Statement of Research Interests

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Understanding the factors that structure ecological communities has fascinated me since my first research position as an undergraduate assisting on studies of primary succession on Mt. St. Helens. Over the years, this question of how communities are structured has developed into the central focus of my research and remains one of the major unanswered questions in ecology. I believe that the most successful and informative research comes from a multifaceted, collaborative approach and I plan to collaborate with faculty throughout the University of Denver, and maintain my collaborations with faculty at other academic institutions and government agencies to better understand the factors that determine community composition and structure. I will couple this collaborative approach with my toolbox of skills that combines observational and experimental studies, plant functional trait measurements, soil resource measurements, functional diversity analyses, community phylogenetic analyses and multivariate statistics to address environmental issues and to explore fundamental questions in ecology. Below I outline three prominent themes in my research on understanding the factors that structure plant communities.

<u>Trait-based community assembly.</u> Recently, trait-based approaches have been advocated as an avenue to explain the different processes that affect community assembly. My research combines observational and experimental work to further develop the field of trait-based ecology by integrating additional assembly processes into trait-based community assembly theory. To assess the role of these additional assembly processes I worked with Prof. Katharine N. Suding to examine functional diversity patterns in plant communities in alpine tundra of the Rocky Mountains. We explored trait patterns along a gradient that varied in productivity, nitrogen availability and soil moisture to explore whether functional diversity is low in abiotic stressful environments and increases in more benign environments as competition becomes more important, and if equalizing fitness processes and facilitation affect functional diversity (Spasojevic & Suding *in press*) [Reprint #1]. The patterns of functional diversity we found suggest at least three assembly processes along the gradient. Abiotic filtering by wind and cold exposure may reduce functional diversity in height and leaf area at the low resource end of the gradient. Also at low resource availability, increasing functional diversity in specific leaf area, stomatal conductance and chlorophyll content suggests competition for belowground resources. At the resource rich end of the gradient, increased functional diversity in height and leaf area suggests increased competition for light or facilitation. Our results suggest multiple contrasting processes act along gradients and to our knowledge, this is one of the first studies to explicitly incorporate additional assembly mechanisms besides abiotic filtering and competition into understanding trait-based community assembly.

In addition, as part of my dissertation I explored a more mechanistic understanding of functional diversity patterns using an experimental approach. We conducted a study where we isolated pairs of species in the field that vary in how similar they are in their traits, with some species pairs being very similar and some species being more dissimilar. Our preliminary results suggest that species that are more similar in their traits compete more; classic limiting similarity. I plan to expand this experiment along an environmental gradient to explore how the mechanisms of species coexistence shift with different environmental conditions. In addition to this experimental work, I am currently preparing a manuscript in collaboration with Jim Grace of USGS using structural equation modeling to explore functional diversity along multiple biotic and abiotic gradients. We are using Robert H. Whittaker's historical (1960) data from the Siskiyou Mountains of Oregon to explore how multiple factors directly and indirectly influence the assembly of plant communities. Lastly, I am analyzing the influence of multiple disturbances (fire, grazing and roads) on patterns of functional diversity across a soil fertility gradient in California grasslands to better understand how these disturbances interact with soil fertility to influence plant community structure.

Dispersal. Functional diversity is increasingly being used to understand patterns of community assembly yet analyses of functional diversity are rarely extended beyond local-scale processes, even though both regional and local scale processes likely structure communities. To assess the role of regional scale processes, as part of my dissertation, I examined functional diversity patterns in 17 sky islands of alpine tundra that varied in geographic isolation (dispersal inputs) to assess the role of dispersal, a regional process, in shaping alpine plant community structure (Spasojevic and Suding, *in preparation*). We found that sites with lower dispersal inputs were more similar in composition and that functional diversity among coexisting species was greatest at sites with lower dispersal inputs. These results suggest that competition plays a stronger role in sites with lower dispersal inputs, suggesting a combination of local and regional processes are important in structuring alpine "sky island" communities.

These above results sparked my interest in dispersal and lead me to my current postdoctoral position with Prof. Susan Harrison at the University of California –Davis, where much of my current research is focused on dispersal and climate change. As climate change is currently affecting many species around the world, the role of dispersal is becoming an important regional process that may affect species distributions at multiple scales. While many species can persist in-situ or adapt to climate change, many species are dispersing to more suitable habitats. However, many species that can neither persist nor adapt may lack suitable habitats to disperse to, or are unable to disperse far enough to cope with the changing climate. My research uses trait-based approaches, data synthesis, and experimental approaches to understand the forces shaping dispersal ability and to assess species' potential for assisted relocation. To assess how environmental conditions determine the composition of dispersal syndromes within a community I led the synthesis of data (in collaboration with Prof. Susan Harrison and Prof. Ellen I. Damschen) from three data sets consisting of over 450 species in grassland, chaparral and forest vegetation types. We analyzed differences in the composition of dispersal syndromes between communities that differed in soil fertility and habitat patchiness while also accounting for correlated functional traits (Spasojevic *et al. in review*) [Reprint #2]. Communities restricted to patchy habitats may contain more dispersal syndromes that facilitate successful seed dispersal to other patches. However, low-quality habitat (such as infertile soils) may constrain the availability and efficiency of dispersal syndromes found within those habitats. We found that within all three vegetation types, low fertility serpentine communities contained significantly greater proportions of wind-dispersed species and lower proportions of syndromes that facilitate successful seed dispersal to other patches, and that these patterns were related to functional traits. Our results suggest that on low-fertility soils, habitat quality may outweigh habitat patchiness as a filter on the availability of dispersal syndromes, potentially adding to the vulnerability of such communities to stochastic extinctions and global change, making these species good candidate for assisted relocation.

Plant species and communities confined to island-like exposures of serpentine soil presumably have extremely limited abilities to survive climatic warming through either latitudinal or elevational migration due to limited ability for directed dispersal to other patches of serpentine. Thus, they may be high-priority candidates for assisted relocation, a strategy for mitigating the loss of species under climate change by moving species to higher latitudes or elevations. Topography creates large differences in microclimate over short distances due to aspect effects and thus offers the potential for species to survive climate change through assisted short-distance movements within rugged landscapes. While it may seem obvious that assessments of the risks and benefits of assisted migration require an understanding of their relationships to geology, soils and biotic interactions, these dimension have been largely missing from the existing literature on assisted relocation. In collaboration with a soil scientist and a geologist, Prof. Susan Harrison and I are asking if cooler microhabitats can act as refugia for species threatened by climate change, or will differences in soil chemical and physical properties, or biotic interactions make these microhabitats unsuitable for the threatened species. Our preliminary results suggest that cooler microclimates can act as microrefugia, but biotic interactions play an important role in the survival of relocated species. We are continuing this experiment and plan to incorporate demographic modeling and a deeper understanding of plant-soil interactions into our experiment.

Plant-soil interactions. Plant-soil interactions are important to consider when studying the factors that structure plant communities. Much of my research has incorporated this theme by exploring factors along environmental gradients and comparing patterns on different soil types. In addition my research has also looked at some of the mechanisms of plant soil interactions in more detail; specifically how plant hemiparasites can influence community structure and nitrogen cycling via litter inputs (Spasojevic & Suding 2011). Hemiparasites are known to influence community structure and ecosystem functioning, but the underlying mechanisms are not well studied. Variation in the impacts of hemiparasites on diversity and production could be due to the difference in the relative strength of two interacting pathways: direct negative effects of parasitism and positive effects on nitrogen availability via litter. Strong effects of parasitism should result in substantial changes in diversity and declines in productivity. Conversely, strong litter effects should result in minor changes in diversity and increased productivity. We conducted field-based surveys to determine the association of *Castilleja occidentalis* with diversity and productivity in the alpine tundra. To examine litter effects, we compared the decomposition of *Castilleja* litter with litter of four other abundant plant species, and examined the decomposition of those four species when mixed with *Castilleja*. *Castilleja* was associated with minor changes in diversity but almost a two-fold increase in productivity and greater foliar N in co-occurring species. Our decomposition trials suggest litter effects are due to both the rapid N loss of *Castilleja* litter and the effects of mixing *Castilleja* litter with co-occurring species. *Castilleja* produces litter that accelerates decomposition in the alpine tundra, which could accelerate the slow N cycle and boost productivity. We speculate that these positive effects of litter outweigh the effects of parasitism in nutrient-poor systems with long-lived hemiparasites. Determining the relative importance of parasitism and litter effects of this functional group is crucial to understand the strong but variable roles hemiparasites play in affecting community structure and ecosystem processes.

Developing themes. In addition to these main themes in my research, I am actively developing new directions for my research. As part of a NCEAS distributed graduate seminar I led the analysis of data from the Konza Prairie LTER examining the hypothesis that "fire is a global herbivore" (Spasojevic *et al.* 2010). Using 22 years of data from a mesic, native tallgrass prairie with a long evolutionary history of fire and grazing, we tested if trait composition between grazed and burned grassland communities would converge, and if the degree of convergence depended on fire frequency. We found that grazing and burning once every four years showed the most convergence in traits, suggesting that these communities operate under similar deterministic assembly rules and that fire and herbivory are similar disturbances to grasslands at the trait-group level of organization. This work sparked my interest in the role of herbivores in structuring plant communities. While I was not able to integrate this into my dissertation I am actively working to include herbivory in my research. I am currently exploring how grazing influences trait patterns across different soil types and exploring how the reintroduction of Tule elk (*Cervus canadensis ssp. nannodes*) influences community structure and nutrient cycling in costal prairie in collaboration with Prof. J. Hall Cushman of Sonoma State University.

At the University of Denver, I will build upon my previous research to develop a better understanding of the ecological factors that structure plant communities with the bulk of my future work being conducted in the Rocky Mountains. I plan to build collaborations at the University of Denver to address new questions and to build upon my research. Additionally, I have an established relationship with several organizations in the Rocky Mountains including the Niwot Ridge Long Term Ecological Research station (situated at 10,000ft. near Nederland, CO), the CU-Boulder Mountain Research Station and the Institute for Arctic Antarctic and Alpine Research. I have represented the Niwot LTER at the Global Mountain Biodiversity Assessment in Switzerland (2009) and at the 20 year synthesis of the International Tundra Experiment (2010 – Present) (Elmendorf *et al. in revision*). I plan to use my established relationships and new relationships at the University of Denver to help develop my research program focusing on using trait-based approaches to understand how plant communities of the Rocky Mountains are influenced by environmental gradients, species interactions, dispersal, herbivory and soils.

References

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