SCIE 637 GLOBAL CHANGE BIOLOGY

Instructor: Dr. Helen Poulos

Lectures: Wednesdays 6-8:30 p.m.

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Course Description: Earth is a system, composed of multiple components and inter-connected processes. The major components of the Earth are the geosphere (the solid earth), the hydrosphere (oceans, glaciers & ice sheets, rivers, lakes, and groundwater), and the atmosphere, all of which interact with the biosphere. No component of this system can be studied in isolation of the others. And, a change in any element of the system has an impact through all components. This class offers an interdisciplinary introduction to the principles of climate, ecosystems, and biogeochemistry that interact with anthropogenic changes in the environment. We will also discuss global change prediction and the scientific bases for global change assessments and policy measures. We will explore global change through the lens of biological systems in this course by reviewing the science of global change, its past trends, future projections and biological consequences. Classroom lectures and discussion are centered on three broad questions:

1) How do we separate the impact of human activities from natural, background variations?
2) What are the most sensitive biological indicators of global change?
3) What are the pros and cons of ecological approaches to ameliorating the impact of anthropogenic global change?

Student Learning Goals: Learning requires you to take an active role in the course. Students in this course are expected to participate in all of the course components including lecture, labs, and lab write ups. Your acquisition of the course material depends on your own personal interpretation of the concepts we cover in class. As an instructor, it is my job to facilitate your learning of global change biology in an active manner, but ultimately it is up to you to process the information I present to you in this course. During class time we will all be involved in working towards the common goal of learning ecological concepts. Although facts and vocabulary are important to any discipline, I ask you to go beyond simple memorization of details and to interconnect those facts to concepts, applications and problems; to ask meaningful questions; to test well developed hypotheses; to develop a range of intellectual abilities, including critical thinking, logical argument, appropriate uses of evidence and interpretation of varied kinds of information; and communication of your understanding in writing and orally.

Achieving Learning Goals: Active class participation and attendance is a must for your success in this course. You will be expected to participate in cooperative group projects, complete assigned homework and lab assignments, complete reading assignments in advance of class meetings, and critically analyze the themes presented in the course material.

Instructor Goals: As the instructor of this course, my goal is to train you in the fundamental principles of landscape ecology using a combination of lecture, field-based learning, statistical analysis, and writing assignments. Through this course, I will lead you through the process of forming research questions, designing experiments, performing statistical analyses, drawing conclusions, and synthesizing results. Through this experience, I hope to help you develop higher-order thinking and reasoning skills so you can successfully explore and demonstrate your abilities to design and execute scientific research projects.

Format: Weekly topics are divided into two meetings. In the first meeting, we will examine the scientific foundation of the topic, relying mostly on materials from the optional textbook. In the second meeting, we will critique the questions posted for the weekly topic (see below), by synthesizing the published literature most relevant to the topic.

Assignments and Grading:

Participation (20%)

Students are required to attend class and actively participate in discussions. They are encouraged to ask questions, make comments, and challenge the assumptions presented in the readings, by the instructor and your classmates.

Weekly reading and critiques (20%)

Reading materials and references for each class will be posted on the class website. By the Saturday morning prior to class each week, students should post on the Discussion section of Blackboard a short critique including comments and questions from that week's readings that they would like to have covered in class. The critiques and comments will be used to inform that week's lectures and discussion.

Student-led discussion (20%)

Each student will receive 2-3 assignments to lead discussion on the reading materials posted on Blackboard.

Final paper (40%)

By the end of the term, students will be required to prepare a concise paper (approximately 15 pages, individual effort or team work) on an aspect of global change science. Policy papers with significant scientific contents are also acceptable. A one-page outline of the proposed paper topic is due on at the end of October. The final paper (in electronic format) is due at the end of the exam period.

Optional Textbook: Schlesinger, W.H. 2004. Biogeochemistry: An Analysis of Global Change. Academic Press.

Tentative Schedule

MAJOR GLOBAL CHANGE PROBLEMS AND THEIR CAUSES

Jan 27: Paleoclimate

Broeker WS (2002) The Glacial World According to Wally. Mechanisms P. 266-278.
Alley et al. (2003) Abrupt Climate Change. Science 299: 2005-2010.
Overpeck et al. (2006) Paleoclimatic evidence for future Ice-Sheet instability and Rapid Sea Level Rise. Science 311: 1747-1750.
Lomborg B (2001) The Skeptical Environmentalist. P. 34-41.

- What mechanisms have underscored climatic changes over the course of the Earth’s history?
- What do historical climatic fluctuations tell us about Earth’s future climatic trajectories?
- How do humans contribute to global climatic forcing? Or do they at all?

Feb 3: Global change at the interface of the atmosphere and the biosphere

- Why are some pollutants globally significant while others are not?
- The icehouse paradox: What mechanisms unlock the earth’s climate from glaciers’ deep freeze?
- Is Gaia a true scientific hypothesis or pseudo-science fantasy?

Reading

Schlesinger – Chapters 2, 3 and 5

Wikipeda (2008) Snowball earth Lenton TM and DM Wilkinson (2003) Developing the Gaia theory. Climate Change 58: 1-12.

Lovelock JE (2003) Gaia and emergence. Climate Change 57: 1-3.

Kirchner JW (2003) The Gaia hypothesis: conjectures and refutations. Climate Change 58: 21-45.

Volk T (2002) Toward a future Gaia theory. Climate Change 52: 4223-430.

Feb 10: The Ozone hole and trend in UVB radiation

- Why is the ozone hole more severe in the southern hemisphere than in the northern hemisphere?
- What are the major biological effects of UV radiation?
- Is the ozone layer on a steady recovery trend after the Montreal Protocol?

Reading

Schlesinger – Chapter 3

Levinson DH (2008) State of the climate in 2007 (abstract, sections 2d and 5.b7). Bulletin of American Meteorological Society. Vol 89, No 7.

Norval M et al (2007) The effects on human health from stratospheric ozone depletion and its interactions with climate change. Photochmeical and Photobiological Society 6: 232-251.

Searles PS et al (2001) A meta analysis of plant field studies simulating stratospheric ozone depletion. Oecologia 127: 1-10.

Tilmes S et al (2008) The sensitivity of polar ozone depletion to proposed greoengineering schemes. Science 320: 1201-1204.

Feb 17: Climate change – evidence beyond the mean temperature records

- How do we isolate global warming signals from urban heat island effects?
- From brightening to dimming: What roles do humans play?
- What agents of change cause variations in the diurnal temperature range?

Reading

Parker DE (2006) A demonstration that large-scale warming is not urban. J Climate 19: 2882-2895.

Stanhill G & S Cohen (2001) Global dimming: a review of the evidence for a widespread and significant reduction in global radiation with discussion of its probably causes and possible agricultural consequences. Agricultural and Forest Meteorology 107: 255-278.

Wild M et al (2005) From dimming to brightening: decadal changes in solar radiation at Earth's surface. Science 308: 847-850.

Wild M et al (2006) Impact of global dimming and brightening on global warming. Geophysical Research Letters 34: L04702.

BIOLOGICAL SOURCES AND SINKS OF AIR POLLUTANTS AND GREENHOUSE GASES

Feb 24: The smog paradox

- Is there any truth to Ronald Reagan's statement "Trees cause more pollution than automobiles do"?
- Is the smog problem limited to the urban environment only?
- Do abatements of vehicle emission of pollutants always lead to smog reduction?

Reading

Bernstein M & D Whitman (2005) Smog alert: the challenges of battling ozone pollution. Environment 47: 28-40.
Chameides WL et al (1988) The role of biogenic hydrocarbons in urban photochemical smog: Atlanta as a case study. Science 241: 1473-1475.
Lin CYC et al (2001) Trends in exceedances of the ozone air quality standard in the continental United States, 1980-1998. Atmospheric Environment 35: 3217-3228.
Seinfeld JH (2004) Air pollution: a half century of progress. Environmental and Energy Engineering 50: 1096-1108.

Mar 3: Global carbon dioxide budget and trend

- Is the current (and projected) CO2 concentration unique to the earth's natural history?
- Why is it difficult to estimate the global CO2 budget in a timely fashion?
- Why measuring tree growth is not enough when it comes to quantifying forest C sequestration?

Reading

Schlesinger – Chapters 5 and 11
Canadell JG et al (2007) Contributions to accelerating atmospheric CO2 growth from economic activity, carbon intensity and efficiency of natural sinks. Proceedings of National Academy of Sciences 104: 18866-18870.
Phillips OL et al (1998) Changes in the carbon balance of tropical forests: evidence from long-term plots. Science 282: 439-442.
Raupach MR et al (2007) Global and regional drivers of accelerating CO2 emissions. Proceedings of National Academy of Sciences 104: 10288-10293.
Wofsy SC et al (1993) Net exchange of CO2 in a mid-latitude forest. Science 260: 1314-1317.

Mar 3 and 10 Mid-Semester Break: No Classes

Mar 24: Global methane budget and trend

- The methane mystery: do living plants really emit a significant amount of methane to the atmosphere?
- Why has the concentration of atmospheric methane leveled off in recent years?
- Which wetland type (salt marsh, fresh water wetland, rice paddy) is the largest methane emitter?

Reading

Schlesinger Chapter 7
Beerling D et al (2008) Missing methane emissions from leaves of terrestrial plants. Global Change Biology 14: 1821-1826.
Keppler F et al (2006) Methane emissions from terrestrial plants under aerobic conditions. Nature 439: 187-191.
Simpson IJ et al (2006) Influence of biomass burning during recent fluctuations in the slow growth of global tropospheric methane. Geophysical Research Letters 33: L22808.

Mar 31: The Global Nitrogen Cycle and Trend

- What are the main sources of global warming potential in intensive agriculture?
- What factors influence the quantity of nitrous oxide release from feedlots and grazing lands?
- Why is nitrous oxide a much stronger greenhouse gas than carbon dioxide?

Reading
Schlesinger – Chapter 6 and 12
Mosier A (1998) A new approach to estimate emission of nitrous oxide from agriculture and its implications to the global nitrous oxide budget. IGACtivites Newsletter no 12.
Robertson GP et al (2000) Greenhouse gases in intensive agriculture: contributions of individual gases to the radiative forcing of the atmosphere. Science 289:1922-1925.
Sommer SG et al (2004) Techniques for measuring gas emissions from a composting stockpile of cattle manure. Atmospheric Environment 38: 4643-4652.

BIOLOGICAL FEEDBACK AND MITIGATION

Apr 7: Impacts of climate change on terrestrial ecosystems

- Why are arctic landscapes particularly vulnerable to climate change?
- How do plants and animals respond differently to climate change?
- Which impacts can be tolerated or accepted and which cannot?

Reading
Both C & ME Visser (2001) Adjustment to climate change is constrained by arrival date in a long-distance migrant bird. Nature 411: 296-298.
Chmeilewski FM & T Rotzer (2001) Response of tree phenology to climate change across Europe. Agricultural and Forest Meteorology 108: 101-112.
Hassol SJ et al (2004) Impacts of a Warming Arctic. Cambridge University Press.

Apr 14: Widespread Tree Mortality

- At what times during a tree's life are they vulnerable to drought/ heat-induced mortality?
- How do large scale tree die off events influence tree distribution patterns across landscapes?
- What are the negative impacts of widespread tree mortality on global ecosystem services?

Reading
Breshears DD et al. (2009) Tree die-off in response to global change-type drought: mortality

insights from a decade of plant water potential measurements. Frontiers in Ecology and the Environment 7, doi: 10.1890/080016.
vanMantgem PG et al. (2009) Widespread increase of tree mortality rates in the western United States. Science 323: 521-524.
Allen, CD et al. (2009) A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. Forest Ecology and Management XX: XXX-XXX.

Apr 21: Biological feedbacks on climate change

- How does warming feed on warming? Will the feedback cause a runaway greenhouse?
- How good is the experimental evidence of enhanced plant growth in a high CO2 environment?
- Is accelerated plant growth enough to offset a higher soil emission of carbon dioxide in a warmer world?

Reading

Luo Y et al (2001) Acclimatization of soil respiration to warming in a tall grass prairie. Nature 413: 622-625.
Oren R et al (2001) Soil fertility limits carbon sequestration by forest ecosystem in a CO2-enriched atmosphere. Nature 411: 469-472.
Melillo JM et al (2002) Soil warming and carbon-cycle feedbacks to the climate system. Science 298: 2173-2176.
Sturm M, C Racine, K Tape (2001) Increasing shrub abundance in the Arctic. Nature 411: 546.
Tape K et al (2006) The evidence for shrub expansion in Northern Alaska and the Pan-Arctic. Global Change Biology 12: 686-702.

Apr 28: Biological mitigations of climate change

- How large is the potential of land management for sequestering atmospheric carbon?
- Are ecological solutions feasible?
- Are there any undesirable climatic effects of reforestation?

Reading

Kauppi P et al (2001) Technological and economic potential of options to enhance, maintain, and manage biological carbon reservoirs and geo-engineering. IPCC Report on Climate Change.
Rubin E et al (2006) Technical Summary. IPCC Special Report on Carbon Dioxide Capture and Storage.
Schulze ED et al (2000) Managing forests after Kyoto. Science 289: 2058-2059.