Mathematical modelling in ecology and evolution (EEB314)

Mathematics is central to science because it provides a rigorous way to go from a set of assumptions to their logical consequences. In ecology & evolution this might be how we think a virus will spread and evolve, how climate change will impact a threatened population, or how much genetic diversity we expect to see in a randomly mating population. In this course you'll learn how to build, analyze, and interpret mathematical models of increasing complexity through readings, lectures, computer labs, and a final project. Our focus is on deterministic dynamical models (recursions and differential equations), which requires us to learn and use some calculus and linear algebra.

Please see the University of Toronto Academic Calendar for more details on the course prerequisites and additional information on the distribution/breadth requirements this course satisfies.

Next taught: Fall 2025

Previously taught: Fall 2024, Fall 2022 (EEB430), Fall 2021 (EEB430)

Instructors

Professor

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Teaching assistant

Erik Curtis (he/him)

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When and where

Lectures

- Monday & Wednesday, 10:10 - 11:00 AM
- Wilson Hall - New College (WI), room 523

Labs

- Wednesday, 3:10 - 5:00 PM
- Sidney Smith (SS), room 561

Course structure

Learning objectives

Mathematics is central to science because it provides a rigorous way to go from a set of assumptions (what we take to be true) to their logical consequences (what we want to know). In ecology & evolution this might be how we think SARS-CoV-2 may spread and evolve given a set of vaccination rates and travel restrictions, how caribou population sizes are predicted to respond to forecasted rates of climate change, or something much more abstract like the expected amount of genetic diversity in a randomly mating population. In this course we'll learn how to build, analyze, and interpret mathematical models of increasing complexity through readings, lectures, computer labs, and a final project. By the end of the course you will be able to:

☒ build a model: go from a verbal description of a biological system to a set of equations
☒ analyze a model: manipulate a set of equations into a mathematical expression of interest
☒ interpret a model: translate mathematical expressions back into biological meaning

Weekly tasks

☒ read text
☒ attend two lectures
☒ attend one lab

Grading scheme

- in-class tests: 4 x 20%
- final project: 20%

Textbook

Otto & Day 2007. A biologist's guide to mathematical modeling in ecology and evolution.

- UofT library e-copies
- UofT library physical-copies
- buy your own copy

Final project

Construct your own model

In this project you will use the tools you've learned in class and apply them to a model that you develop. The model can be about any phenomenon in ecology and evolution, as long as you make up the model.

You'll do the final project in two parts.

☒ Part 1
  - Describe your biological question and why this interests you
  - Describe your model in words (ie, the main assumptions) and explain the main structure with a diagram (eg, flow or life cycle diagram)

  - Write down the equations that you will analyze
  - Describe what your analysis might reveal (ie, your hypothesis)
  - Max 2 pages
  - Example
- ☒ Part 2
  - Re-iterate your biological question and why this interests you
  - Describe your model assumptions in detail, defining all parameters and variables
  - Write down the equations for your model
  - Analyze your model
  - Explain how the results address your original question
  - Suggest how the model could be improved or extended
  - Max 4 pages (not including any code that you used, which can be included as a link or additional file)
  - Example

!!! tip

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If you are having trouble coming up with a new model, take one of the models that we've analysed in the
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Exams

Previous midterms

Roughly covers univariate lectures and labs.

- 2024, solutions
- 2022, solutions
- 2021, solutions

Previous finals

Covers all material, with a focus on the remaining lectures and labs.

- 2024, solutions
- 2022, solutions
- 2021, solutions

General info

Land acknowledgement

I wish to acknowledge this land on which the University of Toronto operates. For thousands of years it has been the traditional land of the Huron-Wendat, the Seneca, and the Mississaugas of the Credit. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and I am grateful to have the opportunity to work on this land. For more information see University of Toronto's land acknowledgement.

Group norms

The University of Toronto is committed to equity, human rights, and respect for diversity. All members of the learning environment in this course should strive to create an atmosphere of mutual respect where all members of our community can express themselves, engage with each other, and respect one another's differences. U of T does not condone discrimination or harassment against any persons or communities. Please contact me if you have any concerns. For more information see the Code of Student Conduct.

Accessibility

The University provides academic accommodations for students with disabilities in accordance with the terms of the Ontario Human Rights Code. This occurs through a collaborative process that acknowledges a collective obligation to develop an accessible learning environment that both meets the needs of students and preserves the essential academic requirements of the University's courses and programs. Students with diverse learning styles and needs are welcome in this course. If you have a disability that may require accommodations, please feel free to get in touch with me and/or the Accessibility Services office.

Religious observances

The University provides reasonable accommodation of the needs of students who observe religious holy days other than those already accommodated by ordinary scheduling and statutory holidays. Students have a responsibility to alert members of the teaching staff in a timely fashion to upcoming religious observances and anticipated absences and I will make every reasonable effort to avoid scheduling tests, examinations or other compulsory activities at these times. Please reach out to me as early as possible to communicate any anticipated absences related to religious observances, and to discuss any possible related implications for course work.

Family care responsibilities

The University of Toronto strives to provide a family-friendly environment. You may wish to inform me if you are a student with family responsibilities. If you are a student parent or have family responsibilities, you also may wish to visit the Family Care Office website.

Resources

There are many resources available at the University of Toronto to help you succeed in this course. Below are a few:

- Writing Center
- Academic integrity
- More on academic integrity
- CTSI list of supports
- Academic success module
- Get help with Quercus