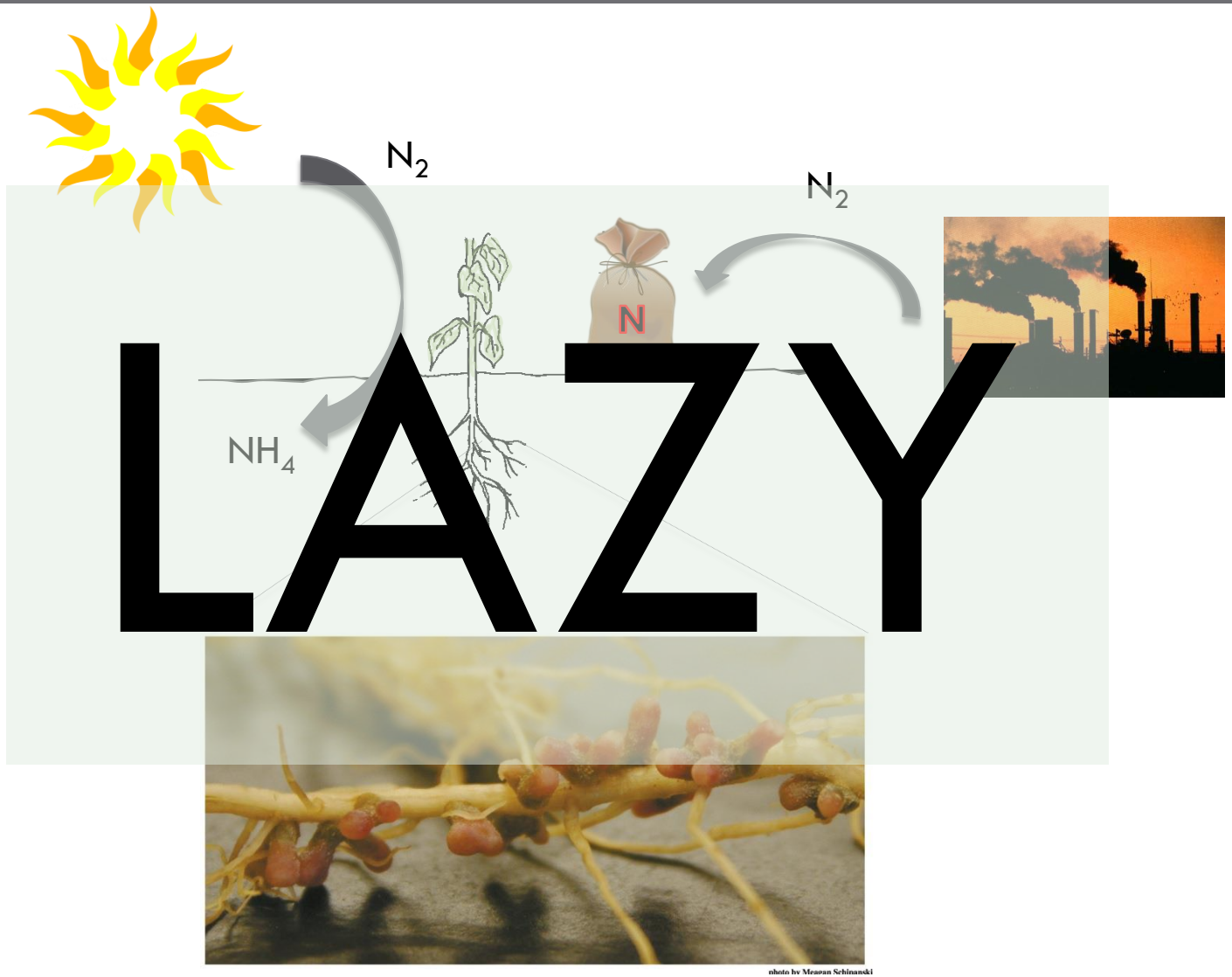
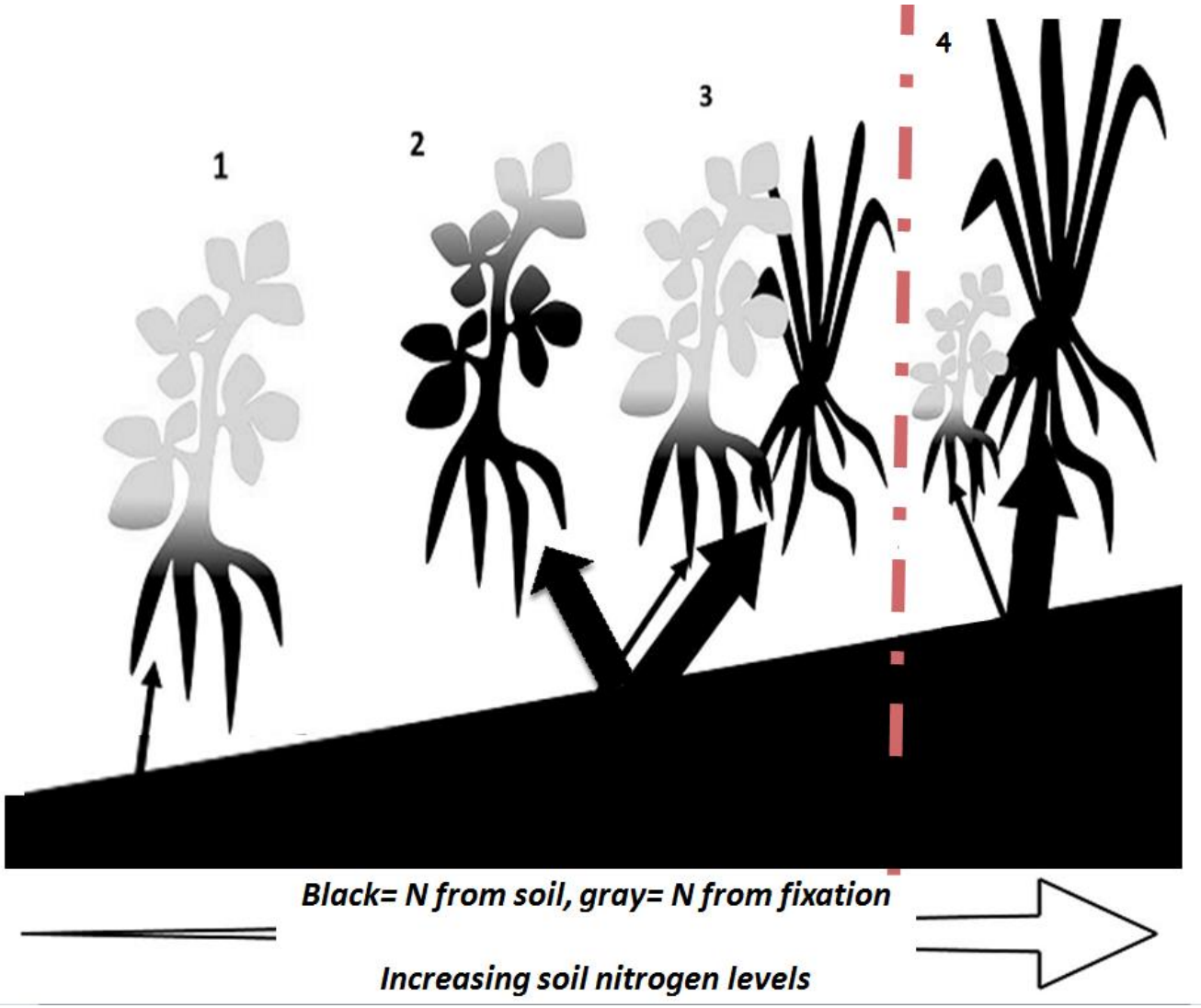


2) As N availability increases, legumes are able to capture more soil N.

3) If a grass is planted with the legume, it will draw down soil N forcing the legume to fix more N.



1) In lower fertility soils where P and micronutrients are adequate, legumes fix more N.

4) If soil N availability is very high, the grass will grow very quickly and legume growth will be suppressed.

All about the environment

Legumes in mixtures show a greater reduction in the amount of N fixed in fields with higher N fertility

Pounds of fixed N per acre

	Medium fertility field	High fertility field
Red clover	80	65
Clover/grass mix	70	38

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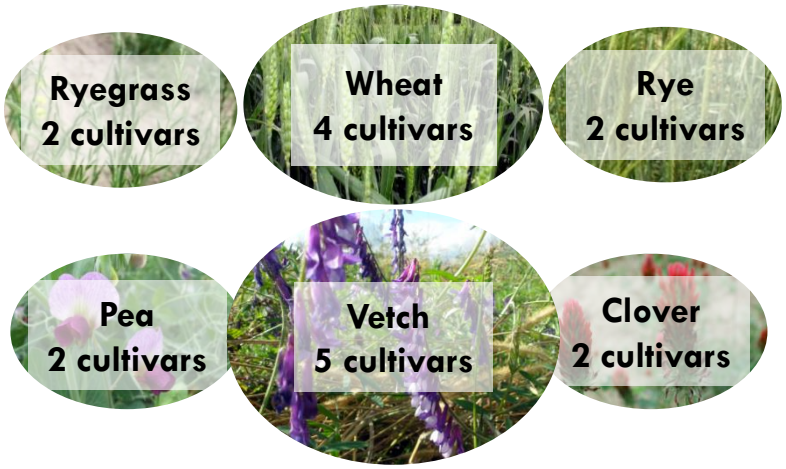
How to wield the double-edged sword of legume/grass mixtures

- Potential for great benefits
- In-field adaptation to soil conditions
- May not deliver expected goals under certain conditions

- Check soil conditions first
- Examine nodules for color
- Adjust future seeding rates

photo by Steven Vanek

Species and cultivar diversity in cover crop mixtures to improve performance



Qty.	Species	Cultivar
17	single species	single cultivars
8	single species	cultivar mixtures
17	species mixtures	single cultivars
7	species mixtures	cultivar mixtures
49	**cover crop treatments total forming a diversity gradient**	

Seeds planted

September

Over wintering planting niche

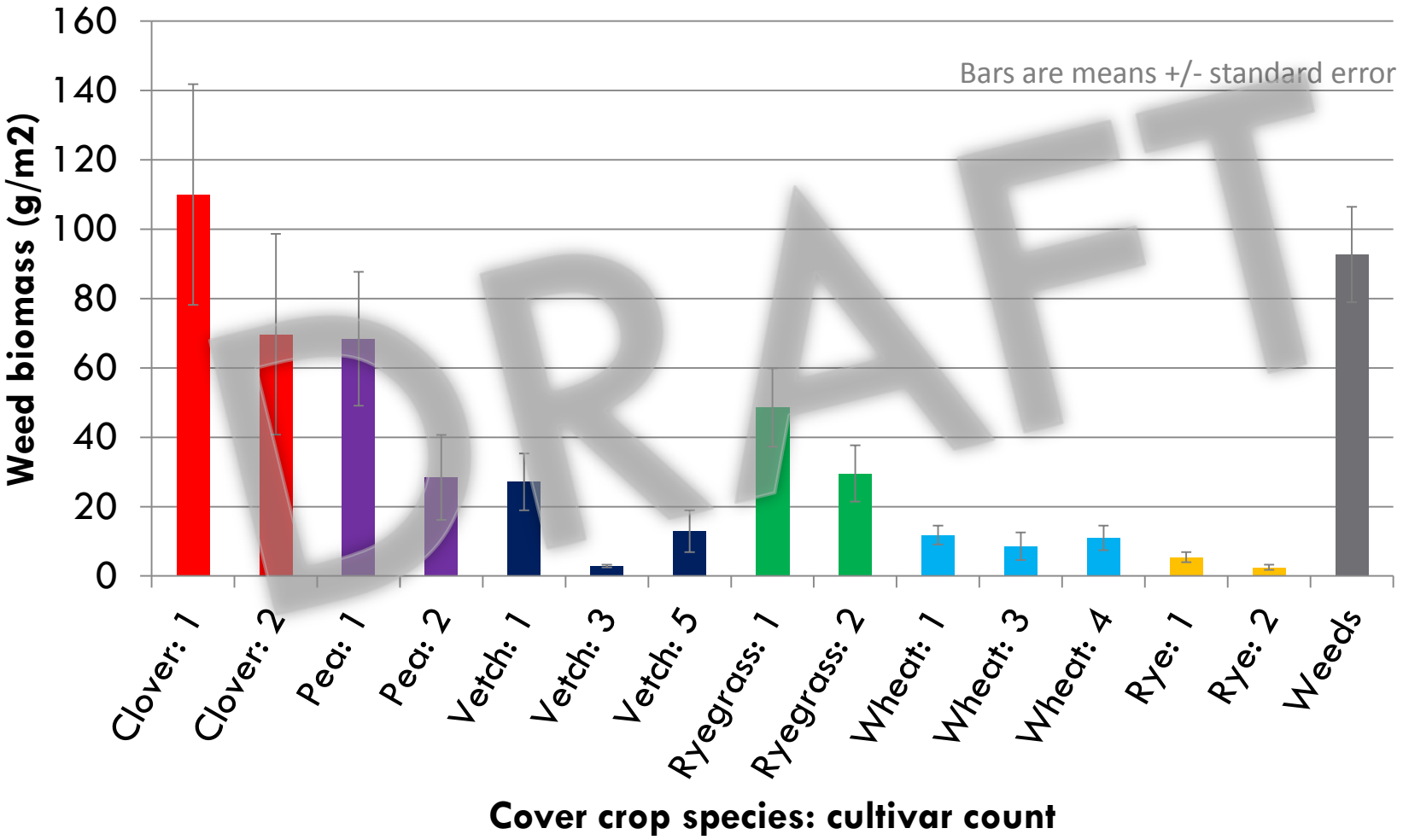
Biomass harvested

June

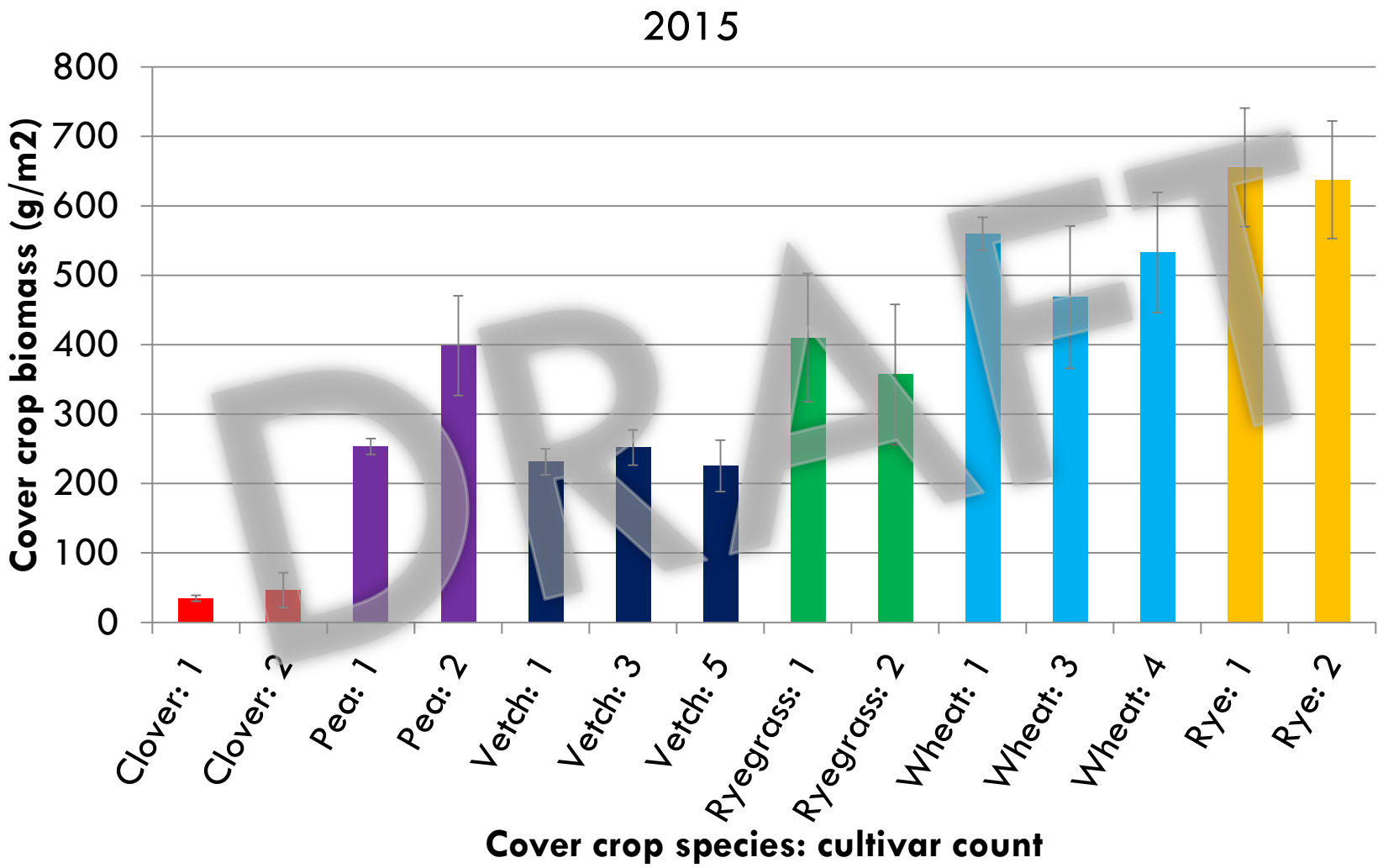
Measured:

- **Weed biomass**
- **Cover crop biomass**
- Nitrogen fixation
- Soil nitrogen

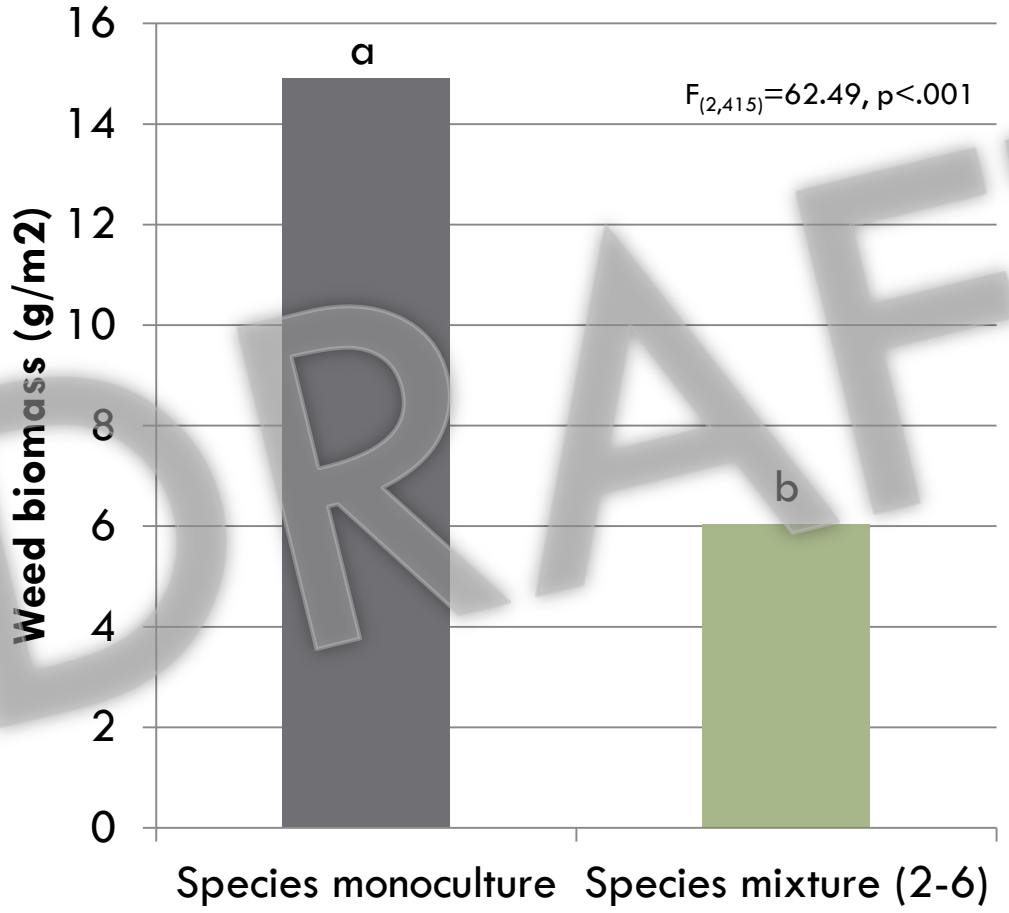
Weed biomass decreases with more cultivars of one species mixed together *(2014, 2015)*



Cover crop biomass responds variably with increasing number of cultivars



Significantly less weed biomass with more than 1 species



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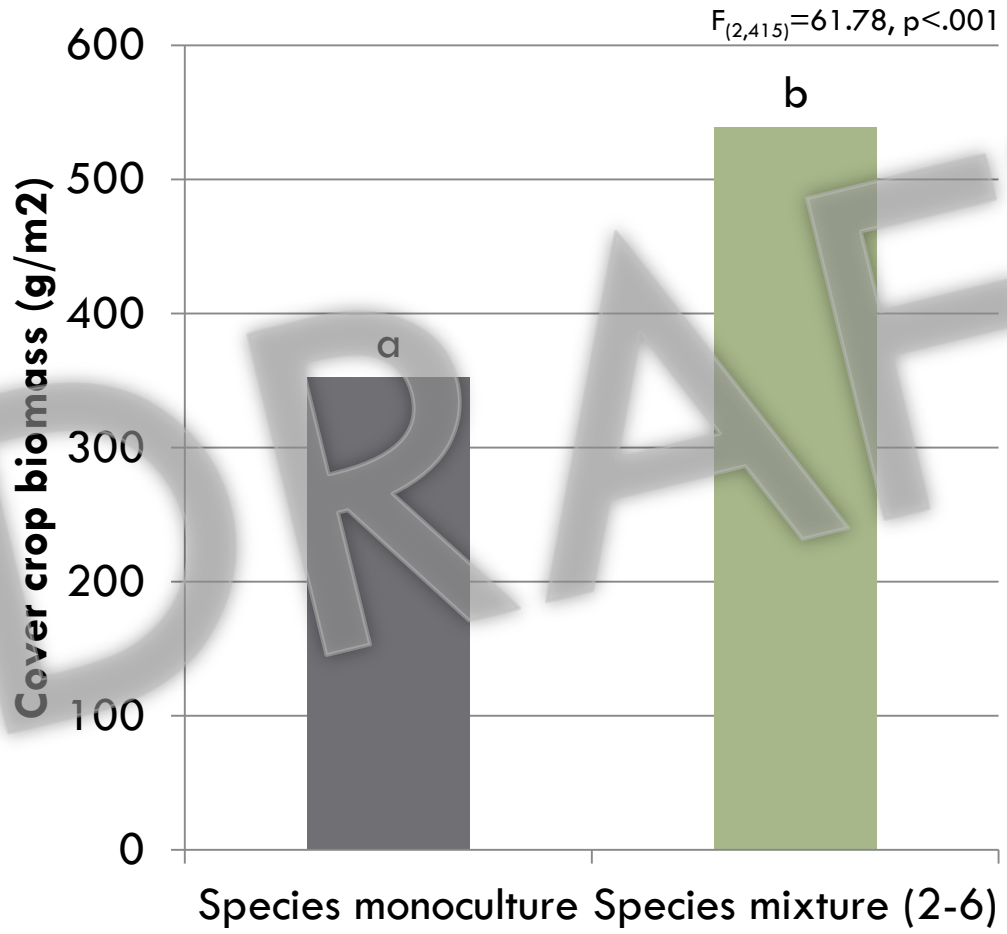

Takeaways

- Plants are the engine of the soil system
- Microbes work with plants to make the necessary nutrients available to plants
- Keep the soil covered and working!
- Diversify your organic matter inputs with rotations and cover crop mixtures
- Balance legume/grass mixtures for the soil conditions
- Incorporate diversity at all levels in cover crop mixtures
  - Species
  - Cultivars

Thanks!

Please contact me at err76@cornell.edu

And come find me at lunch with any other questions!

With support from:

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