Agent-based Modeling – FANR/ECOL 8500 (3 credits)
Syllabus – Fall 2023

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Class times: Tuesday/Thursday 9:35 am-10:50 am
Location: Warnell 1-210

Course Description: As researchers, we are frequently interested in large scale questions and patterns. Though we tend to use aggregate variables, these patterns can be strongly influenced by how agents interact with their surroundings and other agents. Agent-based modeling (ABM) is a powerful tool to explore how large-scale patterns emerge from smaller individual patterns and choices. In other words, it is a way of testing or exploring mechanisms behind large scale patterns. This framework can apply to a wide variety of questions from economics to social networks to ecological systems. This course is an introduction to modeling social-ecological systems (SES). The course will focus on understanding the importance of complexity, system thinking, interdependencies and feedbacks in SES. In this course we will learn:

1. the principles of individual-based ecology and decision-making,
2. what agent-based modeling is and what it can do,
3. how to approach building models, and how to defend modeling decisions,
4. how to write about and compare similar models,
5. coding ABMs in the user-friendly (but powerful!) computer language NetLogo,
6. how to work collaboratively with other students on models.

Course Objectives

1. To provide students with an understanding of the importance of feedbacks and interdependencies when dealing with SESs.
2. To provide students with the technical ability to assess model validity and applicability to the real world.
3. To provide students the ability to design models dealing with specific aspects of human-environment systems.

To facilitate achieving these broad objectives, students will be assigned a variety of tasks to secure this knowledge. Students are expected to read the assigned materials before class and to participate in class discussions. This will not be a standard lecture class. *We will all need to engage in discussion.*

Requirements
To successfully complete this class you will need a laptop (please let us know if you need help accessing a laptop) and the following software:

- Netlogo (version 6.3.0) freeware modeling software, which you can download from https://ccl.northwestern.edu/netlogo/download.shtml.
- MS Office
- PDF reader

We recommend (but do not require) that you also have a statistical software of your choice installed, as it will make some analyses easier than using excel.

Course philosophy: This is a graduate level course and we expect all students to be engaged and interested in mastering the course topics to the best of their abilities. We also recognize that students will be coming to the class from a variety of academic and technical backgrounds, which we think is an asset; however, some students may not catch on to the ideas of modeling and coding as quickly as others. Given the small class size, we will make the most of each other's knowledge and skills by encouraging collaborative work. A substantial portion of each class period will be devoted to working on computer models with your team. At the beginning of the semester, in-class modeling time will be spent on labs to get you familiar with ABMs, and later in the semester you will work on your own models.

Typical Class Format
The course is designed as follows:

- General lecture sessions on Tuesdays will be based on basic concepts for the week topic and discussion of the readings assigned.
- Labs on Thursdays: will be centered upon increasing skills and ability in modeling and analysis and will be mainly focused on doing exercises in class.

Readings: We will be drawing heavily from this book, which you should all acquire:
Railsback, S.F. and V. Grimm. 2019. Agent-based and Individual-based Modeling: a Practical Introduction 2nd Edition. Princeton University Press.

Additional readings will be posted on eLC and will come from the primary literature to explore how ABMs are used and how their methods and results are reported.

Assignments deadline: Unless stated otherwise, general lecture assignments will be due on Mondays at 11:59pm and lab assignments will be due on Wednesdays at 11:59pm.

Grading: To foster a collaborative learning environment, grades will be heavily based on class participation (which includes discussion leads, completion of in-class labs, discussion participation, and working together with your team); however, we also want to encourage mastery of some content areas, which we will evaluate using homework assignments. We also want to know that students can apply what they've learned to their own research, which is why we are including an end-of-course individual project.

Discussion Leads (25 points) Each Tuesday (depending on enrollment), one course participant will need to lead the discussion on the assigned journal article for 30-35 minutes. The purpose of this discussion is to critically assess the validity of the paper assigned. Students are encouraged to search for critiques/validation of the paper assigned. If you have doubts or do not know how to proceed you can organize a meeting with Drs. Nibbelink and/or Vallury and we will provide guidelines for critiquing the paper assigned.

Homework assignments (25 points)
Each week all students will be expected to complete the assignments. Assignments vary. There will be paper and pencil exercises, finding errors in models, simple model analysis and simple model building.

Model peer-review (10 points)

Final project (40 points)

- The final project should address questions from your own research and interests. Our goal with the final projects is that you will produce models and model documentation that could comprise or significantly contribute to a thesis/dissertation chapter or publication.
- Students will have the option to choose from working individually or in groups of 2-3 people.
- Individual projects must complete an annotated bibliography of a topic of their choice and complete a model ODD.
- Group projects must complete a model ODD and develop a working model in Netlogo on a topic of their choice. Projects can replicate an existing model from the literature with extensions or build a new one.
- More details will be provided in class.
- The final project will be due on the final day of class.

Given that we have emphasized class participation so heavily, it should come as no surprise that we expect all students to attend all classes. However, as graduate students, inevitably professional obligations may interfere. When valid professional (or emergency personal) situations arise, please let us know ASAP and plan ahead as much as possible. If you miss class for other reasons (anything not described above) you will have to make use of posted course materials and classmates to catch up.

Class Policies:

1. All academic work must meet the standards contained in "A Culture of Honesty." Students are responsible for informing themselves about those standards before performing any academic work. Violations of the policy will be vigorously pursued and prosecuted.The link to more detailed information about academic honesty can be found at http://www.uga.edu/honesty/index.html http://www.uga.edu/honesty/ahpd/student_honor_code.html
2. Copying of any work that will be turned in for the course will not be tolerated. Students are encouraged to work together, but all work that is turned in must be completed by the individual. Copied work will receive a grade of zero for both the original and copy.
3. Reasonable accommodations will be made for students with disabilities. If you have a disability please register with disability services on campus and accommodations will be arranged through this service.

Class schedule: The first third of the semester will be spent on learning the ideology of individual-based modeling and ecology and how to use NetLogo. The second third of the course will be focused on different design elements of ABMs that students will use in their own models. The final third of the course will be spent on making our models as rigorous as possible. By this time, you will have a simple model of your own to test and analyze and we will be helping each other with various problems that we encounter with our models.

---The schedule is subject to change based on our collective progress. The class will be alerted to any foreseen changes with as much notice as possible.---

CLASS SCHEDULE

Week	Day	Date	Topic	Readings*	Homework**
1	Thurs	8/17	Introduction to ABM (no discussion lead)	● R&G: Ch.1 ● Lansing, J. S. (2003). Complex adaptive systems. *Annual review of anthropology*, 183-204.	
2	Tues	8/22	Introduction to Netlogo	● R&G Ch. 2 ● Bonabeau, E. (2002). Agent-based modeling: Methods and techniques for simulating human systems. *Proceedings of the National Academy of Sciences*,*99*(suppl 3), 7280-728	Ch 2. exercises
	Thurs	8/24	ODD protocol/ Conceptual Framework	● R&G: Ch. 3 ● Smaldino, P. E. (2017). Models are stupid, and we need more of them. *Computational social psychology*, 311-331.	ODD: mushroom hunt model
3	Tues	8/29	Frameworks to understand SESs	● Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science*, *325*(5939), 419-422. ● McGinnis, M. D., & Ostrom, E. (2014). Social-ecological system framework: initial changes and continuing challenges. *Ecology and Society*, *19*(2), 30.	Ch. 3 exercises 2 & 3
	Thurs	8/31	Your first ABM	R&G: Ch. 4	Ch. 4 exercises
4	Tues	9/5	Diversity in SESs	● Kotschy, K., Biggs, R., Daw, T., Folke, C., & West, P. (2015). Principle 1–Maintain diversity and redundancy. Principles for building resilience: Sustaining ecosystem services in social-ecological systems, 50-79.	Finish model from class

	Thurs	9/7	ABMs for science	● Ulanowicz, R. E., Goerner, S. J., Lietaer, B., Gomez, R. (2009). Quantifying sustainability: resilience, efficiency and the return of information theory. *Ecological Complexity*, **6**, 27-36 ● Anderies, J. M., Janssen, M. A., Walker, B. H. (2002). Grazing management, resilience and the dynamics of a fire-driven rangeland. *Ecosystems,* **5**, 23-44 R&G: Ch. 5	Ch 5. exercises
5	Tues	9/12	SES Networks	● Baggio, J.A., Schoon, M.L. & Valury, S. Managing networked landscapes: conservation in a fragmented, regionally connected world. Reg Environ Change 19, 2551–2562 (2019). https://doi.org/10.1007/s10113-019-01567-8 ● Baggio, J. A., Salau, K., Janssen, M. A., Schoon, M. L., Bodin, Ö. (2010). Landscape connectivity and predator–prey population dynamics. *Landscape Ecology*, **26** (1), 33-45.	
	Thurs	9/14	Model testing	Ch 5	Ch. 5 exercises
6	Tues	9/19	Model testing	● R&G: Ch. 6	Ch. 6 exercises
	Thurs	9/21	Final project	-	-
7	Tues	9/26	Emergence	● R&G: Ch. 8	Ch 8 exercises
	Thurs	9/28	Final project	–	-
8	Tues	10/3	Final project chalk talks		Peer-review

	Thurs	10/5	Sensing & Adaptive Behavior	● R&G Ch 10 ● R&G: Ch. 11	Ch. 10 & 11 exercises
9	Tues	10/10	SES Modeling/Project work time	● Schlüter, M., & Pahl-Wostl, C. (2007). Mechanisms of resilience in common-pool resource management systems: an agent-based model of water use in a river basin. *Ecology and Society*, *12*(2).	
	Thurs	10/12	Scheduling	R&G Ch 14	Ch. 14 exercises
10	Tues	10/17	Stochasticity	R&G Ch: 15	Ch 15 exercises
	Thurs	10/19	Final project	–	–
11	Tues	10/24	Parameterization and Calibration	● R&G: Ch. 20 ● Martin, R., & Schlüter, M. (2015). Combining system dynamics and agent-based modeling to analyze social-ecological interactions—an example from modeling restoration of a shallow lake. Frontiers in Environmental Science, 3, 66.	Ch. 20 exercises
	Thurs	10/26	Project status presentations	–	Peer review
12	Tues	10/31	Model Analysis	R&G: Ch. 22	Ch. 22 exercises
	Thurs	11/2	Project work day	--	
13	Tues	11/7	Project work day	–	
	Thurs	11/9	Sensitivity/Uncertainty	● R&G Ch 23 ● Schlüter, M., & Pahl-Wostl, C. (2007). Mechanisms of resilience in common-pool resource management systems: an agent-based model of water use in a river basin. *Ecology and Society*, *12*(2).	TBD
14	Tues	11/14	Work day		
	Thurs	11/16	Work day		

15	Tues Thurs	11/21 11/23	*Thanksgiving break* *No class*		-- --
16	Tues Thurs	11/28 11/30	Final project presentations Final project presentations/ What makes a good model?/Synthesis of what we've learned	-	- **Final projects due**

* Readings are to be done before the class period indicated.