Statement of Research Interests

Marco D. Visser

I consider myself to be an ecologist at the intersection of empirical and theoretical ecology: I'm interested in confronting ecological and evolutionary theory with empirical data. This means I use mathematical, statistical and computational methods to explore ecological questions.

I believe that the essence of ecology is to understand intricate and interrelated systems, and therefore I'm fascinated by the many ways species influence each other in tropical forests. I've been specifically interested in how interactions between species affect population dynamics (survival, growth, reproduction and dispersal) and how these in turn shape community dynamics (as diversity). Recently, I have become interested in how population dynamics are mediated by the environment, as I believe species-environment interactions are a key-limiting factor affecting our ability to predict ecosystem responses.

Topics

My past research has broadly encompassed:

- The evolution of reproductive strategies.
- Development of methods for accurately quantifying dispersal.
- Testing theories of diversity maintenance.
- Disentangling the major demographic processes that structure tropical forests.
- Improving computational literacy in Biology.

Below, I shortly describe past, ongoing and future plans specific to each of the above points and areas of interest.

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 focussed 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.

On quantifying dispersal.

Sessile organism 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 have helped develop a general framework for fitting directional models that quantify the dispersal distributions (van Putten et al 2012 MEE). I have further tested methods that increase the accuracy of estimating long-distance dispersal (Hirsch et al. 2012 MEE), and am currently involved in the application the developed methods towards quantifying mosquito dispersal.

On diversity maintenance.

The extraordinarily high species richness of tropical forests continues to challenge ecologists to answer the elementary question - what mechanisms maintain this diversity? One established idea is that plant performance is diminished by specialist natural enemies - notably insects - which congregate wherever their preferred food source is high. My work has shown that this simple process may be complicated by the activities of the enemies' enemies (Visser et al. 2011 Ecology Letters). In a Panamanian forest, I studied the tri-trophic interactions between the royal palm, its predator beetle, and the rodent predators of the beetle. Here, the potential of beetles to control the population density of the palm were negated by preferential predation by 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.

On the major demographic processes that structure tropical forests.

Despite the wealth of knowledge studies have revealed on tropical forest dynamics, one essential component is missing in most of this work: virtually nothing is known about the relative importance of the different demographic processes that shape the populations of trees. I believe quantitative measures of the most influential 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 combining demographic datasets spanning 30 years, 50 hectares, and hundreds of thousands of individuals, from seeds to forest giants - incorporating a key missing dataset on tree reproduction that I collected during my PhD. One preliminary and exciting result is the unexpectedly strong effects of lianas infestation on tree populations, which may cause directional shifts in forest communities.

On computational literacy in Biology.

Learning how to program and efficiently use computational resources is not only convenient, computing has become fundamental to the practice of science. In biology, research is striving toward ever more accurate projections requiring high levels of detail as natural systems are variable and include intricate levels of biotic and abiotic interactions. I feel that with these challenges ahead, the use of computationally intensive analyses in the biological sciences should not be constrained by programming practices. In a previous review (Visser et al. 2015) I have shown that implementation of straightforward techniques from computing science, while learning to write efficient code can provide efficiency gains of orders of magnitude (10 to 14 000 fold). I have further endeavoured to increase the accessibility of high performance computing techniques towards biologist developing an R package (aprof; Visser 2013 CRAN) that helps to identify computational bottlenecks in R code and determine whether optimization can be effective. Currently, I am 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 scraping the surface of what is computationally feasible.