**Leaky moss: bryophyte-mediated nutrient cycling and community responses**

Keywords: *nutrient cycling, bryophytes, carbon, nitrogen, biogeochemistry, facilitation*

Plant-soil feedbacks have profound effects on community development and ecosystem processes. Our understanding of these feedbacks is overwhelmingly biased towards vascular plants due to their large biomass, productivity, and sheer diversity in most systems. However, non-vascular plants (bryophytes) affect communities and ecosystems in qualitatively and quantitatively different ways than vascular plants. Bryophytes may punch far above their biomass acting as critical “nutrient catchment systems” in ecosystems. This is due to their exceptional absorptive capacity which allows them to accumulate nutrients from: precipitation, canopy throughfall, cyanobacterial associations, and leaf litter decomposition1. Further, as opposed to vascular plants, bryophytes undergo dehydration and rehydration cycles during which their cells become “leaky” and release potentially large amounts of cellular nutrients (amino acids, carbohydrates, and ionic compounds) which become immediately available to microbes and vascular plants2,3,4. The ecological implications of **dynamic pulse nutrient releases** from many bryophyte species are substantial, making them potentially important mediators of community and ecosystem-level processes, including nitrogen and carbon cycling1. Bryophytes also mitigate hydrology and soil stability, and facilitate soil microbes, fungi, microarthropods, and cyanobacteria all of which positively affect ecosystem functioning2,5. To date, bryophyte effects have mostly been studied in boreal systems. For instance, two species of bryophytes, both hosts for cyanobacteria, have been found to contribute up to 2 kg of nitrogen ha-1yr-1 6 . Upon rehydration, these same species release organic carbon compounds in pulses of up to 1544 mgm-1 which can then be directly assimilated by ectomycorrhizae3,7. In contrast to boreal systems, bryophyte effects in other systems with more complex vascular communities are poorly understood. For instance, to my knowledge, the effects of bryophyte rehydration-mediated release of exudates on vascular plant and microbial communities have not been investigated. The ecological implications of dynamic pulse nutrient releases from bryophytes are substantial, making them **potentially important mediators of community and ecosystem-level processes**. I will address these ideas by resolving three complementary questions: **1)** What is released from bryophytes during rehydrating pulses? **2)** How do bryophyte leachates affect vascular plants and microbes? **3)** How do these interactions contribute to ecosystem wide nutrient cycling?

**Study System & Design:** Six sites along Idaho’s Hwy 12 spanning a hydrological gradient from east (wet) to west (dry) have been established and necessary permits obtained. I am currently cultivating the four dominant forest-floor bryophytes from each site in the University of Montana research greenhouses for rehydration leachate extractions and to assess the effects of rehydration leachates on four vascular species that co-occur with the bryophytes.

**Research Plan:** I will compare the carbon and nitrogen content of leachates pre- and post- rehydration (see Previous Research) with a TOC-TN analyzer on both a per mass and area basis. Once I know what is being released, I will examine the effects of bryophyte leachate on vascular plants and soil microbes. A fully factorial 2×2×4 block design comprised of two substrates (sterile and native soil), two watering regimes (no leachate or leachate), and four vascular species (graminoid, non nitrogen-fixing shrub, nitrogen-fixing shrub, and tree) as the treatment factors will determine the effects of leachate (from combined bryophyte species) on plant growth, plant interactions, microbial growth, and microbial-plant interactions. Microbial biomass will be estimated using the phospholipid-PO4 content of the soil8. Common garden results integrated with *in situ* investigations will identify whether or not exudates are **affecting community and ecosystem processes** and will provide a measure of the effect of these interactions in a natural setting. Field removal experiments, maintained for three years, will have fully randomized 2×4 block designs with sites as the block factor and bryophytes (with or without) and vascular plants (same four species as used in the common garden trial) as the treatment factors. Response variables will include measures of both vascular plant and microbial biomass. I predict that the greatest microbial biomass will be found in the presence of bryophyte leachates, demonstrating the importance of these interactions on ecosystem nutrient cycling2. Finally, to assess the potential effects of bryophyte rehydration leachates on nutrient cycling at the ecosystem level, I will establish transects and quadrats across the six field sites to estimate bryophyte frequency and percent cover. These estimates will allow me to scale up the amounts of carbon and nitrogen released by bryophytes during rehydration events to an ecosystem (km2) scale.

The loss of cellular solutes is expected to be difficult to quantify because of: 1) rapid consumption of the compounds by both autotrophic and heterotrophic microbes underground, 2) challenges involved in collecting enough leachate for replication, and 3) the difficulty of isolating bryophyte exudates exclusively. These challenges are confounded by the likelihood of microbial symbionts on the leaf surface and cyanobacteria which, forming an intricately connected community, are challenging to separate the effects of without altering natural conditions. I propose that the best path towards these answers lies in beginning our investigations by looking at the moss-microbial-cyanobacterial component as a whole and quantifying the entire contribution following rehydration events. Future research, in collaboration with Dr. John McCutcheon at UM, will remove one or the other component species to determine individual contributions, further illuminating the complexity of this system.

This research will be strengthened by the expertise of my mentors: community ecology (Ragan Callaway; primary advisor), plant physiology (Anna Sala), biogeochemistry (Cory Cleveland), and restoration ecology (Cara Nelson). Whereas vascular plant contributions to ecosystem processes have been thoroughly investigated, an understanding of similar contributions of bryophytes is surprisingly limited, suggesting that there is great value in intensifying efforts to identify the composition, interactions, and contributions of bryophytes to ecosystems. Quantifying and identifying the nutrients released from bryophytes will assist in our understanding of the **fate of these nutrients and their role in interspecific interactions**.

**Broader Impact:** My findings are relevant to restoration practices including revegetation and preservation within a multitude of habitats, and will be disseminated via peer-reviewed journals as well as through collaborations both within academia and management agencies. I am **actively teaching and pursuing environmental education opportunities** within and outside of the academic community beginning with the Montana Native Plant Society and the Montana Natural History Center, through which I will disseminate my results by way of field forays and evening lectures. I have been actively **recruiting and mentoring** a number of undergraduate students in related research projects, and I am developing an undergraduate research project related to my dissertation for the IM-SURE program at the University of Montana. This NSF-REU funded project will expand the scope of our study to include applications for grassland management and the mitigation of plant invasions in the Western United States.

**References:** 1 **Cornelissen** J et al. (2007) Annals of Botany 99: 987-1001. 2**Bach** L et al. (2009) Plant and Soil 318: 1-2. 3 **Carleton** T **& Read** D (1991) Can. J. Bot. 69: 778-785. 4**Coxson**, D (1991) Can. J. Bot. 69: 2122-2129.

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