COURSE INFORMATION

Scope:
This second instance of a PhD course on Theoretical Ecology will focus on qualitative changes in dynamics of biological systems that occur when conditions change. Examples of such qualitative changes in biological systems are extinctions and a change from a constant and stable equilibrium state to fluctuations, that is, cyclic dynamics. As another example, even in popular media, we may nowadays encounter the term 'tipping point.' In the fifth report of the IPCC (the Intergovernmental Panel on Climate Change) a tipping point is defined as an irreversible change in the climate system. These qualitative changes in dynamics occur in many different systems and at many different levels of organization. They are generic phenomena in mathematical models when the value of a particular model parameter changes. These qualitative transitions in dynamics are called bifurcations. The course aims at giving students an understanding about possible phenomena in dynamic models and transitions between different dynamical outcomes, as well as practical training on how to apply the theory to biological systems. The basics are going to be taught while focusing on simple ordinary differential equation (ODE) models. From this basis we will explore and discuss the applicability of the learned theory to more complex models, such as individual-based models, spatial models or physiologically structured models.

Set-up:
The course is composed of:

1. **Introduction Lectures**
   The course starts off on Monday morning with an introductory lecture on the theory and relevance of bifurcations in ecological dynamics. Background information will be given in lectures by the course organisers, followed by hands-on application in the computer labs. Course (background) documentation can be found on: https://staff.fnwi.uva.nl/a.m.deroos/projects/BifurcationTheory/.

2. **Computer labs**
   The computer labs in the afternoons will provide the opportunity to practice the application of the theory in biological systems.

3. **Evening sessions**
   Evening hours will be filled with discussions on how to use theoretical biology in your own research and a facultative deepening lecture into the more mathematical background of the practiced analysis.

4. **Key-note/guest lectures**
   On Tuesday evening, Prof. Max Rietkerk (Utrecht University) will give a lecture about his work on spatial interactions in ecosystems.
   On Wednesday morning, Prof. André de Roos (University of Amsterdam) will give a lecture about his on size-structured population models.
   On Friday morning, Prof. Martijn Egas (University of Groningen) will give a lecture and workshop on adaptive dynamics, a set of mathematical modelling techniques to study evolution in an ecological setting.

5. **Course requirements**
   There are a few requirements/homework for students who want to join the course.

   1) Students should bring a laptop with a recent version of R (version 4.2 or higher) and Rstudio

installed (the exact version is not so important, just that it is recent).

2) Students should install the required R package already before the start of the course by issuing the command: install.packages("deBif") in Rstudio. This will also immediately make clear that the laptop is properly set up for the course. See the document 'installing_deBif.pdf' for more details.

3) Students are expected to have a foundational understanding of basic math, including working with fractions, solving algebraic equations, sketching various types of functions, and understanding derivatives and integrals, see the pdf 'Math_requirements.pdf' for more details (including a selftest and links to study material)

4) Students should read the papers listed below:

Grainger, T. N., Senthilnathan, A., Ke, P.-J., Barbour, M. A., Jones, N. T., DeLong, J. P., Otto, S. P., O'Connor, M. I., Coblentz, K. E., Goel, N., Sakarchi, J., Szojka, M. C., Levine, J., & Germain, R. M. (2021). An empiricist's guide to using ecological theory. *The American Naturalist*, *40*(January). https://doi.org/10.1086/717206

Rietkerk, M., Bastiaansen, R., Banerjee, S., & Koppel, J. V. D. (2021). Evasion of tipping in complex systems through spatial pattern formation. *Science*, *169*(October). https://doi.org/10.1126/science.abj0359

Brännström, Å., Johansson, J., & von Festenberg, N. (2013). The Hitchhiker's Guide to Adaptive Dynamics. *Games*, *4*(3), 304–328. https://doi.org/10.3390/g4030304

Optional: de Roos, A. M. (2020). Effects of life history and individual development on community dynamics: A review of counterintuitive consequences. *Ecological Research*, *35*(6), 930–946. https://doi.org/10.1111/1440-1703.12174