**“Plant-microbial symbioses are an important factor to consider when assessing patterns expected from eco-evolutionary optimality theory”**

**Abstract**

In this perspective, we (1) review evidence for patterns expected from photosynthetic least-cost theory across eco-evolutionary optimality theory across environmental gradients, (2) explore the potential role of plant-microbial symbioses in modifying patterns expected from theory, and (3) propose experiments and additional work needed to elucidate the role of plant-fungal symbioses on patterns expected from the theory.

**Outline for rest of paper**

1. **Brief review on patterns and mechanisms expected from eco-evolutionary optimality theory across environmental gradients**
2. **Explore the role of plant-microbial symbioses in modifying patterns expected from theory**
   1. Plants allocate carbon belowground in exchange for mineral nutrients
      1. Mined by AMF
      2. Converted from SOM through extracellular enzymes by EcMF
      3. Converted from atmospheric N2 by symbiotic nitrogen-fixing bacteria
   2. Eco-evolutionary optimality theory indicates that plants should optimize plant nutrient uptake efficiency and allocation
3. **Propose experiments and additional work needed to elucidate role of plant-microbial symbioses on patterns expected from theory**

* Plant communities regulate ecosystem biogeochemical cycles.
  + Processes
* Plant communities play an important role in regulating ecosystem biogeochemical cycles
* Plants rely on multiple mutualisms that can affect performance and fitness
  + Growth and reproduction are controlled by soil nutrient availability and exchange with microbial symbioses
  + Microbial mutualisms protect plants from other fungal pathogens by reducing available space in rooting systems for pathogens to occupy
* Maintaining a mutualism requires plants to allocate carbon belowground, implying a maintenance cost of mutualism
  + Plants allocate recently synthesized carbon from photosynthesis belowground in exchange for nutrients mined by mycorrhizal fungi
* Global change reorganizes mutualism function (Smith 2009)
  + Decreased nutrient provisioning by mycorrhizal fungi (Johnson et al 2009)
  + Changing abundance of one or both mutualists (Hale et al. 2011)
  + Changing richness/diversity/evenness of mutualists (Roche et al. 2021)
* Global change affects plant functioning, most often indicated first through a change in physiological processes that scales up to influence fitness, composition, evolution (Smith 2009; Avolio et al 2021)
  + Plant physiology links belowground resource exchange to changes in plant population and community dynamics
* Testable theory provides possible mechanism that drives plant physiological responses to altered resources, including those due to changes in nutrient provisioning associated with microbial mutualism disruption
  + Plants acclimate to environmental change to maximize light interception at minimized summed costs of nutrient and water use
  + Increased costs of acquiring nutrients (e.g., due to decreased nutrient provisioning by mycorrhizal fungi, etc.) should allow similar net photosynthesis rates to be achieved with decreased water use efficiency and increased nutrient use efficiency