Statement of Research Interests

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My research interests lie at the intersection of empirical and theoretical ecology: I confront ecological and evolutionary theory with empirical data using mathematical, statistical and computational methods. I'm particularly fascinated by the many ways species influence each other in tropical forests. My research to date addresses how interactions between species affect population dynamics - specifically, survival, growth, reproduction and dispersal. In the future I envision working on ecological problems across multiple scales, focusing on how individuals influence populations, community and ecosystem dynamics, and on methods to upscale detailed processes at the level of individuals into patterns at the population and community scale.

Topics

My research broadly encompasses:

- Disentangling the major demographic processes that structure communities.
- The evolution of reproductive strategies.
- Advancing computational, mathematical and statistical methodology for ecologists.

Below, I briefly describe past, current and future research in each of these areas.

On the major demographic processes that structure communities.

Despite the wealth of studies on tropical forest dynamics, one essential component has been missing: virtually nothing is known about the relative importance of the different demographic processes that shape tree populations. Yet quantitative assessment of the relative importance of different forces that collectively structure forests communities is fundamental in improving predictions of future change. I am currently actively working towards this goal. One strategy I employ is to quantify full life-cycle population models for as many trees species as possible. Population models can be used to integrate multiple long-term datasets, and such integration can provide insight into the relative importance of demographic process across all life-stages. Currently, I'm applying this approach to combined demographic datasets for tropical tree species on Barro Colorado Island (BCI) spanning 30 years, 50 hectares, and hundreds of thousands of individuals, from seeds to forest giants, including critical data on tree reproduction that I collected during my PhD.

One exciting result of my research on the BCI tree community is an unexpectedly strong effect of lianas infestation on tree populations - an effect that differs systematically and strongly among tree species (Visser et al. in prep). Specifically, I found that lianas strongly depress per capita population growth rates of trees, with highly differential effects across tree species. I therefore suspect that liana-tree interactions are far more important than previously thought, and may play a large role in tropical forest communities. I aim to further explore liana-tree interactions within a disease ecology framework in the future. From a disease ecological point of view the system itself is fascinating, with multiple parasite species infecting multiple host species, with highly variable lethality depending on host identify - as my preliminary work shows. With this system, I hope to answer fundamental questions regarding the extent to which host-parasite interactions between lianas and trees regulate tropical tree population dynamics, and the role of these host-parasite interactions in generating and maintaining host diversity. Addressing these questions is especially important given that lianas are strongly increasing in abundance across the Neotropics.

Within the context of how tropical communities are structured and tropical tree populations are stabilized (or not), I have also conducted empirical and theoretical work on species coexistence using a model system - the palm Attalea butyracea and its natural enemies. It is well known that specialized natural enemies can stabilize populations and contribute to coexistence if they act in a density-dependent manner. My work has shown that this simple process may be complicated by the activities of the enemies' enemies (Visser et al. 2011 Ecology Letters). I studied the tri-trophic interactions between the palm, its specialized seed predator beetle, and the (generalist) rodent predators of the beetle. Here, the potential of beetles to control the population density of the palm were negated by preferential predation of squirrels on beetle-infested seeds. In further research (Jansen et al. 2014 Ecology Letters), I helped quantify the effects of increasing competition for seed dispersers where the same palm species is locally abundant. Dispersal efficiency drastically decreased with increasing palm abundance, penalizing palm populations in high abundance. Currently, I am using demographic data on this palm species, collected during my PhD, to build density-dependent population models and test the interaction of multiple mechanisms, including the previously quantified dispersal competition and seed predation, in determining the equilibrium abundances of this palm species. In the future I aim to expand this model by examining the effects of vertebrate poaching on the equilibrium abundance of this palm species, using a dataset collected at a disturbed site during my PhD.

As I look ahead to future research topics, one question of particular interest is to quantify how important individual variation is towards population (and community) dynamics. For instance, do individuals in particularly favorable micro-habitats disproportionately contribute to population growth? And does this contribution differ systematically among species in relation to important life-history traits (e.g. the slow-fast continuum)?

On the evolution of reproductive strategies

Plant reproductive strategies take on a multitude of fascinating forms. What drives the evolution of large-scale mast events in Southeast Asia, where hundreds of tree species from dozens of families fruit synchronously after many years of vegetative growth? Why do dioecious plants (having distinct male and female individuals) exist, when hermaphrodism seemingly has such clear-cut demographic benefits? My research has focused on quantifying the costs of such strategies and testing whether hypothesized benefits can actually plausibly drive the evolution of plant reproductive strategies. By coupling long-term demographic datasets with population models, while supplementing these with novel field data, I have been able to show that a mast fruiting strategy swiftly confers a fitness advantage in the presence of heavy seed predation (Visser et al. 2011 Journal of Ecology). Using a similar approach I am currently looking to identify the mechanisms that allow dioecious species to co-exist with hermaphrodite species in a diverse tropical forest in Panama. In the future I hope to continue using population models in a game theoretical context, building on my previous work (Visser et al. 2011 Journal of Ecology), to evaluate the hypothesis that the current dominance of the Dipterocarpaceae is South-East Asia is a result of historical competitive exclusion through invasion of a mast-fruiting population into an annual fruiting community.

Advancing computational, mathematical and statistical methodology.

I am keenly interested in advancing methodological approaches in Ecology. I have focused on quantifying dispersal and improving computational literacy, and I aim to continue along these fronts in the future. Sessile organisms such as plants depend on propagule dispersal for movement and so dispersal sets the stage for future interactions, fitness, gene flow, and eventually local diversity. Dispersal is thus of fundamental importance but remains difficult to quantify, with a major challenge being the appropriate mathematical description of observed dispersal patterns. I helped develop a general framework for fitting anisotropic (directionally asymmetric) dispersal models (van Putten et al 2012 MEE). I further tested methods that increase the accuracy of estimating long-distance dispersal (Hirsch et al. 2012 MEE), models that I am applying to mosquito dispersal. Computationally intensive techniques are increasingly important in the practice of science, and efficient coding is important to the application of these techniques. In a previous review (Visser et al. 2015, PLoS Comput Biol) I showed that implementation of computer science techniques for writing efficient code can provide efficiency gains of orders of magnitude (10 to 14 000 fold). I advocate that the use of computationally intensive analyses in the biological sciences should not be constrained by programming practices. Therefore, I have further endeavored to increase the accessibility of high performance computing techniques to biologist by developing an R package (aprof; Visser 2013 CRAN) that helps to identify computational bottlenecks in R code and determine whether optimization can be effective. I am currently organizing workshops on high performance computing at various large ecological meetings. I intend to continue reaching out to the ecological community, as my current experimentation with novel computational techniques shows that we are only just scratching the surface of what is computationally feasible. In extension of this, I'm currently interested in developing automated tracking algorithms, for use in demographic and evolutionary analysis. These will use computer vision combined with statistical learning techniques to automatically count and track populations of Cladocera (water fleas), thereby enabling data collection at a scale beyond what is manually possible.