Soils in Restoration: Applying knowledge to practice

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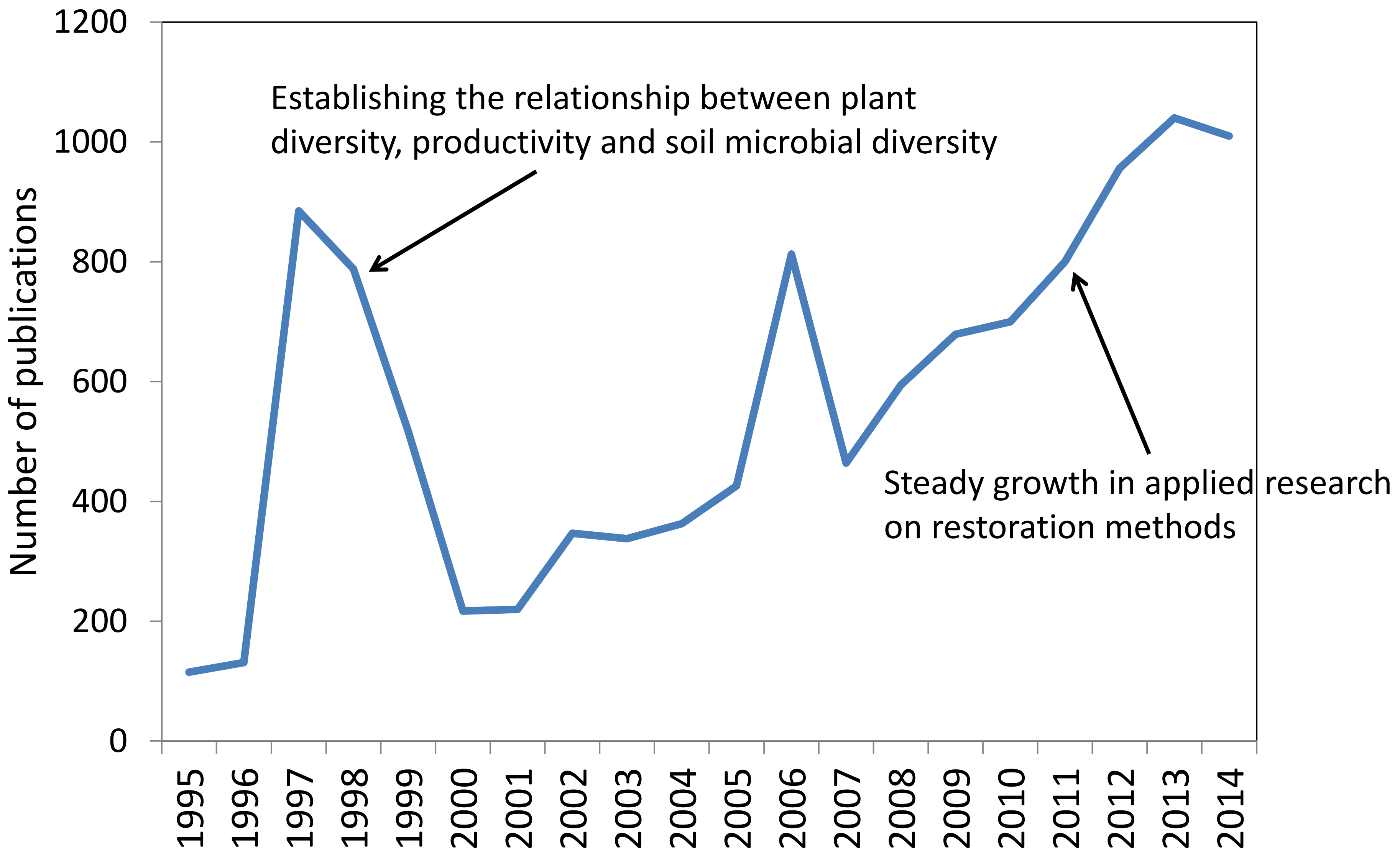
Soils in Restoration

- Much of our knowledge about plant-soil dynamics comes from production systems – agriculture and forests
- Soil ecology has advanced over past 30-40 years to include non-production systems
- Researchers and managers are adapting and applying knowledge of soil structure, chemistry, composition and functioning to restoration prescriptions

Research Progression

- **1980’s**: Effects of forestry & agricultural practices, fire and natural disturbance regimes on soil structure, chemistry, biology
- **1990’s**: Role of soil microbial communities in ecosystem functioning and plant community dynamics; Specificity of mycorrhizal symbioses
- **2000’s**: Plant-soil feedbacks; carbon transfer mechanisms; defining soil functional groups and identifying species

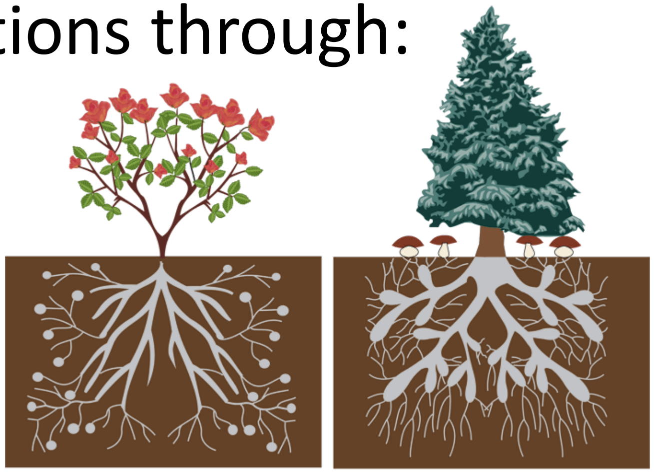
Research on plant-microbe interactions



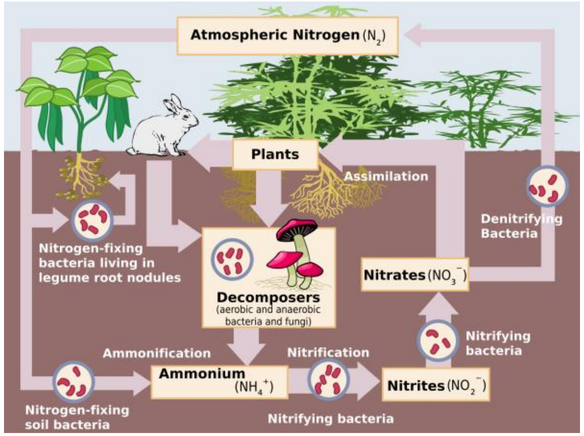
Google Scholar search terms: microbial, inoculation, restoration

Top-down or bottom-up controls?

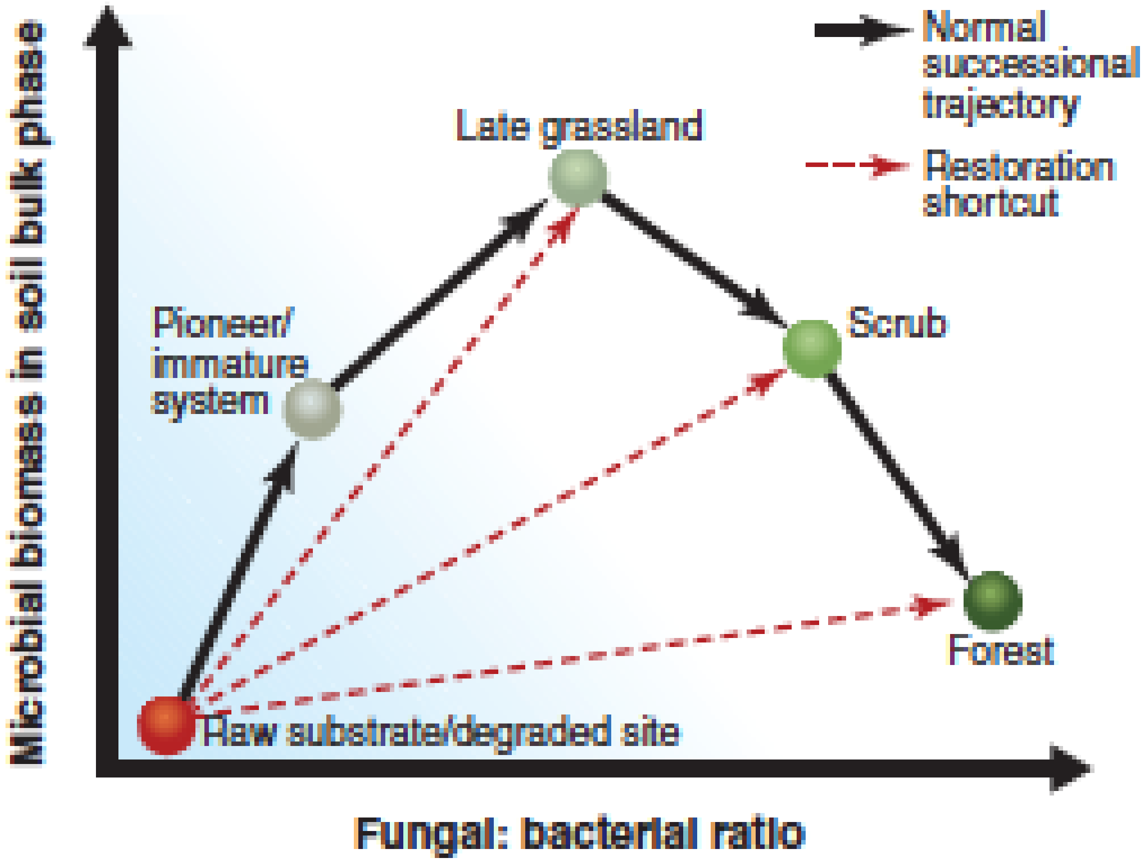
- Plant communities significantly alter microbial community composition and functions through:
  - Rooting patterns
  - Root exudates
  - Water use
  - Litter chemistry
  - Canopy structure



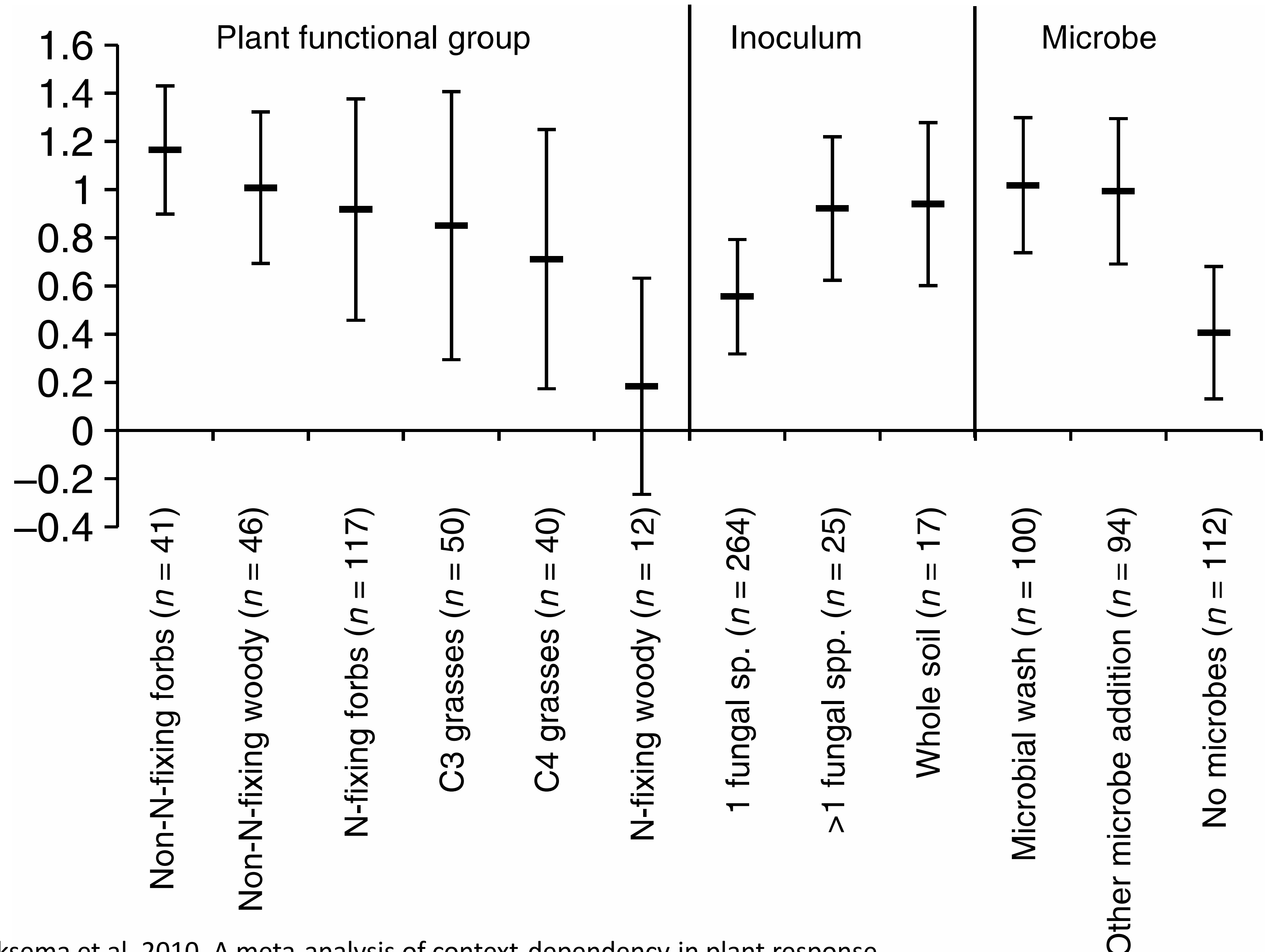
- Soil microbial communities regulate plant community dynamics through:
  - Mediation of nutrient cycling
  - Decomposition of organic materials
  - Mycorrhizal associations
  - Soil aggregation



Chicken or the egg? Or rather….
Plant or the microbe?

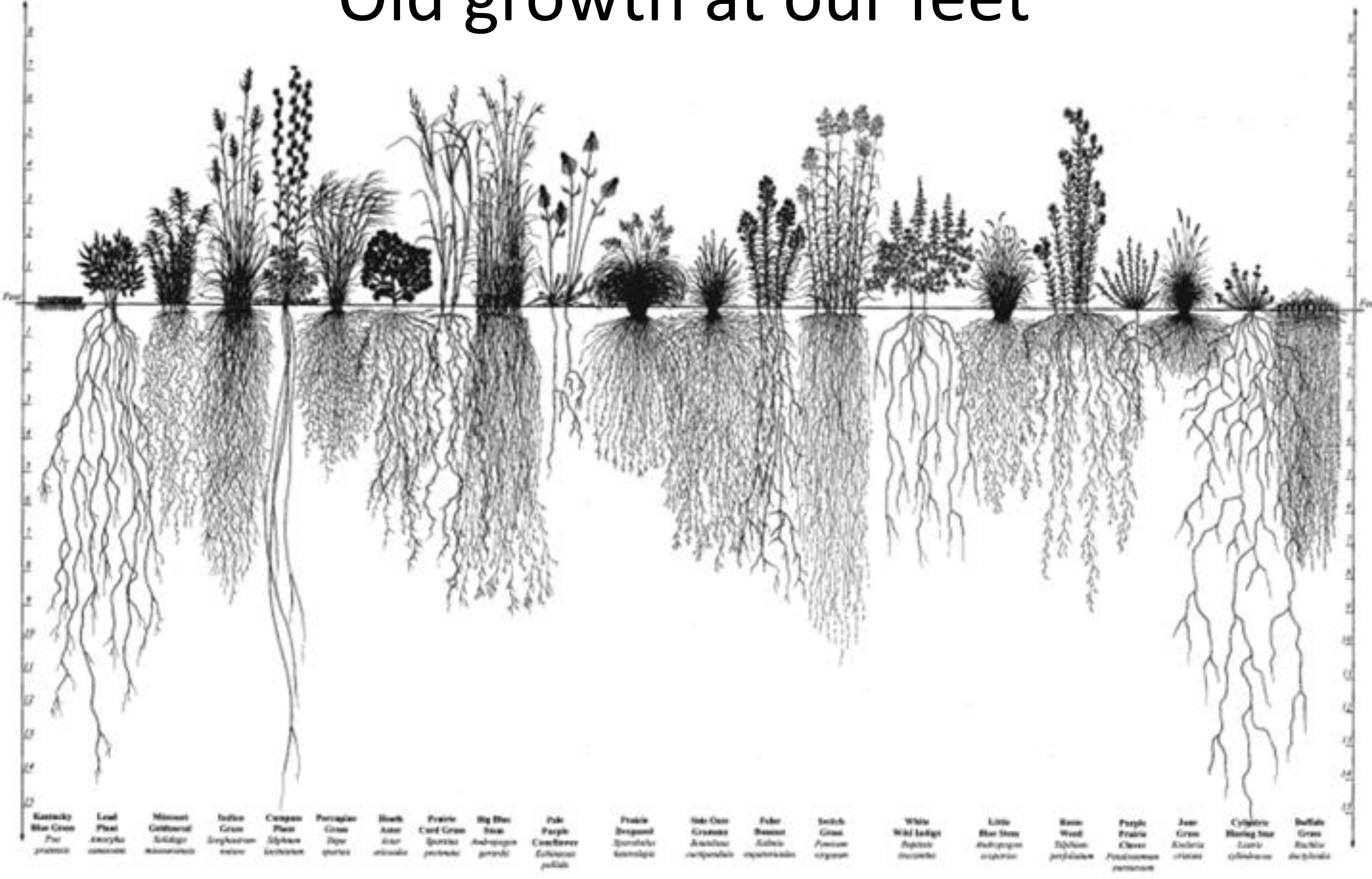


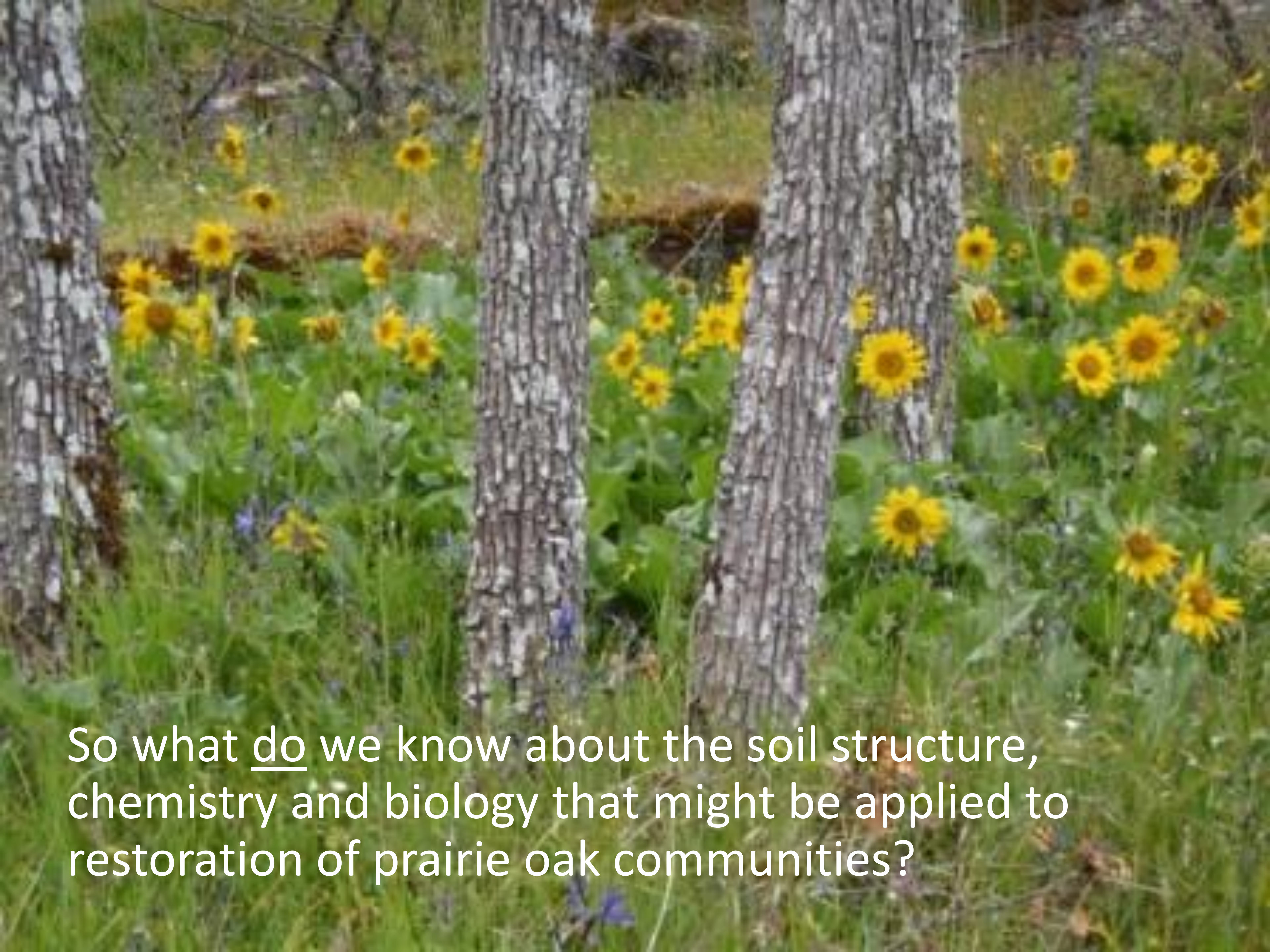
Harris (2009) Soil microbial communities and restoration ecology: facilitators or followers? Science 325: 573-574.



Hoeksema et al. 2010. A meta-analysis of context-dependency in plant response to inoculation with mycorrhizal fungi. Ecology Letters 13:394-407.

“Old growth at our feet”





So what do we know about the soil structure, chemistry and biology that might be applied to restoration of prairie oak communities?

Arbuscular mycorrhizal fungi

- 200-300 described species worldwide, but we've only identified <10% (Öpik et al. 2010)
- High site-specificity (Kivlin and Hawkes 2011)
- < 50 species found locally (Öpik et al. 2010)
- >75% of all plant species host mycorrhizal fungi (Smith and Read 1997)
- Generalists with ability to colonize but specialist in relative preference for and performance with different host species (Bever et al. 2001)

Photo: Yoshihiro Kobae

Specificity and dispersal ecologies

- "Specificity phenomena must be integrated into future efforts to develop mycorrhizal inoculation strategies. How will dispersal ecologies of mycorrhizal fungi and other important rhizosphere organisms...affect future community transitions?"

- "Specificity phenomena in mycorrhizal associations will also play an important role in determining plant species migration during periods of rapid global climate change....As plant species migrate the overlap in shared mutualist and plant ranges will determine the ease of plant community transition (Perry et al., 1990)
- For example in regions with sharp ecotones between EM and VAM dominated ecosystems (e.g. forests-grasslands), EM hosts may have difficulty migrating into VAM ecosystems and vice versa....in broadly contiguous mountainous regions dominated by diverse EM tree species, considerable overlap in compatible root mutualists may facilitate migration across mountain ranges or altitudes for EM hosts.
- We must also consider narrow specificities that have evolved for many EM associations of pioneering plants such as Douglas fir. How will the migration of these narrow-host-ranging mycobionts affect the successful migration of their specific hosts.

Molina, R., H.Massicotte, J.Trappe, M.F Allen, 1992.