Critical transitions, early-warning signs, and coexistence theory.

Monday 20th and Tuesday 21st June 2022, University of Fribourg

A long-standing problem in ecology is how we can quantify the environmental perturbation that a population or a community can tolerate before switching to an undesirable state. This workshop aims to study this essential question from the critical transition and the coexistence theory perspective.

1) Critical transitions arise when systems undergo an abrupt transition in their state. Often, the recovery of the system to its previous state cannot be achieved without intense efforts. A classical example of such a transition is the eutrophication of shallow lakes. Despite the complexity of the underlying dynamics, such regime shifts are preceded by generic early warning signals.
2) Coexistence theory aims to study the conditions for species to coexist at a given place and time. However, the majority of empirical and theoretical understanding comes from two-species systems. The reason is one of practicality: experiments and theory devoted to understanding the interaction of two species are simpler and more tractable. Nonetheless, the focus on pairwise coexistence misses important processes that only emerge in diverse systems of competitors. The maintenance of coexistence in species-rich ecosystems clearly requires a theory that goes beyond the pairwise framework. A multispecies coexistence theory will be introduced and applied to the study of coexistence under changing environment.

Dr. Sonia Kéfi (CNRS, France)

https://biodicee.edu.umontpellier.fr/who-we-are/sonia-kefi/

Title: ***The resilience of ecosystems and their spatial signature***

Summary: *Ecosystems respond differently to changes in environmental conditions: some respond gradually to a gradual change. Others do not appear to change much until a threshold of environmental conditions is reached, at which point the state of the ecosystem changes abruptly. Such nonlinear changes usually occur unexpectedly and can have dramatic ecological and economic consequences. They have therefore attracted increasing attention in the ecological literature in recent decades to identify the underlying ecological mechanisms and predict their approach. In the first talk, I will present the theory behind these types of behaviors as well as examples of these behaviors in nature. In the second presentation, I will discuss one type of indicator: those related to the spatial structure of ecosystems with a particular focus on drylands.*

Dr. Vasilis Dakos (CNRS, France):

https://www.vasilisdakos.info

Title: ***Quantifying resilience: Tipping points and early-warnings***

Summary: *Understanding and measuring resilience in ecosystems and communities has always been a major challenge for ecologists. Definitions and measures of resilience abound and at times are confusing. Some of these measures have been developed to highlight the approach to tipping points, that is transitions between different dynamical states. As long-term data become increasingly available and experimental approaches are improving, the challenge is how to apply such theoretical metrics to quantify resilience in order to understand ecological responses to global change. In the first part, I will discuss what we mean with tipping points and how their link to resilience allows us to develop indicators that can be used as early-warnings for tipping point responses. In the second part, I will present examples of how we can apply these metrics in practice.*

Prof. Nicolas Loeuille (Sorbonne University, France):
https://sites.google.com/site/nicolasloeuille/
Title: ***Implications of eco-evolutionary dynamics for the resilience of ecological networks***
Summary: *Recent works suggest that evolution may happen fast and that adaptation, in certain conditions, could lead to the maintenance of species that would otherwise go extinct (eg, evolutionary rescue). This suggests that eco-evolutionary dynamics could in theory largely contribute to the resilience of ecological assemblages. Such an idea has immediate (and positive) implications given the current global changes. However, the relationship between evolution and stability is still poorly understood. During the two presentations, I will first explain the basics of the adaptive dynamics framework and why it provides an interesting starting point to tackle such questions. I will discuss, using this framework, how evolution may lead to the emergence of diverse, but stable food webs. I will then turn to more general ecological networks that contain all interaction types and show that evolution in this context does not usually provide a stabilizing effect. Finally, I will turn to the tipping point dynamics and discuss whether evolution could possibly lead to ecological systems that exhibit such dynamics. I will also stress that alternative stable states need not be between two ecological equilibria, but could also be linked to alternatives in the phenotypic space, where two stable selected phenotypes could naturally* emerge.

Dr. Rudolf Rohr (University of Fribourg, Switzerland)
https://www.unifr.ch/bio/en/groups/rohr
Title: ***From limiting similarity to coexistence theory***
Summary: *The impressive diversity of species in ecological communities has long motivated ecologists to understand the mechanisms for its maintenance. The first theoretical development to tackle this question has been the concept of limiting similarity. Limiting similarity consists in quantifying the dissimilarity is species niches needed for them to coexist. However, it has also been shown that the limiting similarity can be very small, but at the cost of "fragile" communities. Thus, the question has been turned into: can we quantify how "fragile" are communities to perturbations? Coexistence theory aims to quantify this "fragility". I will start by presenting an historical perspective before introducing the foundation of a species-rich coexistence theory.*

Prof. Serguei Saavedra (MIT)
https://sites.google.com/site/sergueisaavedra/
Title: ***Understanding multispecies coexistence under unknown heterogenous environments***
Summary: *The persistence of virtually all living organisms on Earth depends on the presence or absence of other living organisms and their evolving environment. This observation has established a rich research program in understanding multispecies coexistence. However, experimental studies have shown that coexistence is a random event that depends on the details of a community and the multiple known and unknown heterogenous environmental factors. This has revealed that it is necessary to study emergent processes at the community level leading to the possibility of species coexistence across different environments. In the first part of this talk, we will introduce a theoretical framework to develop a probabilistic systems analysis of multispecies coexistence under unknown heterogenous environments. In the second part of this talk, we will show how to apply this theory to develop an understanding of multispecies coexistence in experimental communities.*

Schedule:

Monday 20th June

9h30 – 10h30	Dr. Sonia Kéfi
10h45 – 11h45	
11h45 – 13h30	*Lunch break*
13h30 – 14h30	Dr. Vasilis Dakos
14h45 – 15h45	
15h45 – 16h15	*Coffee break*
16h15 – 17h15	Prof. Nicolas Loeuille

Tuesday 21st June

9h00 – 10h00	Prof. Nicolas Loeuille
10h00 – 10h15	*Coffee break*
10h15 – 11h15	Dr. Rudolf Rohr
11h30 – 12h30	
12h30 – 14h00	*Lunch break*
14h00 – 15h00	Prof. Serguei Saavedra
15h15 – 16h15	