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Habilitation en Biologie – Date : 27.05.2019

Titre et résumé de la thèse – Title and abstract of the thesis

Coexistence Theory, Ecosystem Functioning, and Ecological Networks

This habilitation thesis is made out of three sections. They cover my main contributions to theoretical ecology. I have contributed to the analysis of ecological networks, to the development of coexistence theory, and to the study of ecosystem-functioning and its relationship with biodiversity (BEF)

In the first section, I present my contribution to the analysis of the structure of ecological networks. Specifically, I aimed to understand to what extent the presence and absence of interspecific interaction could be explained by species traits and by the phylogenetic relatedness between species. My main contribution was to develop statistical models aiming at inferring ecological networks and exploring how species traits explain their structure. Then, I also showed how these models can be used to reconstruct partially observed networks, and to forecast links that a novel species would make when joining an existing network.

The second section is concerned with the coexistence theory. My major contribution was to extend the modern coexistence theory (MCT), which study the coexistence between pairs of competing species only, to species-rich communities. Importantly, with the new approach — the structural approach — one can study to what extent the coexistence observed in species-rich communities results from indirect effects among competitors. This question remained poorly understood. We derived new metrics for multispecies coexistence. Importantly, while the MCT describes coexistence mechanism between competitors, the structural approach can directly by applied to antagonistic and mutualistic interactions and, therefore, provides a general theory.

The development of mechanistic approaches to the BEF theory is presented in the third section. Based on Lotka-Volterra models describing community dynamics, I derived a mechanistic model for the BEF relationship. This model separates explicitly the contribution of species richness, of species carrying capacities, and of the level of competition, to the productivity of horizontal communities. This mechanistic model showed that the slope of the BEF relationship is inversely related to the average level of competition; a weak level of competition results in a large positive slope, while a strong level of competition results in a small or even negative slope. Then based on metabolic theory and, especially, how temperature affects metabolism, this BEF theory predicts that an increase in temperature will result in a decrease of the slope of the BEF relationship and ultimately disrupts the BEF relationships. This theoretical prediction was upheld with experiments.

Titre et résumé de la leçon d'essai – Title and abstract of the inaugural lecture

Une approche mécanique de la relation entre la biodiversité et le fonctionnement des écosystèmes

La relation entre la biodiversité et le fonctionnement des écosystèmes (BEF) décrit l'effet du nombre d'espèces dans une communauté sur le fonctionnement de celle-ci, en particulier sur la production de biomasse. C'est une relation centrale en écologie des communautés et la grande majorité des études empiriques ont montré qu'elle est positive.

Durant cette leçon d'essai, je commencerai par une brève introduction à la relation BEF et des premières théories et expériences. Dans un deuxième temps, je dériverai un modèle mathématique basé sur la dynamique de la communauté. Nous étudierons ce modèle mécanique de la relation BEF et nous le comparerons à des données empiriques. Dans un troisième temps, je présenterai une application de cette approche mécanique pour étudier théoriquement l'impact de l'augmentation de température sur la relation BEF. Je terminerai en montrant comment cette approche mécanique apporte un nouvel éclairage sur la théorie classique de la BEF.