SES Mathematical Modeling

Prerequisites: A basic grasp of calculus

Course Summary

Ecology is a relatively young science that grew from the largely descriptive discipline of Natural History. As the science has matured, it has begun to develop a firm quantitative foundation. For the most part, this foundation has been statistical (Regression, Correlation, Analysis of Variance, Ordination). The purpose of this course is to introduce the students to the other component of this quantitative foundation, dynamic simulation modeling of ecological processes.

The students will first be exposed to the role of models in science and the relationship of models to scientific theories. Then the basics of calculus are reviewed in the context of the mass-balance concept. Next the students are introduced to numerical (as opposed to analytical) solutions of the mass-balance equation; that is, they are taught how to get a computer to do all the hard math. They then apply these techniques to a series of examples such as the growth of an individual organism and of a population of organisms, the interactions within species communities (competition for resources, predator-prey systems), the cycling of elements within ecosystems, the hydrology of a watershed, and an analysis of the CO_2 balance of the atmosphere.

The students will use what they learn over the course of the semester to develop their own simulation model of an ecosystem. They are provided with a model shell that includes a graphical interface, integrator, and graphical-output package. The student then provides a set of equations describing the ecological processes they want to simulate. These equations are typically based on the simple concept of a mass balance and can be applied to ecosystem element cycles, population dynamics, or community interactions.

Required Text

None. Students will be assigned chapters from selected texts and papers from the primary literature.

What I expect from you, the student:

The students will complete several programming problems that illustrate the topics covered in lecture. Students will be evaluated predominantly on a term project. In that project they will develop their own simulation model, address some ecologically significant questions with the model, and write a manuscript describing the model and analysis. The manuscript is to be written as if it were to be submitted to a scientific journal (e.g., *Ecology*). Students are encouraged to relate their project to topics covered in other courses and may use the model they develop as part of their independent research project undertaken during the last 4-6 weeks of the semester. Students are encouraged to discuss their projects with one another during the semester and seek one another's advice. In addition, each student will make an oral presentation describing their project to the class.

There will be readings and worksheet exercises assigned during the semester to illustrate topics covered in class.

Week		
1	Session 1.	Software installation & Why Model
1	Session 2.	Ecosystem C-N model
2	Session 3.	Mass Balance and Ecosystem C-N model
2	Session 4.	The Michaelis-Menton equation.
3	Session 5.	Numerical integration
3	Session 6.	Class model
4	Session 7.	Class model
4	Session 8.	Project proposal presentations
5	Session 9.	Catchment hydrologic budget
5	Session 10.	Catchment hydrologic budget
6	Session 11.	Population logistic and competing populations
6	Session 12.	Predator-prey systems
7	Session 13.	Species coexistence and R-star model
7	Session 14.	Parameter estimation and curve fitting
8	Session 15.	The Multiple Element Limitation (MEL) Model.
8	Session 16.	Island model
9	Session 17.	Foret model
9	Session 18.	Validation & In -class help with projects
10	Session 19.	In -class help with projects
10	Session 20.	Student Presentations. (6 November 2025)

Thursday, 25 September 2025 – project model diagram and mass-balance equations due.
Tuesday, 11 November 2025 – draft paper due.
Friday, 14 November 2025 – Final modeling paper due.