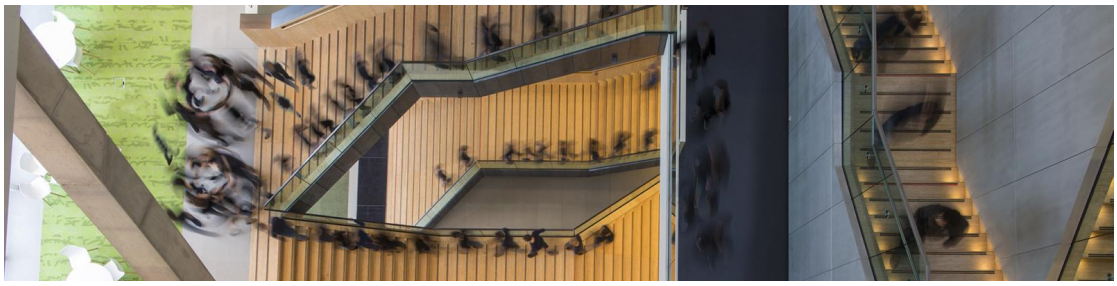
CCSS COMPLEXATON 2021-2022



Challenge 2: Diversity and perturbation relationship in spatially implicit high dimensional models

Representatives:

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Background of the problem:

The well-known and controversial intermediate disturbance hypothesis (IDH) predicts that intermediate frequency or intensity of perturbations maximize biodiversity, allowing the coexistence of many different species competing for the same resources[1,2]. We recently adapted a classical implicit-space model for plant competition and coexistence[3] by including stochastic perturbations to model the effects of forest fires on the persistence of ecosystems[4]. More recently, we have developed the mathematical conditions that determine how periodic perturbations alter species coexistence in a two-dimensional impulsive differential system.

Challenges:

The students are expected to perform simulations exploring the effect of frequency and intensity of (or recovery capacity after) perturbations on species coexistence, and how it is affected by colonization rates and competition hierarchy. Students will also attempt to propose generalizations of the coexistence conditions in higher dimensional systems.

Main questions to be addressed:

1. Is the IDH observed in simulations for large stochastic models?
2. Can conditions in low dimensional systems be generalized for high dimensional models?

Complex Systems Science aspects:

General properties in population ecology are powerful tools in articulating theoretical discussions and inspiring empirical research. Proving them for general systems with partially random elements is a hard task. The proposed modeling scheme allows up-bottom (simulations) and bottom-up (coexistence conditions) approaches to understand the mechanisms behind the IDH.

Possible societal importance/impact:

The loss of biodiversity is one of our main current societal challenges. Understanding general drivers of species coexistence is very relevant. In particular, perturbations (including fires) are expected to increase, both in frequency and intensity, with climate and land use change, threatening ecosystems diversity, functions and resilience.

Initial literature:

1. Huston, M. A general hypothesis of species diversity. *American Naturalist* 113, 81-101 (1979).
2. Hughes, A. (2010) Disturbance and Diversity: An Ecological Chicken and Egg Problem. *Nature Education Knowledge* 3(10):48
3. Tilman, D. (1994) Competition and biodiversity in spatially-structured habitats. Ecology, 75, 2–16.
4. Baudena, M., Santana, V.M., Baeza, M.J., Bautista, S., Eppinga, M.B., Hemerik, L., Garcia Mayor, A., Rodriguez, F., Valdecantos, A., Vallejo, V.R., Vasques, A., Rietkerk, M., 2020. Increased aridity drives post-fire recovery of Mediterranean forests towards open shrublands. *New Phytol.* 225, 1500–1515. https://doi.org/10.1111/nph.16252. Code: https://github.com/baudenam/FireMed-Baudena-et-al-2019-New-Phytologist
5. A. Tchuinté Tamen, Y. Dumont, J.J. Tewa, S. Bowong, P. Couteron. A minimalistic model of tree–grass interactions using impulsive differential equations and non-linear feedback functions of grass biomass onto fire-induced tree mortality. *Math. Comput. Simul.*, 133 (2017)