James Madison University

Department of Geology
And Environmental Science

syllabus
envt 200

Environmental Systems Theory

fall, 2009

CLASS NUMBER:	ENVT 200-1 LEC 93263	
CREDIT HOURS:	03	
LECTURE:	Memorial, Room 7315, TuTh 2:00PM - 3:15PM	
LAB:	*There will be several times during the semester when we run some experiments in the computer lab. Times of these is irregular; we go to lab when it is time for lab, and return to class when it is time for class*	
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FINAL EXAM:		
TEXTS:		

Introduction

"Many of the great ruins that grace the deserts and jungles of the earth are monuments to progress traps, the headstones of civilizations which fell victim to their own success. In the fates of such societies—once mighty, complex, and brilliant—lie the most instructive lessons for our own. Their ruins are shipwrecks that marks the shoals of progress. Or—to use the more modern analogy—they are fallen airliners whose black boxes can tell us what went wrong."

Ronald Wright, A Short History of Progress, p 8

We as a species live on a planet we pretty much take for granted. Unlike earlier peoples before about 15,000 years ago who believed they belonged to the Earth in the same way as the rocks, rivers and trees do, who believed we must respect the Earth's natural rhythms, our relationship with the Earth has become too overwhelmingly human-centered. Most people today live in completely human engineered urban centers as divorced from nature as we can get. As a result we treat the Earth like a black box. Things go into it (like garbage), and things come out of it (like water, and energy, and minerals) but most people do not really know, or care, about what goes on in between.

Yet, virtually every day on the news—rarely through our own experience—we become more aware of environmental problems: global warming, polluted drinking water, not enough landfills for all our garbage, and the loss of rural landscapes (especially in northern Virginia and its suburbs that now extend as far as Pennsylvania), to mention just a few. We wring our hands over how awful the human species is, doing all these things that pollute the Earth, destroy the Bay, over fish the fish. We know there is something wrong, but most of the time we do not know enough, or have the will, or have the ability (for reasons we will explore) to act more responsibly.

Alternatively, we are immersed in news reports of the destructive power of the Earth. Ever watch Storm Stories on the Weather Channel? You might come to think the Earth is out to get us: hurricanes, tornados, floods, fires, landslides, earth quakes, volcanic eruptions.

We blame the Earth for being what it is and doing what it does, without understanding the why of it. We also have the illusion we might be able to do something about these calamities—without inconveniencing ourselves, of course—diminishing them, make they go away, make ourselves safe.

These perspectives are misguided at best. P.M.A.J Atwater expressed it well while commenting on the December, 2004 Indonesian tsunami.

"No government can be blamed for the tsunami tragedy,
or cursed for not having done enough to prevent it.
We are not God.
We can recognize and work with the Earth's evolutionary design,
but we cannot stop it –
Nor should we."

The problem with most thinking about Earth environments and man's relationship to those environments is they are thought of as separate problems. But, the Earth does not have an environmental problem. We humans may have problems with the environment, but the Earth

does not. Over 4 billion years of evolutionary history the Earth has seen glaciations that froze the oceans at the equator, to tropical climates so extensive that even the north and south poles were warm in winter, to widespread desert conditions, to a time when oxygen levels plummeted so low 96% of species went extinct because they could not breath. The Earth does not care what we do—it has seen it all, and survived it all. But, for our own sakes we sure need to care—if we only knew how.

We are not nearly as tough, or as clever as we think we are (the recent economic collapse is evidence of that). In fact, most people are quite ignorant of this planet and how it works. And most people are quite ignorant of how we as a species work. History is littered with civilization after civilization that at the very peak of their power, crashed and burned. Crashed and burned because they were ignorant of their environment, and pushed it way past its limits, and did not have the self-knowledge to do anything about it, just as we are doing now.

But, ever since humans gained consciousness of the world around them they have struggled to gain understanding. The oldest attempts we know of to explain the world go back to the Paleolithic a few tens of thousands of years ago—although they no doubt must be much older. These explanations consisted of myths—timeless true stories about the origins and endings of things—that explained the world in terms of animated forces. But, our explanations, our myths, have not been static—they have evolved and become more elaborate, as human culture has evolved and become more elaborate. Beginning with the spiritual world of the Paleolithic stone age, to the religious replenishing rituals that supported Neolithic agriculture, to the awareness of individual suffering that led to the monothesisms of the Axial Age, to the Modern Age striving (more or less unsuccessfully) to replace the intuitive mythical modes for finding meaning with the more pragmatic, logical spirit of scientific rationality, our views of what is meaningful and necessary have always adapted to our evolving necessity.

This means that scientific explanations in general, and geological explanations in particular, are really quite young. And, just as in the past, our ideas, our myths, our explanations have evolved, so they continue to evolve—even as we speak. And yet, for all our seeming scientific sophistication we are in as deep trouble now as hundreds of civilizations were—before they collapsed. The supposed sophistication of our civilization and science masks our deep naivete, our deep delusions, and our deep ignorance. Lynn Margulis expresses this bluntly.

> ***To me, the human move to take responsibility for the living Earth is laughable, the rhetoric of the powerless. The planet takes care of us, not we of it. Our self-inflated moral imperative to guide a wayward Earth or heal our sick planet is evidence of our immense capacity for self-delusion. Rather, we need to protect us from ourselves.***

The purpose of this course is to put all of this growing and changing understanding into context, to explain where we have come from, how we have gotten to where we are, and how it might change in the future. To explore this history we are going to have to delve into our most ancient explanations, into the history of religion and philosophy, into the psychological makeup and working of each of us. Only in this way do we develop the mental and emotional flexibility and adaptability to truly understand where we are now, and where we are going in the future. Just as the recent economic collapse is presaging a new form of capitalism, great changes are

happening on Earth, and in our relationship with it. Great changes are taking place also in our scientific understanding, although it is probably fair to say this understanding is still in its infancy. Indeed, it is quite likely that none of the science you have been taught so far is adequate to address the questions we need to address—but we will address that this semester too.

It is quite likely that in your lifetimes great changes will be consciously upon us, and then we will be challenged to find creative way to cope with them. (The changes are, in fact, already happening, it is just that we are not ready to acknowledge and face them.)

Thus, what we are about here is not the study of the environment per se, but the study of the study of the environment, from ancient times to the present day. It is also the study of we as humans, and as a species. Why do we think what we think, and believe what we believe? What leads us to change out minds about what we believe, why often times we cannot see or admit what is right in front of our eyes until it has rushed passed us?

catalog description

We explore 3 aspects of understanding the environment. First, the kind of problem the environment is and the thinking strategies that will best yield insights and understanding. Second, how humans create and/or respond to environmental issues and crises. Third, examination of past environmental changes and how humans have been affected by and responded to those changes. Final synthesis explores what we can and cannot do practically to respond to future changes.

texts

Each subject we examine this semester is an enormous subject all its own with entire books, or college courses devoted to it. In some areas you can even get a degree studying it. Plus, these higher degrees are spread across the disciplines: math, biology, chemistry, geology, anthropology, etc.

We have read and incorporated in this course ideas from many sources, but none of them by themselves make a good textbook. All of the books either explore a subject in more detail then we have time for, or they do not begin to explore the breadth of the subject matter we have in mind. During the semester we recommend many books to you as good explorations of some deeper aspect of what we are studying, but if you were to buy every book worth reading to understand environmental systems theory you would purchase a small library.

So, expect handouts, perhaps lot of them. We suggest you get a 3 ring binder to keep track of everything. We also do some laboratory experiments that are accompanied by written lab guides to help you explore and understand the models the programs calculate out.

course procedures

The course is an interplay of three activities. First, lectures that introduce ideas and present their theoretical frameworks. Second, computer modeling of various kinds of systems, exploring how they behave, and the implications of that behavior. Third, Socratic seminars focusing on the results of the models, or readings concerning environmental questions and issues. We will fluidly move back and forth among these.

Some of the issues we explore are philosophically deep, tend to be religiously and/or politically controversial, and yet have everything to do with how civilizations rise and fall. We explore these ideas through readings and Socratic seminars.

The purpose of a seminar is to discuss some work we have all read or examined. From it comes the ideas, questions, and problems we are interested in. A seminar is not for the professors to tell you anything; that is what lectures are for. In a seminar the job of the seminar leader is only to ask question after question after question—until all ideas have been expressed, and all controversies brought to the surface Then we become moderators.

What questions do we ask? First, what is the author saying. Not what we think they are saying. Or want then to say. But what they are saying. Then, second, we aks questions about the meaning and implications of the author's ideas; how these ideas relate to other ideas we are exploring. Finally, we explore what we think and feel about those ideas. More specific instructions are provided with the first seminar.

course outline

Fall, 2009 is the first offering of this course, and although we have pretty clear ideas of what we want to do here, it is also true that we have more ideas to talk about than there are days in a semester. The list of topics below is what we included when the course was created and designed, and we will no doubt keep to most of these ideas. At the same time the profs continue to read widely in this subject, gaining new insights and knowledge, which will no doubt influence what we actually do.

Topics - more or less in the order explored.

The Kind of Problem: Theoretical Considerations:

Where we explore the science of systems theory: simple systems, systems of disorganized complexity, and systems of organized complexity, their properties, their behaviors, and their applications. In particular, we must learn to recognize each system when we see it, and deduce and judge their future behavior.

1. The role of myths in how we view our place in the world.
2. The kind of problem the environment is.
3. Three theories and mechanisms of evolutionary change.
4. Chaos Theory.
   a. Labs on the logistic system and bifurcation diagrams
5. Complex Systems Theory.
6. Self-organizing systems.
7. Bak-Sneppen ecoosystem model
   a. Lab
8. Network Theory
9. Attractors, hysteresis, and bistable systems
   a. Lab: the Lorenz system
10. Universality principles
11. On defining systems, and complex systems

(End unit one)

Natural Earth Systems: The Earth and Its Environments

Where we explore the range of environments the Earth has experienced in 4.0 billion years of evolutionary history, what patterns we see, what those patterns mean, what drives them, and their causes.

12. A brief history of changing Earth Environments over 4.0 billion years.
13. Environmental change: Sea level
14. Environmental Change: Extinctions
    a. Why do systems collapse: Endogenous and Exogenous explanations and mathematical models
15. Environmental Change: Glaciations
    a. Oxygen isotopes and measuring ancient temperatures
    b. Proposed causes of glaciations
    c. Glaciation case studies
16. History of the recent (Pleistocene) glaciation
17. Climate and Evolution in the time of human history

(End unit two)

Complexity and Collapse: Human Processes and the Environment

Where we examine individual humans, human societies, and human civilization as an evolving complex system in its own right. After that we explore how human systems and Earth systems have interacted through human history, the patterns we see, and their causes. From these perspectives we examine the current state of Earth and human environments, what paths are open in the near and long term future. Finally, we examine moral and ethical issues concerning human behavior and the environment; what we have and have not, can and cannot do to bring ourselves back from the brink.

18. Human evolution from the late Stone Age - civilizations building to criticality.
    a. How complex societies grow
    b. Non-Zero and the growth of civilizations
19. Case studies of collapsed civilizations through history
20. Endogenous explanations for social collapse.
    a. Understanding the human animal and its behavior
    b. Ibn Khaldun's 14th century theory of asabiya (the capacity for collective action)
    c. Tainter's economic theory of social collapse
    d. Turchin's historical dynamics - mathematical models of social growth and collapse
    e. SEMINAR - Homer-Dixon's Upside of Down - why people/cultures exhibit denial, and why cultures cannot gracefully back away from disaster.
21. Exogenous explanations for social collapse
    a. Climatic oscillations such as the NAO and El Nino/La Nina oscillations and their impacts on ancient and modern human civilizations.
    b. The Little Ice Age - rapid climatic changes and human responses. A comparison of how two cultures adapted.
22. Environmental: moral and ethical issues concerning the environment
    a. SEMINAR: Garret Hardin: Tragedy of the Common and Living on a Lifeboat
23. The impact of complex systems thinking on ethical questions about the environment
24. The future of the Earth and its environments and human civilization. Just how vulnerable are we, what can we do about it, what will it take for us as individuals, countries, and a species to make the necessary changes.

(End unit three)

Requirements, Exams, and Grading

Since this is a new course we are still working out the number of tests, writing assignments, etc. The scheme here is based on other courses we teach that have a similar organization and format. But, circumstances might change as the semester progresses. If we need to make changes they will be discussed with the class as a whole before the change is made.

GRADING:

There are three lecture exams, the third being the final (not comprehensive). Grading is based upon the following schedule. Because this course is actively developing the system below may change, but any changes will be discussed with the class.

a. First Lecture Test: Theoretical Considerations (scantron) . . . . . 25 %
b. Second Lecture Test: Earth and Its Environments (scantron) . . . . . 25 %
c. Final: Environmental Systems and Human Evolution (essay) . . . . . 30 %
d. Writing Assignments *(in class, out of class, large and small)* . . . . . 10 %
e. Seminar and Class Participation . . . . . 10 %
100%

FIRST TWO TESTS: evaluate your understanding of basic concepts. They are computer graded and consists of multiple choice and True/False questions dealing with understanding of definitions, concepts, and the great variety of charts, diagrams, and graphs used to illustrate or demonstrate these phenomena.

FINAL: The final deals with the application of principles to environmental systems—such as adaptations of early civilizations, bistable climate systems and their influence on civilizations, etc. It will be principally essay in format. A study guide is provided.

WRITING ASSIGNMENTS: A diversity of short writing assignments occur throughout the semester. The purpose is to prepare you for a seminar or discussion, clarify or solidify your understanding of concepts, or provide practice thinking about a certain type of problem. What is important about these assignments is for you to do them, and do them conscientiously, although we will not put grades on all or even most of them. The grading procedure is that if you do all of them, and turn them all in at the specified time, you receive an A grade for that 10% of the total grade. If you fail to turn in a writing assignments, or it is not turned in on time, or is not conscientiously done, the grade for this 10% declines. Like, missing one assignment lowers the grade to a B, and as more and more are missing the grade declines steadily.

Final Grades - Final grades are based on the percent scale, with plus and minus grades distributed as follows:

94-100 = A	87- 89 = B+	77- 79 = C+	67-69 = D+
90- 93 = A -	84- 86 = B	74- 76 = C	60-66 = D
	80- 83 = B -	70- 73 = C -	NO D- GRADES EXIST

studying and getting through the course painlessly and doing well

The ideas we develop are often quite simple—but not simplistic. Many of the models are logical, and their implications almost intuitive. On the other hand, these simple models and ideas feed into, and support, and build on each other in ways of increasing subtlety and complexity. Many of these ideas and models even though empirically straight forward, almost defy deterministic analysis—like how a bunch of non-intelligent ants, without any plans, guidance, or leadership can build a complex colony.

We develop all our ideas logically and systematically, and try to make sure you each understand them at each step. But, slowly, creepingly, imperceptibly, the ideas accumulate and build, and this is where you will be most challenged. It can sneak up on you, and pass you by before you even are aware of it, and then you will have to scramble to make sense of the ideas and their complexity that is beginning to dawn on you. We can help, we can get you through it, but you must be enough aware and in touch with the ideas fermenting in your own mind that you can catch yourself when you see it beginning to happen—and stop us to question us, probe your own growing but yet incomplete awareness—and learn some of the most fascinating ideas you will encounter. Some strategies to get through.

1. **Power Point Presentations:** Most of the course is on Power Point presentations. You may have these files to take to your own computer. The files are available on the class room computer or in the geology computer labs; bring a memory stick. Go to **S:\ENVT200-EnvirSystTheory**. These files tend to be large and in the past some have not been able to down load them. Ask if you have problems.

2. **Use the Power Points as study guides.** When we make up a test we go through the power points slide by slide, reminding ourselves what we discussed and emphasized, and compose questions from that. My tests follow the order and logic of the power points almost exactly. There is a story and logic to everything we study, and if you get in the rhythm of the stories and logic it will all flow more smoothly.

3. **Take good notes.** Because there is no formal text, good note taking is important. It is very hard to miss classes and get through the class well. Find a good partner whose academic abilities you trust to exchange notes with if you do have to miss class.

4. **Create a Study group.** Perhaps the most efficacious thing you can do. Find 1, or 2, or 3 people to study with. Go through the power points together, and talk about the logic of the ideas as they develop. Try to explain to each other what you know; saying it out loud sets it in your mind, and if you misunderstand something your partners will quickly correct it so you do not learn it wrong.

learning objectives

The **learning objectives** for this course are as follows:

- Define, describe, explain the universal properties of complex systems theory, including logistic systems (population growth models), fractal relationships, sensitive dependence, power-law relationships, self organized criticality, strange attractors, bistable behavior, and oscillating (bistable) reactions.
- Recognize and apply the properties listed above to a wide variety of real, natural systems, including climatic, environmental, and human.
- Understand and apply self-organizing, and genetic algorithm models to understanding the behavior of complex, agent-based systems.
- Describe and explain patterns and interactions of long-term Earth changes, such as changing concentrations of atmospheric gasses, climate changes and glaciations, sea level changes, and extinctions. Describe where the Earth is now in these changing patterns, and the possible future directions they will take, and their causes.
- Relate a diversity of examples from 11,000 years of human history that show how human civilization has adapted, or failed to adapt to environmental problems and crises.
- From the framework of Earth systems theory (complex systems theory) address the effectiveness of various practical, ethical, political, social, and psychological responses to an environmental crisis.

Skills we expect you to be able to demonstrate upon successful completion of the course.

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