MATH 599 and 599S / BIOL 763 / SCCC 411B **Fall, 2003**

Course Information

Professors. Matt Miller (Mathematics, 7-3690), Dave Wethey (Biology, 7-3936).

Title, time, place. Topics in Mathematics: Population Biology (3 credits for MATH 599 or BIOL 763), TTh 11:00-12:15 in CLS 202 for all listed course numbers, with an additional hour TBA for SCCC 411B (4 credits) and for MATH 599S (1 credit)

Prerequisites. Completion of a full year of calculus is required. BIOL 301 (or comparable substitute such as MSCI 311) is recommended as a prerequisite. The less formal, but more significant prerequisite is that the student be an active and independent learner, not afraid to ask questions, challenge the instructors, read original literature (not just pre-digested text material), and write and speak on their findings. Questions concerning registration should be directed to either professor. Freshmen and sophomores must have the permission of one of the professors.

Intended audiences. This course offers an opportunity for math majors to see how mathematics is used in a focused area of application. They will see applications of differential equations and linear algebra in the setting of modeling populations in biology. Undergraduate biology majors may use the course as part of their cognate; it will enhance their applications to graduate programs in biology and related areas (such as biotechnology) to have boosted their mathematical skills. Honors College students should consult their advisors to be clear whether the course will count for math major elective credit or biology major cognate credit. Students in other disciplines such as marine science, geology, or engineering are welcome, but should consult their advisors concerning the place of this course in their program of study. Graduate students entering the ecology program in Biology or the biological track of Marine Science are strongly recommended to take this course.

Description. Our goal is to make the theoretical and modeling literature in population biology accessible to the students, so that they will be able to follow how mathematics is used, and be able to critically examine this usage both analytically and by running computer simulations. Some students may incorporate this capability into current or future research projects. We will study mathematical models, with emphasis on the dynamics of population change. We begin with simple rate equations that describe unconstrained and density dependent growth in a single species over time, and then move on to study the effects of competition, predation, parasitism, and cooperation (mutualism), leading to examples of oscillation, stability and instability. By way of comparison and contrast discrete models will be introduced for analysis of population growth in populations with well-defined generations, and to study age distribution within a population. The computer algebra package called Maple will be used extensively; however, no computer background is needed and the online help is quite adequate.

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Goal. Our larger goal is to change some attitudes. Life scientists are now likely to see literature in their field that, on the one hand, looks intriguing, but on the other hand, looks intimidating because of a bunch of math, and too often they will therefore let it go. We want them to be willing and able to plunge in and say, "I can make some sense of that,"and we are convinced that they can do this. Mathematics students, on the other hand, are trained largely in computational technique and rigorous abstraction, and are unaware how mathematics is used (and misused) by scientists. For these students, we hope to finally offer them an apportunity to discover an answer to the perenial question "What is all this for, anyhow?"

Course work. There will be required reading, both from the textbook and from papers published in biological journals. Approximately 1/2 of class time will be lectures, and the remainder will be devoted to discussion and collaborative work, including time on the computer. Mastery of the mathematical tools will be tested by one in-class exam (complusory for students taking 4 credits, optional for the rest) and a take-home final exam (compulsory for all). The exams will consist largely of short answer questions involving interpretation and analysis of mathematical models in the context of biological applications; there will be little mathematics for its own sake. There will be two out of class group projects on topics taken from the current biological literature; each group will prepare a written report. Groups will not mix undergraduate and graduate students; the graduate students will be expected to work on more difficult papers and to make a formal oral presentation of their project; presentations will be optional, but encouraged, for the undergraduates. Each of these components (exams and projects) will be weighed approximately equally in the final grade; class participation and attendance will also be taken into account.

Text. *An Illustrated Guide to Theoretical Ecology* by Ted J. Case is required. We also recommend other books; you can find an extensive bibliography on the course home page. In terms of the text, our plan for part I of the course is to get through chapter 1 and appendix 1 (continuous and discrete Malthusian models are the focus, as they are central to any model analysis; nearly all deterministic models are formed by tweaking these basic models), chapter 3 and appendix 2 (perhaps slighting how the Leslie matrix is built from the data, but emphasizing how it is used), a bit of chapter 8, chapter 5, where we encounter non-linear phenomena and begin to examine stability issues in some detail (the first exam will be somewhere in there). We will probably omit chapters 6, 7, and 9, for while these are extremely important from the biological point of view, we want to have the time for you to see many different mathematical techniques, and move on to part II of the course, which will consist of analysis of multi-species models. We'll begin with a thorough treatment of chapter 10, then a smattering from chapter 11, chapters 12, 13, and 14 in detail along with appendix 3, and, time permitting, game theoretic genetic models and spatial patch models. See the schedule and assignments link for more details. Please note that we will not lecture out the text; it is well written, beautifully illustrated, and, we believe, a readable complement to our lectures, and to the papers that we will read. On occasion we will assign problems from the text.