Species interactions in heterogeneous landscapes: how do functional traits, intra-specific trait variation, and plant-microbe interactions shape community assembly?

Abstract

How do interactions between organisms and their environment influence the dynamics of ecological communities? Ecologists have long understood that species performance can be impacted by both their response to the abiotic variation and by their interactions with other organisms. In my dissertation I aim to experimentally investigate how species coexistence is impacted by plant resource use strategies (as summarized by functional traits) and species-specific interactions with soil microorganisms in an annual plant community in coastal California. A longstanding assumption has been that the coexistence of species with dissimilar functional traits is stabilized due to their distinct responses to environmental heterogeneity (Adler et al. 2013). For Chapter 1 I plan to test this assumption using recent advances in coexistence theory that decompose the outcome of species interactions in patchy landscapes into coexistence-promoting stabilizing niche differences and fitness differences that drive competitive exclusion (Chesson 2000). Specifically, I propose to test whether functional trait differences are predictive of the similarity in the functional responses of species to environmental gradients. Another striking observation from nature is that individuals within a species can have vastly different phenotypes. Despite considerable interest, the consequences of this variation on species coexistence remain largely unclear (Violle et al. 2012, Turcotte and Levine 2016). For Chapter 2, I aim to investigate how intra-specific variation in functional traits might influence community dynamics beginning from understanding of how trait differences influence species coexistence generally. Over the past two decades, a great deal of research has also highlighted the role of soil microorganisms in shaping terrestrial plant communities (Bever et al. 2015). A key insight to emerge from this line of inquiry is that plant species coexistence can be promoted when plants cultivate a soil microbial community that has more negative impacts on plants of the same species than on plants of other species, which is in agreement with traditional coexistence theory (Chesson 2000, Bever 2003). Although these biotic interactions influence plant community dynamcics in nature in conjunction with abiotic factors, their effects are generally considered independently of one another (van der Putten et al. 2016). For Chapter 3, I aim to demonstrate how the relative contributions of plant-plant competition and plant-microbe interactions can be jointly considered under the established coexistence framework of Chesson and Kuang (2008) via a critical review of existing plant-soil feedback literature. This thesis will involve novel applications of recent advances in theoretical ecology to plant community and itegrate the historically disjunct fields of plant competition and plant-microbe interactions.

References

Adler, P. B., A. Fajardo, A. R. Kleinhesselink, and N. J. B. Kraft. 2013. Trait-based tests of coexistence mechanisms. Ecology Letters 16:1294–1306.
Bever, J. D. 2003. Soil community feedback and the coexistence of competitors: Conceptual frameworks and empirical tests. New Phytologist 157:465–473.
Bever, J. D., S. A. Mangan, and H. M. Alexander. 2015. Maintenance of plant species diversity by pathogens. Annual Review of Ecology, Evolution, and Systematics 46:305–325.
Chesson, P. 2000. Mechanisms of maintenance of species diversity. Annual Review of Ecology and Systematics 31:343–366.
Chesson, P., and J. J. Kuang. 2008. The interaction between predation and competition. Nature 456:235–238.
Turcotte, M. M., and J. M. Levine. 2016. Phenotypic plasticity and species coexistence. Trends in Ecology & Evolution 31:803–813.
van der Putten, W. H., M. A. Bradford, E. P. Brinkman, T. F. J. van de Voorde, and G. F. Veen. 2016. Where, when and how plant-soil feedback matters in a changing world. Functional Ecology 30:1109–1121.
Violle, C., B. J. Enquist, B. J. McGill, L. Jiang, C. H. Albert, C. Hulshof, V. Jung, and J. Messier. 2012. The return of the variance: Intraspecific variability in community ecology. Trends in Ecology & Evolution 27:244–252.