

## SYLLABUS

### PRINCIPLES OF SUSTAINABILITY IN COMPLEX SYSTEMS

SPRING 2007

ESS 578

3 CREDITS

TOM WESSELS

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#### COURSE CONTENT

This course will begin with a historical examination of complex systems science as opposed to linear reductionistic science. We will then explore the three foundational laws that govern sustainability in all complex systems; these are the law of limits to growth, the second law of thermodynamics, and the law of self-organization. We will work with these laws at various spatial and temporal scales in biological, ecological, and physical systems to develop a firm grounding in their functioning. We will then apply them to human systems as a means to develop sustainable models.

#### EVALUATION CRITERIA

Class Attendance—We will be involved in many application exercises in this class that will be difficult to reproduce outside of class. Therefore class attendance is a must. Any student missing three or more classes will receive a No Credit for the class. If you will need to miss a class and your schedule allows you to participate in the other section that week, please do so.

Reaction papers—Following class discussions you will be asked to reflect on the topic of discussion and develop your personal stance. These reaction papers should be somewhere between 2-6 pages in length, but the quality of thinking and evidence to support one's arguments are more critical than the length of the paper. The first of the two papers will be due the week of **Feb. 8-9**. The second will be due **April 12-13**. The topics for the papers will be discussed during the previous week's class of when they are due. The first topic will involve limits to growth and the second self-organization.

Presentations—There will be three presentations that you will do for this class. The first will be done by individuals, the second in pairs, and the third either by individuals or in pairs.

*Complex systems theorists*: These will be short, 3-5 minute presentations on the complex systems scientists listed below. Each student will present one theorist. These short presentations should cover the individual's work, where it fits in the history of complex systems thinking, other researchers who influenced their thinking, and any interesting or unusual attributes about the researcher. Subjects will be chosen during the first class and these presentations will take place the following week of **Jan. 25-26**. Prior to the presentations students will sort themselves out in a chronology based on when their individual's significant work

was done. The presentations will be presented in this chronology to create a timeline for the development of complex systems science. The theorists include: Henri Poincare, Hans Driesch, Werner Heisenberg, Max Wertheimer, Alexander Bogdanov, Frederic Clements, Vladimir Vernadsky, C.D. Broad, Ludwig von Bertalanffy, Norbert Wiener, John von Neuman, Gregory Bateson, Margoroh Maruyama, Ilya Prigogine, Hermann Haken, Edward Lorenz, James Lovelock. Lynn Margulis, Humberto Maturana.

*Energy resources:* These will be 15-20 minute presentations done in pairs the weeks of **March 1-2**. Each pair will examine one energy resource and critique its efficiency and environmental impacts with a cradle to grave assessment. For example how much energy does it take to find, mine, process uranium, build a nuclear reactor, decommission a reactor, and handle radioactive waste in comparison to the amount of electricity a nuclear reactor generates? What are the environmental impacts from all these activities? These topics will be chosen the first week of class. The energy resources to be presented include: coal, oil, natural gas, hydrogen, nuclear, wind, solar, wood, geothermal, biodiesel, ethanol.

*Sustainability assessment of an anthropogenic system:* These 20-30 minute presentations can be done in pairs or by individuals and will occur during the last two weeks of classes May 3-4 and May 10-11. For this presentation students will choose a system to assess in terms of its sustainability based on the material covered during the term. The system could be a state-wide energy system, a municipal transportation system, an intentional community, a local economy, a school, a farm, an environmental education center, a business or just about any human created system. For this presentation you will need to investigate inputs and outputs as well as the system's organization to ascertain if it is a sustainable system. Recommendations for improving sustainability should be included in the presentation. I'll be glad to brainstorm with students about their topic of focus for this assignment. Students should decide on their human system and let me know their choice by Feb. 16.

## TEXT

Wessels, Tom. 2006. *The Myth of Progress: Toward a Sustainable Future*. University of Vermont Press. Lebanon, NH.

## RESERVE READINGS

Allen, Timothy and Thomas. Hoekstra. 1992. *Toward a Unified Ecology*. Columbia University Press. New York. Introduction.

Capra, Fritjof. 1996. *The Web of Life*. Anchor Books Doubleday. New York. Chapters 2-5.

Ehrlich, Paul. 1986. *The Machinery of Nature*. Simon and Schuster. New York. Chapter 4

Foster, David. 1988. Disturbance history, community organization and vegetation dynamics of the old-growth Pisgah forest, south-western New Hampshire, U.S.A. *Journal of Ecology* 76:105-134.

Gosz, James, et. al. 1978. The Flow of Energy in a Forest Ecosystem. *Scientific American*. March: 93-102

Jantsch, Erich. 1980. *The Self-organizing Universe*. Pergamon Press. Oxford. Chapter 6.

Molles, Manuel. 2006. *Ecology: Concepts and Applications*. McGraw Hill. Boston. Chapter 11.

Raven, Peter and George Johnson. 2002. *Biology*. McGraw Hill. Boston. Chapter 17.

Schumacher, E. F. 1973. *Small is Beautiful: Economics as if People Mattered*. Harper and Row. New York. Chapter 5.

Thomas, Lewis. 1975. *The Lives of a Cell: Notes of a Biology Watcher*. Bantam Books. Toronto. Organelles as Organisms.

Wilson, Edward O. 1992. *The Diversity of Life*. W.W. Norton and Company. New York. Chapters 7 and 10.

## FIRST CLASS FOLDER

The First Class course folder will be used for posting, sharing resources, asking questions, and any other productive communications. If you have a personal question use my personal e-mail and not the class folder. However, if you have a question that will benefit the class post it in the course folder.

## SCHEDULE

Jan. 18-19      Course overview, Deconstructing science, The importance of scaling, Introduction to linear and complex system science

### **Assignments due:**

READINGS: Introduction and Chapter1 The Myth of Progress,  
Introduction Toward a Unified Ecology

Jan. 25-26 Chronology of complex systems science theorists, Positive and negative feedback in complex systems, Bifurcation events

**Assignments due:**

READINGS: Chapter 2-5 The Web of Life

PRESENTATIONS: Complex systems science theorists

Feb. 1-2 Limits to growth, r and k selection, Population growth

**Assignments due:**

READINGS: Chapter 2 the Myth of Progress, Chapter 11 Ecology

Concepts and Applications

Feb. 8-9 Limits to growth at the organismal level, Limits to growth at the ecosystem level, The second law of thermodynamics

**Assignments due:**

READINGS: Chapter 3 The Myth of Progress, Chapter 7 The Diversity of Life

REACTION PAPER: Limits to growth

Feb. 15-16 Field trip to visit some Green Buildings, evaluating energy footprints

**Assignments due:**

READINGS: The Flow of Energy in a Forest Ecosystem

Feb. 22-23 Prep time for energy resources presentations

March 1-2 Energy resource presentations, mid-semester course evaluation

**Assignments due:**

PRESENTATIONS: Energy resources

March 8-9 Field trip to Pisgah Old Growth, examination of energy states

**Assignments due:**

READINGS: Disturbance history, community organization and vegetation dynamics of the old-growth Pisgah forest, south-western New Hampshire, U.S.A.

March 29-30 The law of self-organization at the ecosystem level, Symbioses, Coevolution and niche separation, Species richness

**Assignments due:**

READINGS: Chapter 4 the Myth of progress, Chapter 4 The Machinery of Nature, Chapter 10 The Diversity of Life

April 5-6 Self-organization at the organismal and biospheric levels, Castles of Clay

**Assignments due:**

READINGS: Chapter 17 Biology, Organelles as Organisms in The Lives of a Cell, Chapter 6 The Self-organizing Universe

April 12-13 The human dimensions of self-organization, Prep for Putney field trip

**Assignments due:**

READINGS: Chapter 5 and epilogue The Myth of Progress, Chapter 5 Small is Beautiful  
REACTION PAPER: Self-organization

April 19-20 Prep time for final presentations

April 26-27 Field trip to Putney Central School Forest, an examination of ecosystem self-organization

May 3-4 Presentations on Anthropogenic systems

**Assignments due:**

PRESENTATIONS: Human systems

May 10-11 Presentations continued, course evaluation

**DIRECTIONS FOR FIELD TRIPS**

Pisgah (20 MINUTES FROM ANTIOCH): For this trip we will meet at the Horseshoe Road Trailhead. To get there travel west from Keene on route 9. At route 63 turn left and take 63 south to the village of Chesterfield. Just before the elementary school take a left, and in a short distance take your first right onto Horseshoe Road. The trailhead is at the end of the road.

Putney(40 MINUTES FROM ANTIOCH): The class will meet at the Putney Central School outdoor pool. To get to the school take interstate 91 to exit 4 and follow route 5 into the center of Putney. Turn left off of route 5 between the Putney General Store and the Tavern. Drive about a mile and the Central School will be on the right. Turn right down the dirt driveway just before the school building to the outdoor pool.