ABE6933: Modeling Coupled Natural-Human Systems

Spring 2019, 3 Credit hours

Time & Location: M 9:35-10:25AM & W 8:30-10:25AM, Frazier Rogers 283

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

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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. Students develop models—with guidance—for final projects.

Notes on the graduate section: Students enrolled in the graduate section will be given additional, more advanced problems in both homework assignments and midterm exam.

Learning Objectives:

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

- Perform stability analysis, construct a bifurcation diagram, and determine critical parameter values for 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 and assess the applicability and limitations of different modeling approaches to coupled natural-human systems.
- Develop a 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.

Assessment and Evaluation:

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

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 | 51-60 = D | 0-50 = E

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.

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.

Grades and Grade Points

For information on current UF policies for assigning grade points, see http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#attendance.

Attendance and Make-Up Work

Requirements for class attendance and make-up exams, assignments and other work are consistent with university policies that can be found at: http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#attendance.

Online Course Evaluation Process

Student assessment of instruction is an important part of efforts to improve teaching and learning. At the end of the semester, students are expected to provide feedback on the quality of instruction in this course using a standard set of university and college criteria. These evaluations are conducted online at https://evaluations.ufl.edu. Evaluations are typically open for students to complete during the last two or three weeks of the semester; students will be notified of the specific times when they are open. Summary results of these assessments are available to students at https://evaluations.ufl.edu/results.

Academic Honesty

As a student at the University of Florida, you have committed yourself to uphold the Honor Code, which includes the following pledge: *"We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity."* You are expected to exhibit behavior consistent with this commitment to the UF academic community, and on all work submitted for credit 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*."

It is assumed that you will complete all work independently in each course unless the instructor provides explicit permission for you to collaborate on course tasks (e.g. assignments, papers, quizzes, exams). Furthermore, as part of your obligation to uphold the Honor Code, you should report any condition that facilitates academic misconduct to appropriate personnel. It is your individual responsibility to know and comply with all university policies and procedures regarding academic integrity and the Student Honor Code. Violations of the Honor Code at the University of Florida will not be tolerated. Violations will be reported to the Dean of Students Office for consideration of disciplinary action. For more information regarding the Student Honor Code, please see: http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code.

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

Services for Students with Disabilities

The Disability Resource Center coordinates the needed accommodations of students with disabilities. This includes registering disabilities, recommending academic accommodations within the classroom, accessing special adaptive computer equipment, providing interpretation services and mediating faculty-student disability related issues. Students requesting classroom accommodation must first register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the Instructor when requesting accommodation

0001 Reid Hall, 352-392-8565, www.dso.ufl.edu/drc/

Campus Helping Resources

Students experiencing crises or personal problems that interfere with their general well-being are encouraged to utilize the university's counseling resources. The Counseling & Wellness Center provides confidential counseling services at no cost for currently enrolled students. Resources are available on campus for students having personal problems or lacking clear career or academic goals, which interfere with their academic performance.

- *University Counseling & Wellness Center, 3190 Radio Road, 352-392-1575,* www.counseling.ufl.edu/cwc/
  Counseling Services
  Groups and Workshops
  Outreach and Consultation
  Self-Help Library
  Wellness Coaching
- *Career Resource Center,* First Floor JWRU, 392-1601, www.crc.ufl.edu/