

Intraspecific Variation and Community Assembly along Latitude and Elevation Gradients

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Introduction: The term community assembly refers to the set of all processes that shape the composition and abundance of co-occurring species. Among the most important niche-based processes that have been hypothesized to determine the assembly of species within a community are (i) habitat filtering, in which species converge in ecological strategy, primarily due to limitations imposed by the abiotic environment, and (ii) niche differentiation, in which coexisting species diverge in strategy due to interspecific competition.¹

In plants, the contributions of these effects have been tested largely through functional trait-based approaches. These involve measuring phenotypic characteristics of plants which reflect their economies and the strategies they adopt with respect to the trade-offs they face. For example, one commonly used functional trait is specific leaf area (SLA), the ratio of leaf area to dry mass. Plants whose leaves contain more dry mass per unit area tend to have long-lasting leaves that cannot capture as much light as less dense leaves requiring the same resources.²

In trait-based studies of community assembly, it is common for researchers to average traits for conspecific samples to yield a species mean trait value.¹ Statistical analyses are then conducted on interspecific variation in mean trait values. However, this approach ignores the role that intraspecific variation, created by genetic variation or phenotypic plasticity, plays in niche-based community assembly. For example, a species whose mean trait value would be filtered out or competitively excluded from a community may persist if some individuals of that species have traits that are not filtered or excluded.³ In short, it may be more useful to consider community assembly as a process acting on individuals, not on species.

Prior research in a temperate flood meadow determined that quantifying intraspecific variation allows us to better determine the effects of habitat filtering and niche differentiation on functional traits along a flooding gradient.³ Because elevation affects functional traits and the ratio of intraspecific to interspecific variation,^{4,5,6} an elevational gradient seemed like an ideal system to test hypotheses about whether accounting for intraspecific variation allows better detection of niche-based assembly on a larger scale.

I propose to determine the proportion of total trait variation accounted for by intraspecific variation along an elevational gradient in tropical or temperate forests. Furthermore, I will examine whether, in each ecosystem, it allows us to better determine when niche-based assembly processes are occurring.

Hypothesis 1: *The ratio of intraspecific to interspecific trait variability across an elevational gradient will be greater in temperate forests than in tropical forests.* Tropical forests typically have much greater biodiversity than temperate forests.⁷ They also exhibit higher beta-diversity, or species turnover with distance, than temperate forests,⁸ and their species may be more specialized, showing less intraspecific trait variation. As a result, I expect that intraspecific trait variability will comprise a smaller proportion of total trait variation in tropical forests than in temperate forests. According to this prediction, more of the trait differences along gradients in tropics will be due to species turnover than intraspecific variation.

Hypothesis 2: *Intraspecific trait variation will have a greater effect on our ability to detect habitat filtering and niche differentiation across an elevational gradient in sites where intraspecific variation comprises a greater portion of total trait variation.* Jung et al. found that including intraspecific variation improves detection of habitat filtering and niche differentiation in a community where more than a third of trait variation was intraspecific.³ But if intraspecific variability accounts for a smaller component of total variation between communities, I expect

species turnover will be more useful as a proxy for total variation. In this case, accounting for intraspecific variability may not improve detection of niche-based assembly processes.

Methods: This study will take place in two sites: [Redacted] in [a mountainous temperate site], and [redacted] in [a mountainous tropical site]. In each site, I will set up several 25 m x 25 m plots at sites 100 m apart in elevation. In each plot, I will sample leaves from one or several individuals of each broadleaf tree species present. For each sample, I will measure SLA and leaf nitrogen, traits that reflect the “leaf economics” spectrum.

The average trait values of all samples from a single species inside a single plot will be considered the population mean trait value for that species. Because these population means may differ for a single species from plot to plot along the gradient, they will be used for analyses of intraspecific variability. The average of the population means of a species for all plots in which a species is found will be the species mean trait value.

To determine the contribution of intraspecific variability to a trait, I will calculate the percent reduction in the slope of the trait-gradient relationship when species mean traits are used in place of population mean traits.⁹ We may also use T-statistics, which were developed to quantify the contributions of interspecific and intraspecific trait variation at different levels.¹⁰

To test the ability to detect habitat filtering and niche differentiation, we will first construct null models, random with respect to both interspecific and intraspecific variability.³ Habitat filtering will likely shift the mean or variance of trait values within a plot compared to the null model.¹ Niche differentiation will be reflected by a lowered coefficient of variation of nearest neighbor distances between trait values of species within a plot (i.e. traits are more evenly spaced).¹ We expect that the signature of both these processes will be clearer when population means are used as trait values within a plot rather than species means, especially in environments where intraspecific variability comprises a larger portion of total trait variation.

Broader Impacts: Many plant species exhibit great trait variability along environmental gradients. Understanding the effect of this variability on fundamental mechanisms of community assembly could help us better predict the response of vegetation to environmental changes, such as global climate change. High levels of intraspecific variation may contribute strongly to the coexistence of competing species,¹¹ and understanding the effect of this variation on community assembly could help solve decades-old problems about the maintenance of biodiversity.

To disseminate my findings to the scientific community, I plan to use means such as publishing in peer-reviewed journals and presenting at conferences such as the Ecological Society of America meeting. I will make functional trait measurements and other data freely available through global trait database TRY.¹² As for public outreach, I plan to continue doing scientific outreach in public schools, and I hope to incorporate social media, such as blogging or online video, in disseminating scientific information to the public.

As a participant in organizations promoting multiculturalism at Michigan State, I am aware of the myriad benefits that diversity holds, and that as a discipline, ecology is sorely lacking in it. I will make a special effort to involve people from a variety of backgrounds, including underserved groups, in all aspects of my research, from fieldwork to analysis.

1. N. J. B. Kraft, R. Valencia, D. D. Ackerly. *Science* 322, 580 (2008). 2. H. A. Mooney, E. L. Dunn. *Evolution* 24, 292 (1970). 3. V. Jung et al. *J. Ecology* 98, 1134 (2010). 4. Q. D. Read et al. *Funct. Ecol.* in press (2013) 5. N. G. Swenson, P. Anglada-Cordero, J. A. Barone. *Proc. Biol. Sci.* 278, 877 (2011). 6. C. M. Hulshof et al. *J. Veg. Sci.* 24, 921 (2013). 7. M. R. Willig, D. M. Kaufmann, R. D. Stevens. *Annu. Rev. Ecol. Syst.* 34, 273 (2003). 8. R. Condit et al. *Science* 295, 666 (2002). 9. W. K. Cornwell and D. D. Ackerly. *Ecol. Mono.* 79, 109 (2009). 10. C. Violle et al. *TREE* 27, 244 (2012). 11. J. S. Clark. *Science* 327, 1129 (2010). 12. J. Kattge et al. *Glob. Ch. Bio.* 17, 2905 (2011).