# Fundamentals of Ecological and Evolutionary Modeling
## 11:216:431 (Spring, 4 credits)

**Meeting times and place:**
Tuesdays and Fridays 10:20am-11:40am, Cook/Douglas Lecture Hall (CDL) 110
Fridays 12:10pm-1:30pm, Cook/Douglas Lecture Hall (CDL) 110

**Professor:** Juan A. Bonachela, juan.bonachela@rutgers.edu
**Teaching Assistant:** Koustav Halder, koustav.halder@rutgers.edu
**Office hours:** Please send an email to schedule a meeting.

**Course description:**
This course will focus on how to apply simple mathematical language and techniques to gain a deeper understanding of biological systems. We will use basic calculus to study the ecological and evolutionary changes of populations, learn how to represent and interpret such changes, and predict their short- and long-term behavior. We will discuss classic examples covering a wide range of terrestrial and marine systems, from microbial growth to predator-prey interactions, vegetation patterns, and biogeochemical cycles.

**Pre-reqs:** Calculus (Calculus I 01:640:135, or similar).

**Learning goals:**
- Biological interpretation of figures and mathematical equations.
- Understand how mathematical models are constructed in theoretical biology.
- Understand how to choose the right analytical techniques to extract biological information from models.
- Develop critical thinking regarding assumptions and level of detail needed to model specific biological systems.
- Develop critical quantitative thinking.
- Communicate successfully theoretical biology.

**Grading:** The final course grade will be calculated using the breakdown below. **Attendance and active participation is mandatory,** and important for learning purposes but also because it will be **considered when calculating the final grade**. Please note that the course material is cumulative, and therefore it is important that you keep up with every week's concepts and work. The latter will mostly focus on weekly exercise sets, which will include exercises that will count against the final grade. In addition, there will be two exams, and a team project that will be presented as a group (plus an individual project report). Your critical review of your peers' presentations and of one individual report will complete your final grade.

**Grading breakdown:**
Weekly assignments, 25%; Mid-terms, 17% each; Project, 35%; Peer review, 6%

**Recommended textbooks:**

- Hastings, A: "Population biology: concepts and models" (ISBN-13: 978-0387948539).
- Otto, S and Day, T: "A biologist's guide to mathematical modeling" (ISBN-13: 978-0691123448).
- Murray, J: "Mathematical Biology: I. An Introduction" (ISBN-13: 978-0387952239).

**Important:** Please switch off and put away your cellphone before class starts. Recording, pictures, or snapshots cannot be taken (including during office hours). Laptops or other digital equipment cannot be used in this class unless you have made special arrangements with the professor.

**Tentative schedule:**

| Date | Topic |
| --- | --- |
| 01/21/2025 | Introduction (Self-assessment exercise set available) |
| 01/24/2025 | Figures and plots (2$^{nd}$ exercise set available) |
| 01/24/2025 | Lab session to work on 2$^{nd}$ exercise set |
| 01/28/2025 | Pseudo-models |
| 01/31/2025 | Units  (2$^{nd}$ exercise set due; 3$^{rd}$ exercise set available) |
| 01/31/2025 | Lab session to work on 3$^{rd}$ exercise set |
| 02/04/2025 | Borrowing from other disciplines |
| 02/07/2025 | Discrete models (3$^{rd}$ exercise set due; 4$^{th}$ exercise set available) |
| 02/07/2025 | Lab session to work on 4$^{th}$ exercise set |
| 02/11/2025 | Assumptions |
| 02/14/2025 | Modeling population demography (4$^{th}$ exercise set due; 5$^{th}$ exercise set available) |
| 02/14/2025 | Lab session to work on 5$^{th}$ exercise set |
| 02/18/2025 | Modeling population demography…and space |
| 02/21/2025 | Modeling resource uptake and competition (5$^{th}$ exercise set due; 6$^{th}$ set available) |
| 02/21/2025 | Lab session to work on 6$^{th}$ exercise set |
| 02/25/2025 | Modeling antagonistic interactions |
| 02/28/2025 | Modeling management and conservation |
| 02/28/2025 | Lab session to work on all past exercise sets (6$^{th}$ exercise set due at the end of class) |
| 03/04/2025 | Review/Q&A session |
| 03/07/2025 | Midterm exam |
| 03/11/2025 | Structured models  (7$^{th}$ exercise set available) |
| 03/14/2025 | Modeling biodiversity |
| 03/14/2025 | Lab session to work on 7$^{th}$ exercise set |
| 03/25/2025 | Modeling evolution I (8$^{th}$ exercise set available) |
| 03/28/2025 | Modeling evolution II |
| 03/28/2025 | Lab session to work on 8$^{th}$ exercise set |
| 04/01/2025 | Modeling evolution III: game theory 1$^{st}$ part (8$^{th}$ exercise set due; 9$^{th}$ set available) |
| 04/04/2025 | Modeling evolution III: game theory 2$^{st}$ part |
| 04/04/2025 | Lab session to work on 9$^{th}$ exercise set |
| 04/08/2025 | Review/Q&A session (9$^{th}$ exercise set due) |
| 04/11/2025 | Midterm exam |
| 04/15/2025 | Group project session |
| 04/18/2025 | Group project session |
| 04/18/2025 | Group project session |
| 04/22/2025 | Group project session |
| 04/25/2025 | Group project session |
| 04/25/2025 | Group project session |
| 04/29/2025 | Presentation sessions I |
| 05/02/2025 | Presentations session II |
| 05/02/2025 | Peer review session |

**Disclaimer:** Please note that the syllabus and schedule are flexible, and therefore changes can occur if they improve the student experience and/or help the student achieve the learning goals above.

**Academic Integrity:** Your learning experience depends on your academic integrity. You are expected to adhere to University policies and code of conduct (http://academicintegrity.rutgers.edu). These principles forbid plagiarism and require that every Rutgers University student i) properly acknowledge and cite all use of the ideas, results, or words of others; ii) properly acknowledge all contributors to a given piece of work; iii) make sure that all work submitted as his or her own in a course or other academic activity is produced without the aid of unsanctioned materials or unsanctioned collaboration; iv) treat all other students in an ethical manner, respecting their integrity and right to pursue their educational goals without interference. This requires that a student neither facilitate academic dishonesty by others nor obstruct their academic progress. Violations of academic integrity will be treated in accordance with university policy, and sanctions for violations may range from no credit for the assignment, to a failing course grade to (for the most severe violations) dismissal from the university.

**Diversity and Inclusivity Statement:** In keeping with Rutgers's mission statement, this class strives to be an inclusive learning community, respecting those of differing backgrounds and beliefs. As a community, we aim to be respectful to everyone in this class, regardless of race, ethnicity, religion, gender, or sexual orientation.

If you go by a different name than what is on the class roster, please let us know. Using correct gender pronouns is important to us, so please do not hesitate to share your pronouns with us.

We are committed to supporting the learning of all students in our class, and recognize that you may experience a range of emotional, physical, and/or psychological issues, both in and out of the classroom, that may distract you from your learning. If you are experiencing such issues, please do not hesitate to let us know so we can make the necessary accommodations and/or come up with a plan to ameliorate the impact on your learning.

If you have or think you have a disability (learning, sensory, physical, chronic health, mental health or attentional), please contact the Office of Disability Services (ODS). If you have already registered with the ODS, please meet with us as soon as possible to discuss your accommodations in the course; please note that no accommodations are in place until then.

**Other considerations:**

It is important that you communicate with us if any special circumstances make it impossible for you to attend class or complete assigned classwork. We will try to find a solution being both flexible and fair.

Please make sure to be in class on time. If, for some reason, you arrive after the lecture starts, please enter the classroom as quietly as possible; if you need to leave before the lecture is over, please leave the classroom quietly (and talk to the instructor before the class!).

Please note that, as per Rutgers policy, "although masks are optional, we encourage all individuals who prefer to wear them to do so, and we fully respect that personal decision".

**Additional resources:** https://success.rutgers.edu/