

Modeling Coupled Natural-Human Systems
ABE4641 Section CMNH
Time: MWF, Period 7, 1:55-2:45PM
Rogers Hall 211
Fall 2024

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Office Hours: TBD and by appointments
Graduate Teaching Assistants (email, office hours and location): N/A

Course Description

Approaches to modeling coupled natural-human systems are explored, drawing from both natural and social sciences. Topics include regime shift from dynamical systems and basic concepts from game theory and social-ecological system literature. These are combined in models that operationalize a conceptual framework. Properties and implications of these models—e.g., resilience and robustness of the coupled systems—will be derived and discussed. Students develop models—with guidance—for final projects. 3 credit hours.

Pre-requisites: Basic calculus and college-level probability courses

Learning Objectives:

Upon completion of this course, students will be able to:

- Perform stability analysis and construct a bifurcation diagram for simple dynamical systems.
- Articulate the nature of regime shifts or tipping points in the context of coupled natural-human systems.
- Make connections between concepts such as resilience and robustness to their mathematical basis.
- Identify the applicability and limitations of different modeling approaches to coupled natural-human systems.
- Develop a simple model for a coupled natural-human system and analyze it, using tools learned in this course. This is what you are expected to do in your final project.

Sample Readings:

No textbooks are required. The materials for this course will be drawn from several sources. Below are some examples (we would likely not cover all of them):

- Anderies, J. M., M. A. Janssen, and E. Ostrom (2004), A framework to analyze the robustness of social-ecological systems from an institutional perspective, *Ecology and Society*, 9(1), 18.
- Anderies, J. M., A. A. Rodriguez, M. A. Janssen, and O. Cifdaloz (2007), Panaceas, uncertainty, and the robust control framework in sustainability science, *Proceedings of the National Academy of Sciences*, 104(39), 15194–15199.
- Gintis, H. (2000). *Game theory evolving: A problem-centered introduction to modeling strategic behavior*. Princeton University Press.
- Hardin, G. (1968). The tragedy of the commons. *Science*, 162(3859), 1243-1248.

- Madani, K. (2010). Game theory and water resources. *Journal of Hydrology*, 381: 225-238.
- Müller-Hansen, F., Schlüter, M., Mäs, M., Donges, J. F., Kolb, J. J., Thonicke, K., & Heitzig, J. (2017). Towards representing human behavior and decision making in Earth system models—an overview of techniques and approaches. *Earth System Dynamics*, 8(4), 977.
- Muneepeerakul, R. & J.M. Anderies (2017), Strategic behaviors and governance challenges in social-ecological systems, *Earth's Future*, 5: 865–876, doi:10.1002/2017EF000562.
- Nowak, M. A. (2006). *Evolutionary dynamics: Exploring the equations of life*. Harvard University Press.
- Nowak, M. A. (2006). Five rules for the evolution of cooperation. *Science*, 314(5805), 1560-1563.
- Ostrom, E., Burger, J., Field, C. B., Norgaard, R. B., & Policansky, D. (1999). Revisiting the commons: local lessons, global challenges. *Science*, 284(5412), 278-282.
- Scheffer, M., *et al.* (2009). Early-warning signals for critical transitions. *Nature*, 461(7260), 53-59.
- Scheffer, M., *et al.* (2012). Anticipating critical transitions. *Science*, 338(6105), 344-348.
- Young, H. P. (2001). *Individual strategy and social structure: An evolutionary theory of institutions*. Princeton University Press.
- Yu, D. J., M. R. Qubbaj, R. Muneepeerakul, J. M. Anderies, and R. Aggarwal. The effect of infrastructure design on commons dilemmas in social-ecological system dynamics, *Proceedings of the National Academy of Sciences*, 112(43): 13207—13212.

Tentative Schedule:

Week	TOPIC*
1	Overview, introductions, logistics
2	Basic game theory: classic 2x2 games and their Nash equilibriums
3	Mixed-strategy Nash equilibrium
4	3x3 games; Basic evolutionary game theory—replicator equations
5	Analysis of 1-D replicator equations
6	1-D stability analysis Regime shifts; Examples of models with regime shifts
7	MATLAB introduction
8	2D stability analysis
9	2D stability analysis; MIDTERM
10	Putting them together: develop CNH models
11	Analysis of selected CNH models
12	Analysis of selected CNH models; PROJECT PROGRESS REPORTS
13	MATLAB sessions on selected systems.
14	MATLAB workshops for final projects
15	Review; FINAL PROJECT PRESENTATIONS

* The schedule is tentative. Actual schedule would depend on progress and interest in class.

Assignments

Tentative topics in assignments:

HW**	TOPIC**
1	Finding Nash equilibriums of 2x2 and 3x3 games Memo of one or more relevant papers
2	Stability analysis, regime shift, and bifurcation of a replicator equation Memo of one or more relevant papers
3	Stability analysis, regime shift, and bifurcation of a 2-D dynamical system Memo of one or more relevant papers
4	Analysis of a CNH model Memo of one or more relevant papers

** The number of assignments and their topics are tentative; the actual number and topics would depend on progress and interest of class. The assignments are usually due 1 to 1.5 weeks after the date they are assigned. Regardless of the actual number and topics of the assignments, they would collectively count for 45% of the final grade.

There will be 4-5 in-class quizzes, whose topics reflect those of the assignments. These quizzes are designed to help prepare the students for completing their assignments.

There will be a final group project. The students will work in group—with the instructor's guidance—to develop a two- or three-dimensional dynamical model of a coupled natural-human system of their interest. They are to present two progress reports throughout the semester and a final presentation of their project at the end of the semester. It will be encouraged that a group consist of both undergraduate and graduate students. The progress reports and final presentation will be the group's collective work, and the expectations will be the same for both undergraduate and graduate students.

Attendance Policy, Class Expectation, and Make-Up Policy

Students are expected to attend class, participate in discussion of the materials, and contribute to a group project. Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Click here to read the university attendance policies: <https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/>

Evaluation of Grades

Assignments: 45% | Midterm Exam: 25% | In-class Quizzes: 5% | Final Project: 25%

Grading Policy

Your final score will be rounded to the nearest integer—for example, 86.5 will be rounded to 87—and your final grade will be determined accordingly to the scale below.

91-100 = A | 86-90 = A- | 81-85 = B+ | 76-80 = B | 71-75 = B- | 66-70 = C+ | 61-65 = C | 56-60 = C- | 51-55 = D+ | 46-50 = D | 41-45 = D- | 0-40 = E

More information on UF grading policy may be found at: <https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Conduct Code (<https://sccr.dso.ufl.edu/process/student-conduct-code/>) specifies a number of behaviors that

are in violation of this code and the possible sanctions. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

Campus Resources

Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: <https://counseling.ufl.edu>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence: If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the [Office of Title IX Compliance](#), located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS): Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or

<http://www.police.ufl.edu/>.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. <https://lss.at.ufl.edu/help.shtml>.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling;

<https://career.ufl.edu>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.

<https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.

<https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: <https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>; <https://care.dso.ufl.edu>.

On-Line Students Complaints: <https://distance.ufl.edu/state-authorization-status/#student-complaint>.