Introduction to Theoretical Ecology

Instructor: Po-Ju Ke Teaching Assistant: Gen-Chang Hsu

2021 Fall at National Taiwan Univeristy

Contents

Course Information

Description

The development of theory plays an important role in advancing ecology as a scientific field. This three-unit course is for students at the graduate or advanced undergraduate level. The course will cover classic theoretical topics in ecology, starting from single-species dynamics and gradually build up to multi-species models. The course will primarily focus on population and community ecology, but we will also briefly discuss models in epidemiology and ecosystem ecology. Emphasis will be on theoretical concepts and corresponding mathematical approaches.

This course is designed as a two-hour lecture followed by a one-hour hands-on practice module. In the lecture, we will analyze dynamical models and derive general theories in ecology. In the hands-on practice section, we will use a combination of analytical problem sets, interactive applications, and numerical simulations to gain a general understanding of the dynamics and behavior of different models.

Objectives

By the end of the course, students are expected to be familiar with the basic building blocks of ecological models and would be able to formulate and analyze simple models of their own. The hands-on practice component should allow students to link their ecological intuition with the underlying mathematical model, helping them to better understand the primary literature of theoretical ecology.

Requirements

Students are expected to have a basic understanding of **Calculus** (e.g., freshman introductory course) and **Ecology**.

Format

Tuesday 1:20 pm ~ 4:20 pm at Room 204, Gongtong Lecture Building

- Main lecture (two hours): theories and models (blackboard writing)

- Hands-on practice (one hour): programming and simulation (using R) + discussion

Grading

The final grade consists of:

(1) Assignment problem sets (60%)
(2) Midterm exam (15%)
(3) Final exam (15%)
(4) Course participation (10%)

Course materials

We will be using a combination of textbooks and literature articles on theoretical ecology in this course. Textbook chapters and additional reading materials will be provided (see **Syllabus** for more details).

Below are the textbook references:

- Case, Ted J. *An illustrated guide to theoretical ecology.* Oxford University Press, 2000.
- Gotelli, Nicholas J. *A primer of ecology* 4^{th} *edition.* Sinauer Associates, 2008.
- Pastor, John. *Mathematical ecology of populations and ecosystems.* John Wiley & Sons, 2011.
- Otto, Sarah P. and Troy Day. *A biologist's guide to mathematical modeling in ecology and evolution.* Princeton University Press, 2011.

Contacts

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Syllabus

Date

Lecture topic

Lab

Reading

Week 1 28-Sept-2021

Introduction: what is theoretical ecology?

Week 2 05-Oct-2021

Exponential and geometric population growth

Gotelli [Ch.1] Case [Ch.1]

Week 3 12-Oct-2021

Age-structured population models

Gotelli [Ch.3] Case [Ch.3]

Week 4 19-Oct-2021

Density-dependence and logistic population growth

Gotelli [Ch.2] Case [Ch.5]

Week 5 26-Oct-2021

Stability analysis of single population dynamics

Otto & Day [Ch.5]

Week 6 02-Nov-2021

Metapopulations and patch occupancy models

Gotelli [Ch.4] Case [Ch.16]

Week 7 09-Nov-2021

Lotka-Volterra model of competition: graphical analysis

Gotelli [Ch.5] Case [Ch.14]

Week 8 16-Nov-2021

Lotka-Volterra model of competition: linear stability analysis

Otto & Day [Ch.8]

Week 9 23-Nov-2021

Midterm exam

Week 10 30-Nov-2021

Predator-prey interactions

Gotelli [Ch.6] Case [Ch.12 & 13]

Week 11 07-Dec-2021

Mutualisms

Vandermeer & Boucher, 1978.

Week 12 14-Dec-2021

Multispecies models of competition: apparent and exploitative competition

Holt, 1977.

Week 13 21-Dec-2021

Multispecies models of predation: food chains and intraguild predation

Holt & Polis, 1997.

Week 14 28-Dec-2021

Disease dynamics and SIR models

Anderson & May, 1979.

Week 15 04-Jan-2022

Ecosystem models and feedbacks

Pastor [Ch.11 & 12]

Week 16 11-Jan-2022

Final exam

Week 17 18-Jan-2022

General discussion: how to develop new theoretical models and the role of theory in modern ecology?

Otto & Day [Ch.2] Otto & Rosales, 2020.

Week 1

Introduction: what is theoretical ecology?

Week 2

Exponential and geometric population growth