Earth System Science 185/Earth Systems 183: Adaptation

Instructor: James Holland Jones

3 January 2022

Monday/Wednesday 13:30-15:00
STLC, Room 104
Winter Quarter 2022

1 Course Description

From the Course Catalogue: Adaptation is the process by which organisms or societies become better suited to their environments. In this class, we will explore three distinct but related notions of adaptation. Biological adaptations arise through natural selection, while cultural adaptations arise from a variety of processes, some of which closely resemble natural selection. A newer notion of adaptation has emerged in the context of climate change where adaptation takes on a highly instrumental, and often planned, quality as a response to the negative impacts of environmental change. We will discuss each of these ideas, using their commonalities and subtle differences to develop a broader understanding of the dynamic interplay between people and their environments. Topics covered will include, among others: evolution, natural selection, levels of selection, formal models of cultural evolution, replicator dynamics, resilience, rationality and its limits, complexity, adaptive management.

The ideas that underlie climate adaptation have circulated in biology, anthropology, geography, and related fields for well over a century. How do these broader notions of adaptation inform our understanding of climate adaptation? Socioecological systems are complex, meaning that they are comprised of multiple, interacting components and these interactions can lead to abrupt transitions and generally make long-range prediction difficult. How do the challenges of socioecological complexity play into adaptive processes? People facing changing environments and livelihoods typically do so within a context of extreme uncertainty. When uncertainty can't be reduced by any reasonable amount of information-seeking, it is called *structural*. How does structural uncertainty affect optimal and actual decisions? It turns out that many of the problems that people face under global climate change have already been faced, to one degree or another, by people somewhere in the world. How can an understanding of the variety of the lived experience and approaches to problem-solving of diverse people help us engineer sensible and sustainable climate adaptations?

2 Expectations

This course uses mathematics to describe processes relevant to the study of adaptation, human biology, and behavior. It is not, however, a course in mathematics. You will not be expected to complete mathematical proofs or derive complex formulae. You will be expected to understand the theory contained in the mathematics as described in class lectures and in the readings. A basic understanding of calculus will be assumed.

Class meets twice weekly on Monday and Wednesday afternoons. Following the Provost's notice of 16 December 2021, the first two weeks of class will be on Zoom. These lectures will be recorded and available via Canvas. When we resume in-person instruction, I will do my best to record lectures and make them viewable/downloadable for asynchronous use as well, but the quality of these will depend on technological details that are outside of my control. I encourage you to attend the synchronous meeting if possible because these will typically be at least somewhat interactive.

2.1 Theoretical Supplements

In addition to the standard class lectures, I will record a series of short *theoretical supplements* that will provide a tutorial on specific technical/theoretical topics relevant for the course material. These videos fall into three broad headings: Selection and Adaptation, Dynamical Systems, and Risk, Uncertainty, and Management. These supplements allow for a partial flipping of the class, providing more time during lecture to address case studies, and questions about concepts, readings, etc. In some of these videos, I will sometimes use the `R` statistical programming language to show calculations, make plots etc. This does not mean that you need to know or use `R`, though you would benefit from learning! I will always post code used in the videos on the class Github repository.

1. Selection and Adaptation
   (a) Price equation
   (b) Fisher's fundamental theorem
   (c) Breeder's equation
2. Dynamical Systems
   (a) Perturbation analysis of stable points
   (b) Perturbation analysis of several variables
   (c) Cobwebbing (logistic map, poverty trap)
   (d) Catastrophes
   (e) Critical slowing down
3. Risk, Uncertainty, and Management
   (a) Risk aversion and expected utility

(b) Time discounting

(c) Hierarchical preferences and selection

(d) Heavy-tailed probability distributions

2.2 Problem Sets

There will be five total problem sets (approximately every other week). The problem sets will reinforce skills discussed in lecture and call on the weekly readings. Problem sets will be made available on Canvas.

2.3 Learning Outcomes

Students who successfully complete this class will achieve several learning outcomes: students will be able to (1) apply the related concepts of selection and adaptation to a wide range of phenomena, while avoiding the common intellectual traps of teleology and progressivism, (2) apply concepts from linear stability analysis to a range of social, ecological, and economic problems, (3) apply the concepts of coupling and complexity to diverse socioecological systems, (4) deploy critical skills to see beyond simplistic dichotomies (e.g., natural vs. human, mitigation vs. adaptation, rational vs. emotional) and narratives (e.g., evolution as progress, human decision-making as hopelessly irrational, economic "development"), (5) interpret complex scientific figures (e.g., recruitment curves, attractors, graphs), (6) deploy critical skills for evaluating cost-benefit analyses in the presence of complexity and structural uncertainty.

3 Grading

The breakdown of grading for this class will be as follows:

60% Problem Sets. Take these seriously as they are the majority of your grade. You will be able to drop one.

15% Midterm Exam.

25% Final Exam.

4 Prerequisites

There are no specific requirements for this class, though familiarity with evolution and ecology will be helpful. You have to be willing to push your boundaries a bit. Some part of this course is almost certain to be unfamiliar to all students. This is OK – it's actually how we learn. We will discuss mathematical ideas such as complex systems and decision theory to understand problems of adaptation. You've gotta be cool with that. This mostly boils down to familiarity with ideas from calculus.

5 Readings

I have a philosophy of not using textbooks (or using open-access) whenever possible. All the readings for this class come from the primary scientific literature and are available electronically. Note that nearly all readings listed in this syllabus are linked to electronic sources via their respective digital object identifier (doi). Papers without a doi (e.g., two papers currently in press) will be provided on Canvas. In addition to these readings, we will utilize electronic course notes I've developed over several iterations of teaching this and related classes.

Each week, there are required readings (noted as "Readings" in the schedule). There are also readings listed as "Optional." The optional readings relate to the week's content and are often a bit more technical or represent an elaboration on the main theme of the week. While they are not required, ideas discussed in them are likely to be included in the week's lecture material. To the extent that ideas from these readings are included in lectures, they are fair game for problem sets.

6 Course Outline (Subject to Change)

Week 1 Why Bother with Models?

Readings: Smaldino (2017), Muthukrishna and Henrich (2019), Bergman and Beehner (2021)
Optional Readings: Levins (1966)

Week 2 Evolutionary Foundations

Adaptation, Natural Selection, Fitness, Fisher's Fundamental Theorem, Price Equation, Extinction

Readings: Lewontin (1978), Pisor and Jones (2021), Jones et al. (2020)
Optional Readings: Frank (2012), Queller (2017)

Week 3 Does Culture Evolve?

Cultural Evolution, Transmission Dynamics, Coevolution, Rogers' Paradox

Readings: Henrich and McElreath (2003), Creanza et al. (2017), Kolodny et al. (2018)
Optional Readings: Derex and Mesoudi (2020), Rogers (1988), Fogarty and Kandler (2020), Whitehead and Richerson (2009)

Week 4 Risk and Uncertainty

Axiomatic Rationality, Expected Utility Theory, Risk-Management, Uncertainty, Ecological Rationality

Readings: Gigerenzer and Gaissmaier (2011), Price and Jones (2020)
Optional Readings: Elster (1986), Simon (1955), Tversky and Kahneman (1974), Pepper and Nettle (2017), Waldman et al. (2020), Houston et al. (2007), Fawcett et al. (2014), Weber (2017), Peters (2019)

Week 5 Complexity

Coupling, Nonlinearity, Emergence, Catastrophes, Chaos, Critical Slowing Down

Readings: Scheffer and Carpenter (2003), Lansing (2003)
Optional Readings: Scheffer et al. (2012), Zeeman (1976)

Week 6 Emergence and Governing the Commons

Commons, Resource Management

Readings: Ostrom (2015), Moritz et al. (2018), Lansing et al. (2017)
Optional Readings: Cinner et al. (2018), Barnes et al. (2020)
Video: Self-Organization of Balinese Water Temples

Week 7 Resilience

Vulnerability, Resilience, Adaptive Capacity

Readings: Holling (1973), Adger (2000), Berkes (2007)
Optional Readings: Ludwig et al. (1997), Gunderson (2000), de Zeeuw (2014), Bonds et al. (2010)

Week 8 Networks, Exchange, and Traditional Ecological Knowledge

Strong Ties/Weak Ties, Sharing, Exchange Networks, Livelihood Diversity, Traditional Ecological Knowledge, Structural Uncertainty

Readings: Wiessner (2002), Ready and Power (2018), Pisor et al. (2022)
Optional Readings: Ortiz (1979), Berkes et al. (2000)

Week 9 Innovation, Complex Contagion, Diffusion

Complex Contagion, Diffusion

Readings: Centola (2019), Fogarty et al. (2015), Boyd and Richerson (2007)
Optional Readings: Dodds and Watts (2005), Centola and Macy (2007)

Week 10 Structure of Successful Problem-Solving

Diversity, Wisdom of Crowds, High-Reliability Organizations, Curse of Complexity, Redundancy, Networks

Readings: Hong and Page (2004), Sagan (2004)
Optional Readings: Weitzman (2009)

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