Stability and resilience of ecological networks

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Introduction

Species in a ecological community form networks of interactions that determine the functioning of the ecosystem. Chiefly, interactions can be antagonistic —like those between hosts and parasites or plant and herbivores— or mutualistic —like those between plants and pollinators or coral and their symbiotic algae.

Anthropogenic pressures are a major driver of ecosystem change (Large et al. 2015). The way ecosystems respond to those drivers is largely determined by the structure or their interaction networks. Because ecosystem interactions are of tremendous importance for global biogeochemical cycles, ecosystem services, and the maintenance of global biodiversity, understanding the implications of network structure for ecosystem response is paramount.

For my dissertation I propose to study the role of species' interactions on the response of ecosystems to drivers of change. Specifically I aim to build a general understanding of how network structure and species coexistence interplays with the ecosystem's stability, resilience and adaptive capacity.

These three concepts —introduced by Holling (1973) and later reviewed by Gunderson (2000)— have been key in quantifying the dynamics and behaviour of ecosystems. **Stability** describes the property of a system to return to an equilibrium point after disturbance. On the other hand **Resilience** is a meassure of stability that mediates transitions between ecosystem stable states; it is defined by "the amount of disturbance that an ecosystem could withstand without changing self-organized processes and structures" (stable states) or as "the return time to a stable state following a perturbation". In turn the **adaptive capacity** describes “the processes that modify ecological resilience”.

I start by stuyding the outcome of species invasions under different structures of mutualistic networks. Species invasions are a major driver of change in many ecosystems, with important consequences on ecosystem functioning and biodiversity (Ehrenfeld 2010; Powell, Chase, and Knight 2011; Thomsen et al. 2014). Mutuallistic networks, on the other hand, are crucial for the maintenance of global biodiversity. For instance mutuallistic networks are responsible of 90% of seed dispersal in tropical plants (Bascompte and Jordano 2007) and the pollination of arround 70% of the global food crops (Klein et al. 2007).

In reality ecosystems dynamics are comprised by feedbacks that include more than one type of interactions. I propose to expand the understanding of ecosystem invasibility when it includes agonistic interactions in the second chaper of my dissertation. Previous evidence shows that the network’s structural patterns that promote stability vary depending on the type of interaction (Thébault and Fontaine 2010; Sauve, Fontaine, and Thébault 2014), but little is known about the factors that make an ecosystem more resilient against invasors and other drivers.

Species that share similar interactions in a ecological network can be grouped in modules. Because the species’s functional role in the community is, at least to a great extent, defined by its interactions (Dehling et al. 2014), modules should implicitly group species with similar functional roles (Dupont and Olesen 2009). Functional redundancy has been proposed as an important factor in determining the ecosystem’s response to disturbaces (Brandl and Bellwood 2014). For the trhid chapter, I propose to analyse the role that functional groups have in the ecosystem’s resilience, and how the disruption of functional groups affects the ecosystem’s adaptive capacity.

In these first three chapters, I analise stability ignoring one important aspect: that some ecosystem stable states are more desirable than others (in terms of ecosystem services). Anthropogenic drivers or ecosystem change are multidimensional and are escalating at an alarmant rate. Understanding what causes the transition between different different ecosystem’s stable states is a crucial step towards preventing undesirable transitions and restoring ecosystems that are already in an alternate undesirable state.

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Pet projects

Global biogeographic patterns of plants and pollinators

Biogeography and phylogenies: evolutionary patterns of tropical coral reefs and fishes

Effect of coevolution on network stability

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