Proposal - Ecosystem responses to escalating drivers: linking species interactions and resilience

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The intensity of human-driven global changes---climate change, land use, defaunation, nutrient enrichment, and biotic invasions---is increasing, and the trend is likely to continue1. These drivers are heavily modifying the functioning of many of the ecosystems we depend on2. On the other hand, species in an ecological community form an network of interactions of tremendous importance for example, for the provision of ecosystem functioning, the provision of services, the maintenance of global biodiversity, and biogeochemical cycles3–6.

The overall objective of my proposed research is to improve our current understanding of the ecosystem responses to multiple anthropogenic drivers and their cumulative impacts. In particular, I will focus on the role of interaction networks in modulating the resilience of ecosystems, i.e.the amount of disturbance a system can withstand without entering a regime shift7.

Regime shifts are large, persistent changes in the function and structure of an ecosystem8---like the (often sudden) shift from a transparent to a turbid lake, from a woodland to a grassy landscape, from a self-sustaining fishery to a collapsed one, or from a coral dominated reef to one dominated by algae9. A necessary step to anticipate, prevent and reverse unwanted regime shifts caused by drivers of environmental change, is to understand the processes that support or undermine resilience and the role played by species interactions10,11.

Despite the fact that the effect of those drivers permeates across entire communities, our understanding of their impacts is mostly based on studies of one or few species. For my research I will use a complex network approach, which favours a community perspective that comprehends species interactions at a larger scale. This approach---built upon tools from statistical physics and social sciences---has been key in revealing structural patterns that transcend specific ecosystems12–14. Using a combination of complex system theory, population models, resilience theory and previoulsy published empirical data, I aim to untangle the mechanisms that link species interactions with ecosystem resilience to drivers of environmental change.

As a model system, I will use mutualistic plant-pollinator networks, which are critical for global food production and biodiversity maintenance15,16. Initially I will focus on biotic invasions as the environmental driver. Because of the paucity of empirical observations of network dynamics subject to invasions, I will simulate community-wide interspecies coexistence dynamics, and explicitly quantify the stability of the population fluctuations from the system 17,18. This approach will enable me to predict how the structural and dynamic characteristics of the network determine the "invasibility" of an ecosystem, and when invasions are likely to lead to a regime shift19–21.

Biotic invasions often affect ecosystems that are already degraded22. Using a similar methodology as for the species invasions, I will follow by studying how defaunation---from a functional perspective---affect the pre-invasion ecosystem resilience. Although some species (e.g. beavers) fulfill unique functions in the ecosystem, others are redundant in that they contribute in similar ways to an ecosystem function23. Despite theoretical and empirical evidence showing that the degree of functional redundancy has major effects on ecosystem stability and species coexistence24–29, it remains unclear how diversity within functional groups maps into different stability domains in the ecosystem20.

The final objective of my proposed research is to translate the gained insight into useful lessons for ecosystem management. Recent work has highlighted that it is possible to control a complex network by inducing perturbations that compensate previous disturbances30. However this approach has never been used in ecology. I propose to expand this method to find the minimum number of species that have to be directly managed to move the ecosystem from one state to another, or to rescue one at the brink of collapse. To do that I will use empirical and simulated networks from ecosystems that have undergone a regime shift to evaluate the feasibility of such an approach and its management consequences.

Over the last years I have been focused on studying the ecology of tropical marine organisms. Through my previous research I have witnessed how entire ecosystems transform due to human pressures. Understanding what makes ecosystems vulnerable, and how to prevent and revert those undesirable transformations---not only in marine ecosystems---became my top scientific interest. I want to answer fundamental questions in ecology and ultimately improve the management of the ecosystems I love. I am aware this is a long-term goal that is likely to guide my scientific career for the next decade. My proposed PhD research, and the support from the NZIDRS, are going to be essential to reach those goals.

I think my main point here is that I reckon you should make the structure of your proposal super clear. You were concerned about stating your hypotheses, but before that, I would rather try to show you have a clear roadmap (even if it’s not entirely true – this is a proposal and everyone knows it’s going to change anyway), i.e. question #1, #2, #3. From what I gather here, this could be:

1. Using a combination of complex system theory, population models, resilience theory and previoulsy published empirical data, I aim to untangle the mechanisms that link species interactions with ecosystem resilience to drivers of environmental change.
2. I will follow by studying how defaunation---from a functional perspective---affect the pre-invasion ecosystem resilience.
3. Find the minimum number of species that have to be directly managed to move the ecosystem from one state to another, or to rescue one at the brink of collapse.

With such few space, you shouldn’t be scared to use a military, bullet-like style (without bullets though): short intro sentence - general objective of whole research (which you did) – “my first objective will be to…” – “to do that, I will use this data and this method” – same for objectives 2 and 3 – paragraph about relevance of proposed research – your motivation – done.

It kind of stinks to write stuff like this but I think you need to make the job as easy as possible for your evaluators, and show that you’re clear, clean, rigorous and motivated.

Are you allowed any figures? It could be nice to try to summarize your stuff into a conceptual figure with boxes and arrows and shit. It’s tricky and may take a lot of work though so might not be worth it. Just an idea.

Otherwise I think you comply with guidelines, the questions are interesting, you didn’t use too much jargon. I think that the proposal will be shortened if you apply military style.

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