Statement of Research Interests

Marco D. Visser

Countless species inhabit our planet and interact in myriad ways with each other and the environment often giving rise to complex hierarchies and spatial arrangements, where many life-forms seemingly coexist. None more so than tropical forests, here myriads of dirverse species seem to be able to live within the same area, relying on the same resources without one single species dominating. My overarching research goal is understanding the processes underlying such biological patterns. I consider myself to be an ecologist at the intersection of emperical and theoretical world. Broadly defined, I am interested in confronting ecological and evolutionary theory with emperical data. To this end I use mathematical, statistical and computational methods to unite theory with data and explore ecological questions. I believe that the essence of ecology is to understand intricate and interrelated systems, and therefore I've remain fascinated by the many ways species influence each other in tropical forests. In past I've been specifically interested in how interactions between species affect population dynamics (survival, growth and reproduction) and how these inturn shape community dynamics (diversity). Recently, I have become more interested how species interactions are mediated by the enviroment, as I believe species-environment interactions are a key-limiting factor affecting our abilty to predict ecosystem responses.

Topics

In the past my research interest have broadly encompassed;

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

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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 facinating 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 distict 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 demorgaphic datasets with population models, while supplementing these with novel field data, I have been able to show that a mast fruiting strategy swiftly confer a fitness advantage in the presence of heavy seed predation. Using a similar approach I am currently looking to identify the mechanisms that allow diecious species to co-exist with hermaphrodism species in a diverse tropical forest in Panama.

On quantifying dispersal.

Sessile organims as plants depend on propagule dispersal for movemnet towards site suitable for recruitment or invastion into novel and as such dispersal sets the stage for competitor interactions, plant fitnesss, gene flow, and eventually local diversity. Dispersal is fundamental importance but unfortunately seed and pollen dispersal remains poorly understood, I believe mainly because they are difficult to quantify. A major challenge is the appropriate mathematical description of observed dispersal patterns. I have helped develop a general framework for fitting directional dispersal kernels (mathematical models that quantify the dispersal distributions). This method allows for far greater flexibility in dispersal modelling. I have further tested methods that increase the accuracy of estimating long-distance dispersal, the so-called tail of the dispersal kernel, which is known to be particularly important for modelling species invasions.

On diversity maintainance.

In the struggle for existence between organisms that compete for the same limiting resources, the expected outcome is that dominance will be attained by those species better adapted to the given conditions. Yet tropical rain forests are renowned for extraordinarily high species richness, this remarkable diversity continues to challenge ecologists to answer the basic question - what mechanisms maintain this diversity? An established mechanism for limiting the abundance of individual tree species involves natural enemies. The idea being that plant performance is diminished by specialist natural enemies - noteably insects - which congregate wherever their prefered food source is high. During my MSc research I have shown that this process is complicated by the activities of the enemies' enemies. I studied a tri-trophic interaction in a Panamanian rainforest, between the native royal palm, its predator beetle, and the rodent predators of the beetle. As predicted by theory, infestation of palm seeds by beetle larvae increased where seed concentration were high, but any strong density-dependent effects were negated by preferential predation by squirrels on beetle-infested seeds. Such top-down control of seed predators, shows that the potential of insects to control plant populations may be lower than previously assummed when they themselves can be controlled. In further research I quantified the effects of increasing competition for seed dispersers where the same palm species is locally abundant. Here, dispersal efficiency drastically decreased with increasing abundance of the palm conveiging a advantage for lower densities of palms. 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 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 I have shown that implementation of straightforward techniques from computing science, while learning to write efficient code can can provide efficiency gains of orders of magnitude (10 to 14 000 fold). I have further endeavored to increase the accesablity of high performance computing techniques towards biologist developing an R package (aprof) that helps to identify computational bottlenecks in R code and determine whether optimization can be effective. This work has shown me that it is therefore increasingly necessary for biologists to become versed in efficient programming, as well as in mathematics and statistics. I am currently giving workshops on high performance computing at various large ecological meetings, and om the future I hope to continue reaching out to the ecological cummunity with more novel compuational new techniques that show that we are only just scraping the surface of what is compuationally possible.

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. This fundamental knowledge would provide quantitative measures of the most influential forces that collectively structure forests communities will improve predictions of future change and aid better forest management. Any analysis that attempt this will require a full life-cycle focus, and as trees are long-lived organisms this also requires massive effort of data collection over decades. I am currently actively working towards this goal, I'm combining demographic datasets that spans 30 years, 50 hectares, and hundreds of thousands of individuals, from seeds to forest giants, with a key missing dataset on tree reproduction that I collected during my PhD. I aim to use population models to integrate these datasets, to qualify the relative importance of demographic process and life-stage for multiple tropical tree species. This full-life cycle approach has allowed me to recently quantify the effects of liana infestation on tree populations, this has lead to the quantification of unexpectedly strong effects of liana infestation on trees. Furthermore, the strength of the effect of infestation differed among species, indicating the lianas may play a much stronger role in structuring forest than previously thought.