

## DEPARTMENT OF CITY AND REGIONAL PLANNING

University of North Carolina at Chapel Hill

### PLAN 722: Systems Thinking and Modeling for Planners

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Office Hours: 4 – 5 M, and by Appt. (email to confirm availability)

Office: New East 307

Spring 2017

2:30 – 3:45 MW (Lecture)

Location: Phillips 222

9:30 – 10:45 T (Lab)

Location: Carolina Hall 322

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#### Objectives

This course will introduce systems thinking and system dynamics computer simulation modeling, a computer-aided approach to policy analysis and design. The goal of this course is to enhance knowledge and skills in understanding and analyzing the complex feedback dynamics in social, economic, and environmental problems. We will also spend substantial time understanding how policy interventions affect the behavior and structure of systems.

These topics will serve as important background for students' future courses in land use, transportation, and economic development planning. Students will have a better understanding of feedback and its non-intuitive effects within social and physical systems, as well as an understanding of how to quantify causal relationships in dynamic, complex systems. The course will introduce system dynamics modeling through the STELLA modeling platform.

#### Approach

We will strive to help you think about planning issues in rigorous feedback and causal terms. The systems thinking and modeling methods taught in the class will provide one of the key lenses with which you can view and analyze planning problems and evaluate solutions. You will learn about techniques that can help you make decisions in complex planning situations, where you can use powerful methods to develop insights, understand key relationships and predict outcomes. We will emphasize the application and interpretation of modeling concepts and output rather than mathematical theory.

Adapted from the *System Dynamics Society*:

System dynamics is a computer-aided approach to policy analysis and design. It applies to dynamic problems arising in complex social, managerial, economic, or ecological systems — any dynamic systems characterized by interdependence, mutual interaction, information feedback, and circular causality. The span of applications has grown from corporate and industrial problems to include the management of research and development, urban stagnation and decay, commodity cycles, and the dynamics of growth in a finite world. System dynamics is now applied in economics, public policy, environmental studies, defense, theory-building in social science, and other areas, as well as its home field of management.

The system dynamics approach involves:

- Defining problems dynamically, in terms of graphs over time (something we weren't able to do easily in PLAN 721).
- Striving for an endogenous, behavioral view of the significant dynamics of a system, a focus inward on the characteristics of a system that themselves generate or exacerbate the perceived problem.
- Thinking of all concepts in the real system as continuous quantities interconnected in loops of information feedback and circular causality.
- Identifying independent stocks or accumulations (levels) in the system and their inflows and outflows (rates).
- Formulating a behavioral model capable of reproducing, by itself, the dynamic problem of concern. The model is usually a computer simulation model expressed in nonlinear equations, but is occasionally left un-quantified as a diagram capturing the stock-and-flow/causal feedback structure of the system.
- Deriving understandings and applicable policy insights from the resulting model.
- Implementing changes resulting from model-based understandings and insights.

## Course Prerequisites

There are no pre-requisites for this course other than college-level algebra and computer literacy.

PLEASE REGISTER FOR BOTH THE LECTURE AND LAB PORTIONS OF THE COURSE.

## Course Requirements and Grading

The requirements for the course include:

- Active class participation and attendance (20% of the grade).
- Assignments (80% of the grade).

**Grading Notes:** Generally, an **H** grade is given for exceptional work that demonstrates a real mastery of course material. **L** or **F** work substantially fails to meet minimum requirements either due to incomplete coverage of required information, incorrect results, or sloppy, unprofessional reporting of results.

## Other Academic Business

**Missing Class:** Students are permitted to miss class for EXCUSABLE absences only (details about excused absences, see UNC-Chapel Hill's attendance policy: <http://www.catalog.unc.edu/policies-procedures/attendance-grading-examination/>).

**Policy on Late or Incomplete Work:** As a matter of departmental policy, and in order to be fair to your fellow students (particularly in light of the extensive time requirements of this course), **late assignments will not ordinarily be accepted.**

- **No extensions will be given.**
- **Zero points will be assigned to work not turned in on time.**

IF YOU HAVE A MEDICAL EMERGENCY, PLEASE INFORM THE INSTRUCTOR AS SOON AS POSSIBLE. Grades of incomplete may be given in the event of a medical or another emergency. In these cases, a written application for an incomplete on any assignment must state the reasons for the request and propose a new deadline.

### Important points:

1. This course, like others at DCRP, considers reading comprehension and time management to be a skill. \*\*\*PLEASE READ THE ASSIGNED MATERIAL BEFORE EACH CLASS \*\*\*.
2. Please bring calculators to all classes.
3. Students are expected to complete all assignments individually. Discussions with classmates about assignments are encouraged, but all final work must be entirely your own.
4. You are expected to show all work on your assignments.
5. HARD COPIES of assignments must be turned in at the beginning of class on the due date. [this means you need to find a printer ahead of time – not printing the assignment is not an excuse!]
6. Please arrive on time and turn off cell phones in class.
7. Please contact the instructor or TA if you have any questions, problems with the readings or the course, or any other issues that you wish to discuss.
8. Students in this class are encouraged to speak up and participate during class meetings. Because the class will represent a diversity of individual beliefs, backgrounds, and experiences, every member of this class needs to show respect for every other member.

**Resources:** Our purpose as professors is to help you to excel in this learning environment. Should you need further assistance beyond the help of the professor, please consult the following on-campus resources:

- The Writing Center: <http://writingcenter.unc.edu/>
- The Learning Center: <http://learningcenter.unc.edu/>
- The Learning Center resources for students with learning disabilities (LD) and/or attention-deficit/hyperactivity disorder (ADHD): <http://learningcenter.unc.edu/ldadhd-services/>
- The Center for Student Success and Academic Counseling: <http://cssac.unc.edu/>
- Counseling and Wellness Services: <http://campushealth.unc.edu>

**The University's Honor Code is in effect.** The University of North Carolina at Chapel Hill has had a student-administered honor systems and judicial system for over 100 years. The Honor Code represents UNC-Chapel Hill students' commitment to maintain an environment in which all students respect one another and are able to attain their educational goals. As a student at Carolina, you are entering a community in which integrity matters – integrity in the work you submit, and integrity in the manner in

which you treat your fellow Carolina community members. Because academic honesty and trustworthiness are important to professional planning, this is a significant University and Departmental tradition. Your attention is called to the Instrument of Student Judicial Governance for policies and procedures pertaining to the honor system. We are committed to treating Honor Code violations seriously and urge all students to become familiar with its terms set out at <https://studentconduct.unc.edu/>. If you have questions it is your responsibility to ask the professor about the Code's application. Please consult with the instructor if you are uncertain about your responsibilities under that code with respect to this course.

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The University of North Carolina – Chapel Hill facilitates the implementation of reasonable accommodations, including resources and services, for students with disabilities, chronic medical conditions, a temporary disability or pregnancy complications resulting in difficulties with accessing learning opportunities. All accommodations are coordinated through the Accessibility Resources and Service Office. Any student who feels s/he may need an accommodation based on the impact of a disability should contact me privately early in the semester to discuss your specific needs. Students with documented disabilities should contact the Department of Disability Services at 919-962-8300 (SASB North, Suite 2126) to coordinate reasonable accommodations.

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## Course Materials

### Required

- Andrew Ford. 2009. Modeling the Environment: An Introduction to System Dynamics Modeling of Environmental Systems (2<sup>nd</sup> Edition). Washington, D.C.: Island Press.
- Donella H. Meadows. 2008. *Thinking in Systems: A Primer*. Chelsea Green: White River Junction, Vermont.
- Please purchase a package of 3x5 index cards for use during class and bring them to each class meeting.
- Scientific/graphing calculator capable of logarithmic calculations (e.g. found on smart phones when held horizontally).

Additional reading materials and links will be posted on the course Sakai website.

### Software

- STELLA – system dynamics modeling software used to graphically represent complex feedback systems. The STELLA software is available on the UNC Virtual Computing Lab ('VCL'). We will be posting information on Sakai about accessing the VCL during the first week of class.
- Vensim PLE (Personal Learning Edition; <http://www.vensim.com/>) is another sophisticated dynamic modeling package that is freely available online. It is not compatible with STELLA and has a sharper learning curve, but it can perform all of the same (and many additional) functions.

## Assignment and Lab Schedule

### Assignments

HW	Due Date	Topic
1	Apr. 3	Building blocks: Stocks, Flows, and Archetypes
2	Apr. 12	Feedback in Modeling
3	Apr. 17	Cyclical Behavior
4	Apr. 28	Advanced Modeling

### Computer Lab Sessions

Computer lab sessions will be offered during the semester to help familiarize students with the software packages that will be used in the class. The schedule of these lab sessions is given below.

Lab	Date	Topic
1	Mar. 28	Dynamic Modeling I (STELLA/Vensim) <i>Reading: Ford Textbook, Chapter 2</i>
2	Apr. 11	Dynamic Modeling II (STELLA/Vensim) <i>Reading: Ford Textbook, Chapter 14</i>

The professor reserves the right to make changes to the syllabus, including project due dates, when unforeseen circumstances occur. These changes will be announced as early as possible so that students can adjust their schedules."

## Course Outline

\*\*\*PLEASE READ THE ASSIGNED MATERIAL BEFORE EACH CLASS \*\*\*  
PLEASE BRING CALCULATORS TO ALL CLASSES

### Mar 20. Introduction to Systems Thinking and Modeling

- Batty, Michael. 2001. Models in planning: Technological imperatives and changing roles. *International Journal of Applied Earth Observation and Geoinformation*, 3(3): 252-266.
- *Meadows Textbook*: Introduction and Chapter 1
- Kauffman, Draper. 1980. *Systems One: An Introduction to Systems Thinking*. Chapter 1: What is a System?

#### Additional Reading:

- Sterman, J. D. (1991). A Skeptic's Guide to Computer Models. In Barney, G. O. et al. (eds.), Managing a Nation: The Microcomputer Software Catalog. Boulder, CO: Westview Press, 209- 229.

### Mar 22: Stocks and Flows

- *Meadows Textbook*: Chapter 2
- *Ford Textbook*: Chapter 3 and 4 (Stocks and Flows: The Building Blocks of System Dynamics Models; Accumulating the Flows).

### Mar 27. Dynamic Equilibrium and System Archetypes

- Kauffman, Draper. 1980. *Systems One: An Introduction to Systems Thinking*. Chapter 2: Stability
- *Ford Textbook*: Chapter 6 and 7 (Equilibrium Diagrams and S-Shaped Growth).

## Part 2: Positive and Negative Feedback

### Mar 29. Introduction to Feedback

- Kauffman, Draper. 1980. *Systems One: An Introduction to Systems Thinking*. Chapter 3: Things in Common
- *Ford Textbook*: Chapter 9 (Information Feedback and Causal Loop Diagrams).

#### Additional Reading:

- Sterman, J. D. Business Dynamics: Systems Thinking and Modeling for a Complex World. Boston, MA: Irwin McGraw-Hill. Chapter 5: Causal Loop Diagrams. Pgs. 137-190.
- *Ford Textbook*: Chapter 5 (Case #1. Water Flows in the Mono Basin).

### Apr 3. Feedback Loops and Homeostasis

- Kauffman, Draper. 1980. *Systems One: An Introduction to Systems Thinking*. Chapter 4: Change and Growth and Chapter 5: Putting the Pieces Together
- *Ford Textbook*: Chapter 10 (Homeostasis).

### Apr 5. NO CLASS

## Part 3: Policy Development: Application to Urban Dynamics and Climate Change

### Apr 10. The Modeling Process and First Policy Application

- Navid Ghaffarzadegan, John Lyneis, and George P. Richardson. 2011. How small system dynamics models can help the public policy process. *System Dynamics Review* 27(1): 22-44
- *Ford Textbook*: Chapter 13 and 16 (The Modeling Process, Managing a Feebate Program for Cleaner Vehicles).

### Apr 12. Introduction to Cyclical Behavior

- *Ford Textbook*: Chapter 18 and 19 (Introduction to Cyclical Behavior; Cycles in Real-Estate Construction).

### Apr 17, 19. Guest Lectures on Triangle Light Rail SD Model (Rochelle Araujo, Jenna Kolling; Environmental Protection Agency)

- J. Kolling, L. Cox, N. Flanders, A. Procter, N. Tanners, A. Bassi, R. Araujo. 2015. Executive Summary: A System Dynamics Model for Integrated Decision Making: The Durham-Orange Light Rail Project. Environmental Protection Agency: Durham, NC.

Additional Reading:

- Collins, John F. 1974. Chapter 1: Managing Our Cities – Can We Do Better? In: Readings in Urban Dynamics: Volume 1. Edited by Nathaniel Mass. Cambridge, MA: MIT Press. Pgs 3-11.
- Schroeder III, Walter W. Chapter 3: Urban Management Actions. In: Readings in Urban Dynamics: Volume 2. Edited by Walter W. Schroeder III, Robert E. Sweeney, and Louis Edward Alfeld. Cambridge, MA: MIT Press. Pgs. 31-48
- *Ford Textbook*: Chapter 23 (CO<sub>2</sub> in the Atmosphere).

Apr 24, 26: Agent-Based modeling

- Kauffman, Draper. 1980. *Systems One: An Introduction to Systems Thinking*. Chapter 6: Complex Systems
- Zellner, Moira. L. 2008. Embracing Complexity and Uncertainty: The Potential of Agent-Based Modeling for Environmental Planning and Policy. *Planning Theory & Practice*, 9(4): 437–457.
- BenDor, Todd. Chapter 6: Agent Based Modeling (Chapter 6). (In Process) *Agent-Based Modeling of Environmental Conflict and Cooperation*. Book Manuscript.

Apr 28<sup>th</sup>: **Final assignment due (hardcopy) at 5pm in TA's mailbox on second floor of New East.**