Mathematical modeling in ecology and evolution – PhD course, 5 hp

Introduction

Ecological and evolutionary processes operate at spatial and temporal scales that are often too large (or small) to monitor efficiently. For this reason, these fields have been using mathematical models as prosthetic devices ever since their conception.

Models extend our view of what is possible and what one should expect under well-defined sets of assumptions, even when experiments are unfeasible.

Mathematical models have thus become an integral part of ecology and evolution, and one will inevitably come across them when reading the scientific literature. Despite this fact, student training is often lacking in the field of mathematical modeling, making a large part of the literature inaccessible.

This course is aimed at bridging this gap. It starts from the absolute basics of “what is a model?”, “how can one construct them?”, and goes on to cover the theory of nonlinear dynamical systems.

The focus is on deterministic systems only, because getting a solid foundation in those is better than a superficial overview of broader topics. By the end of the course, students will be confident in both formulating dynamical models as well as analysing them with a wide array of tools.

Target group

The course is developed with those PhD students in the division of Biology in mind who have an interest in learning the basics of mathematical modelling in population biology. But anyone with an interest in these topics is welcome to join, with priority given to Agora Materiae, Forum Scientium, and IFM students.

It helps if one can use a computer, as some of the simulation and symbolic computation work is well-aided by programming and computer algebra systems. Some basic mathematical knowledge is also helpful, even though the course will take everything from the basics.

Intended learning outcomes

After completing the course, students will be able to:

- Understand what mathematical models are, and how models and biological knowledge can be fitted together to contribute to scientific knowledge.

- Formulate dynamical mathematical models to analyse a wide variety of phenomena. While the focus is on ecology and evolution, the same tools work in other contexts as well, and it is expected from students to be able to formulate simple models even outside of these two strict areas.
- Apply a wide range of tools used to analyse dynamical models. These include explicit recursion, linearisation, stability analysis, and perturbative solution methods.

Schedule

The course will run during the fall term of 2026. It consists of biweekly meetings where we discuss the readings for that occasion, and the problem sets the students needed to work on.

Examination is based on (i) submitted homework, and (ii) a final project (see below).

Course material

The course is based on the book "A Biologist's Guide to Mathematical Modeling in Ecology and Evolution" by Sarah P. Otto and Troy Day, with some additional readings assigned from other sources if and as necessary.

Final project

Students come up with their own project ideas, based on scientific questions they themselves formulate. The project plan is then discussed with the instructor and adjusted if needed to make it neither too simple nor too ambitious for the purposes of this course.

The project should rely on the tools and methods learned during the course.

Course leader

György Barabás

Associate professor, Division of Biology, IFM

Email: gyorgy.barabas@liu.se