“Towards the role of plant-microbial symbiosis on patterns expected from photosynthetic least-cost theory”

**Abstract**

Photosynthesis represents the largest carbon flux between the atmosphere and biosphere and is a process that links terrestrial carbon, water, and nutrient cycles. Photosynthetic least-cost theory provides a framework for understanding variability in photosynthetic processes across environments, positing that variance in leaf photosynthetic capacity across environmental gradients is the product of (1) climate-driven demand to build and maintain photosynthetic enzymes and (2) modifications in the ratio of intercellular CO2 to atmospheric CO2 that result from changes in the cost of acquiring nutrients relative to water. Recent work has shown strong empirical support for theoretical expectations across environmental gradients and manipulative experiments; however, results from such studies largely ignore impacts of plant-microbial symbioses on patterns expected from the theory. Plants rely on symbioses with soil microbial communities such as arbuscular mycorrhizal or ectomycorrhizal fungi for nutrient acquisition, water uptake, and pathogen defense. Plant-microbial symbioses are typically maintained on the basis of nutrient exchange, where plants allocate carbon derived from photosynthesis belowground in exchange for nutrients mined by microbial symbionts. The relationship between belowground carbon allocation and nutrient acquisition, or the carbon cost for acquiring nitrogen, varies in species that form associations with different microbial symbionts, indicating that plant-microbial symbioses may be an important factor to consider when evaluating patterns expected from theory. Here, we review evidence for patterns expected from photosynthetic least-cost theory across environmental gradients, synthesize a conceptual framework for understanding the role of plant-microbial symbioses on photosynthetic least-cost expectations, and use this framework to propose experiments that will help elucidate the role of plant-microbial symbioses on patterns expected from the theory.

**Crude Outline**

1. Field and experimental evidence for patterns and mechanisms expected from photosynthetic least-cost theory
   1. Overview of theory
   2. Field evidence
   3. Experimental evidence
   4. Applications of the theory