ENVS 112 Natural Science and the Environment Spring 2010

Lecture: Hillcrest 103, MWF 9:05 – 9:55
Labs: MBH 309 (sections W, X, Y, Z), 1:30 – 4:15 on M, T, W, or Th

Instructors

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Fundamentals

Welcome to the Environmental Studies Program's course on environmental science. ES 112 is one of the three introductory-level courses offered by the ES Program. In it, we explore in detail the science that underlies the principles of sustainability, focusing on concepts from biology, chemistry, geology, physics, and quantitative systems analysis. Topics covered will emphasize the dimensions of sustainability, particularly human population growth, agriculture, energy production, pollution, and ecosystem functions and services. You will also gain experience with the scientific method, tools for critical analysis, and systems modeling. This material is designed to complement other introductory environmental studies courses on social sciences (ES/PS 211) and humanities (ES 215), *but our focus will be first and foremost on the natural sciences.*

Science as a broad set of disciplines has characteristic conventions, features, and tools that often go unspoken, but are very important and used every day by practicing scientists. Citizens are bombarded daily with scientific and sometimes seemingly scientific environmental information in newspapers, on radio, TV, and the Internet. It can even be difficult for practicing Ph.D. scientists to make sense of information they read about other fields of science! In order to sift through and distinguish the reliable information from the unreliable information it helps to understand how scientists gather, validate, interpret, and report data. Some important features of current scientific practice include *1) external peer-review, 2) source validation and citation, and 3) the use of multiple pieces of evidence* to support proposed explanations. You will learn about and try your hand at some of these practices in the course of studying several issues in environmental science.

The interdisciplinary nature of most environmental science often distinguishes it from traditional sciences such as biology, chemistry, geology, and physics. It draws on many aspects of the traditional sciences to examine issues that range from population analysis and contamination of natural environments to climate and land-use change. To truly understand the impacts of soil contamination, for example, we need to understand sources of contamination, geological and chemical transport and uptake, plant-related transport and uptake, food-web interactions, microbial activity, solid-liquid-gas phase relationships, and the potential for vapor production and atmospheric contamination. Clearly, knowledge of chemistry, geology, plant physiology, ecology, microbiology, and physics plays an important role in environmental science.

Environmental *studies* is even broader and more interdisciplinary in scope than environmental *science*, and includes perspectives from other disciplines, such as policy, philosophy, economics, and literature. If you choose to take additional courses in the Environmental Studies Program at Middlebury College, you will focus on some of these other perspectives and gain further insight into the relationship between humans and the environment.

Course Objectives

We hope that each of you will choose to participate actively and conscientiously in this course. This includes preparing for class, contributing respectfully to discussions, raising thoughtful questions, and seeking help when you need it. If you do so, by the end of the course you will:

- understand the relationship between sustainability and natural systems on Earth;
- use knowledge of current science practices to evaluate environmental information and to construct scientific arguments;
- connect specific concepts across multiple topics to support broader themes in environmental science;
- feel comfortable developing and interpreting conceptual models of how environmental systems function;
- communicate science effectively in written work and oral discussions; and
- critically read and evaluate several formats of scientific writing, including peer-reviewed literature, popular science writing, and environmental journalism.

Course Structure

The broad theme of this course for both lecture and lab relates to the science that underlies society's search for sustainable practices. Our exploration of this theme will lead us to focus on a number of general environmental issues that are of both global and local concern and simultaneously to explore the scientific principles governing important human-environment interactions:

Human population growth	**Soils & agriculture**
Ecosystem functions and services	**Energy**
Water resources & pollution	**Climate change**

These issues will be linked through the concept of sustainability, the conversion of energy and matter by people today in ways that do not jeopardize the abilities of people to meet their needs in the future.

The lecture portion of this course is intended to cover material that is typically more global in nature and therefore less amenable to laboratory investigation. In contrast, laboratory sessions will investigate environmental science issues from an experiential and hands-on basis with a greater emphasis on local manifestations of global issues. Both lecture and laboratory are intended to provide intellectual and scientific background.

Information Acquisition Beyond the Lectures and Labs: reading, viewing, listening

The textbook will provide a concise primer on each topic we will cover. In particular, it provides background on important concepts and themes in environmental science and introduces terminology and quantitative problem-solving approaches. We also want to emphasize the acquisition of information through multiple media that will connect you with current thinking and current events. These media will include (1) current journal articles and related articles, and (2) on-campus seminars.

1. Readings.—These will include journal articles, book chapters, newspaper articles, web sites, and any other form as is useful. These will be made available to you in a variety of ways, including:

- **Textbook**: Essential Environment: The Science Behind the Stories (3d ed.) by Withgott, J.; Brennan, S. 2009. Available at the college bookstore and elsewhere.
- ENVS0112A Handouts Folder on the Classes Server: many readings will be deposited in the handouts folder; so be sure you know how to access this.

- E-mail to Class List: some readings will show up as file attachments in your E-mail Inbox. You are responsible for information and material sent to your college email address, so be sure to check your e-mail daily.

- Internet: some readings will be accessible on web sites, for which we will send you the URLs.

- Hand-outs: occasionally, photocopies will be handed out in class or lab.

Readings will fall into one of three categories: (a) background information like that provided by the text book, (b) current news, and (c) research reports from the scientific literature. These readings are provided because they present the bases for in-class discussion, data analyses, and a deeper appreciation for the importance of environmental science to you as a citizen. They also include many of the styles of publications in science, including peer-reviewed journal articles, textbooks, newspaper and magazine articles, government documents (e.g., EPA and USGS publications), and various types of web dissemination. If you choose to print these materials for reading and review, we recommend that you get a three-ring binder to keep them organized.

We have noted in the syllabus (see below) as many of the readings we will want you to do during the semester as possible. However, new information is being published all the time and current events are reported in the news every day. Therefore, new reading assignments will be added throughout the semester. You are responsible for keeping track of these readings.

We cannot overemphasize the importance of doing the readings in this class. Reading these materials critically will make the difference between active engagement and passive boredom. To this end, for a number of reading assignments for lecture we will ask you to turn in a one-page reading report, and for lab there will be occasional reading questions for which we will ask you to write brief answers. The exact day on which these are due will be announced in class. The format for the reading reports is very important, and is described in detail on the last page of this handout. Articles that will require a reading report are noted in the syllabus with an asterisk, and will be further noted in class. Lab reading questions will be emailed during the week prior to the assignment date.

2. Seminars.—The College brings onto campus numerous speakers who present topics of relevance to environmental science. They also maintain a large digital library of seminars that have been presented in the past. As relevant, we will assign you to attend or view a seminar.

Course Grading and Assignments

Exams (2)	March 19th & during Finals Period	40%
Lab reports (3)	See schedule	35%
Lab exercises	See schedule	15%
Reading reports / participation	Periodically / in lecture & lab	10%

Grade Assignment: Grading is based on a straight percentage scale: 90-100% is an A, 80-89% is a B, 70-79% is a C, 60-69% is a D, and less than 60% is an F, with high and low points within those ranges being given + or - grades.

Exams: A midterm exam (March 19th; 15%) and a final exam (during Finals Period; 25%). Each exam will build on information, skills, and concepts developed to that point in the course. The final exam will emphasize material covered in the 2nd half of the course but will also draw on material from the 1st half and should, therefore, be considered a cumulative exam. Exams will include qualitative and quantitative questions and will mainly cover materials from lecture and related readings and assigned seminars, but also will incorporate pertinent concepts or examples from lab.

Lab Reports: You will write three lab reports. The topics will be our legume nodulation experiment, our water quality and land use study, and our forest carbon analysis. Among the objectives of writing lab reports are 1) to give you an opportunity to analyze and interpret data, 2) to concisely describe the global and local context of the study, and 3) to discuss the broad implications of our results. For some of the lab reports you will be required to include

information from peer-reviewed papers that we have not had assigned in class (i.e., you will conduct your own literature searches). More details will be provided in lab.

Lab Exercises: We will have a number of small assignments, which will include a worksheet related to renewable energy and a presentation on an aspect of energy, a farm-systems model, and a wetlands worksheet. Brief responses to reading questions will be required for a selection of readings; questions will be distributed by email.

Reading Reports: Reading reports, as described earlier, are associated with some of the required readings.

Participation: One additional way to display that you are involved with and understand the materials in this course is to ask informed questions and participate in Q & A.

General Policies

Late Assignments: In order to ensure that grading is uniform and fair to all students, all assignments are due at the beginning of the lecture or lab period (as appropriate) unless otherwise noted. Late assignments will be penalized 5% if they are turned in after the designated time on the day it is due, and 20% per day for each day after that. This means that if an assignment is due on Thursday at the start of class, it will be penalized 5% if you turn it in on Thursday afternoon, and it will be penalized 25% if it is turned in on Friday. The exceptions to this are reading reports and reading questions, which will be penalized one point if it is turned in after the designated time on the day it is due and one point per day for each day after that.

Assignment Formatting: All assignments should be typed and printed double-sided. **And STAPLED!** Assignments that are not stapled will be automatically penalized 5%. Graphs should be completed with a computer program such as Excel. On homework assignments, you are welcome to hand in calculations written out by hand. **All literature citations** must be in the format specified for this class (one of many science-writing formats); see last page of syllabus and lab report guidelines for details.

Laboratory Attendance: Due to constraints on equipment availability and van sizes, you must attend the lab session in which you are registered. **Missed laboratory sessions must be made up, which involves communicating and planning with Marc in advance.**

Lecture Attendance: Attendance is required at all lectures. Your final grade will be reduced by a third of a grade (e.g., B+ to B) for every three unexcused absences. In this class, the lectures are interactive, and you should come to each class prepared to ask questions, and to be called upon to answer questions about the reading and lecture material. You are responsible for all material presented in lecture, reading, and for all assignments and exercises.

Field Lab Attire: We will spend about ½ of our time outside. Please come to lab prepared for any weather. You will need warm, waterproof gear and comfortable footwear. Do not wear sandals for field labs, except for the day we collect and sample stream water. If you do not have access to appropriate gear for being outdoors on foul-weather days, let us know ahead of time, and we will do our best to help you out. Inadequate preparation is NOT a valid excuse for missing a lab.

Syllabus: schedule of topics, locations, readings, and assignments (subject to amendment)

Week 1 (February 8-12)

Lecture topics	Introduction to sustainability; human population; sources of energy
Lab topic	Foundations of sustainability
Lab activity	Small group and individual explorations
Lab location	MBH 309
Reading	***LECTURE***: TEXT: Ch 1; Ch 4 (pp. 81-86), Ch 6 Holdren, J.P. 2008. Science and technology for sustainable well-being. *Science* 319: 424-434. Lutz, W. et al. 2008. The coming acceleration of global population ageing. *Nature* 451: 716-719. ***LAB***: Lab handout for Week 1

Week 2 (February 15-19)

Lecture topics	Energy (continued)
Lab topic	Renewable electricity
Lab activity	Measuring electrical parameters from wind and solar generation
Lab location	MBH 309
Lab assignments due / Exams	None—do research for lab presentations
Reading	***LECTURE***: TEXT: Ch 3 (pp. 49-59), Ch 15, Ch 16. Charles, D. 2009. Renewables test IQ of the grid. *Science* 324: 172-175. Kerr, R.A. 2008. World oil crunch looming? *Science* 322: 1178-1179. Kerr, R.A. 2009. How much coal remains? *Science* 323: 1420-1421. ***LAB***: Lab handout for Week 2

Week 3 (February 22 – 26)

Lecture topics	Climate system, history (e.g. ice cores), projections
Lab topic	Hydroelectric and nuclear technologies
Lab activity	Student group presentations
Lab location	MBH 309
Lab assignments due / Exams	
Reading	***LECTURE***: TEXT: Ch 14, 15, 16 Campbell, J.E. et al. 2009. Greater transportation energy and GHG offsets from bioelectricity than ethanol. *Science* 324 : 1055-1057. Charles, D. 2009. Corn-based ethanol flunks key test. *Science* 324: 587. Ewing, R.C., and von Hippel, F.N. 2009. Nuclear waste management in the United States—starting over. *Science* 325: 151-152. Richter, D. et al. 2009. Wood energy in America. *Science* 323: 1432-1433. Tilman, D. et al. 2009. Beneficial biofuels—the food, energy, and environment trilemma. *Science* 325: 270-271.

Week 4 (March 1 - 5)

Lecture topics	Climate, soils, agriculture
Lab topic	Food production and the environment
Lab activity	Farm visit
Lab location	**VAN PICKUP LOCATION**
Lab assignments due / Exams	
Reading	***LECTURE***: TEXT: Ch 7.

	Battisti, D.S., and R.L. Naylor. 2009. Historical warnings of future food insecurity with unprecedented seasonal heat. *Science* 323: 240-244. Fox, D. 2007. Back to the no-analog future. *Science* 316: 823-825. Kintisch, E. 2009. Projections of climate change go from bad to worse, scientists report. *Science* 323: 1546-1547. Williamson, C.E. et al. 2009. Sentinels of change. *Science* 323: 887-888. ***LAB***: Lab handout for Week 4 Gleissman, S.R. 2007. Ch. 1. The need for sustainable food production systems, pp. 3-21 *in* Agroecology: the ecology of sustainable food systems, 2nd ed. CRC Press, Boca Raton, FL. Masumoto, D.M. 2009. Wisdom of the Last Farmer. Free Press/Simon and Schuster, Inc., New York. excerpt: chapters 1 and 2.

Week 5 (March 8 - 12)

Lecture topics	Soils, agriculture, nutrient cycles
Lab topic	Nitrogen management for sustainable agriculture
Lab activity	Nodulation experiment
Lab location	MBH 309
Lab assignments due / Exams	**Farm system sketch model due at start of your lab**
Reading	***LECTURE:*** TEXT: Ch 3 (pp. 65-69). Galloway, J.N. et al. 2008. Transformation of the nitrogen cycle: recent trends, questions, and potential solutions. *Science* 320: 889-892. Jordan, N. et al. 2007. Sustainable development of the agricultural bio-economy. *Science* 316: 1570-1571. ~~Kiers, E.T. et al. 2008. Agriculture at a crossroads. *Science* 320: 320-321.~~ ~~Pennisi, E. 2008. The Blue Revolution, drop by drop, gene by gene. *Science* 320: 171-173.~~ Pimentel, D. et al. 2005. Environmental, energetic, and economic comparisons of organic and conventional farming systems. *BioScience* 55: 573-582. Rozema, J., and T. Flowers. 2008. Crops for a salinized world. *Science* 322: 1478-1480. Service, R.F. 2007. A growing threat down on the farm. *Science* 316: 1114-17. ~~Vitousek, P.M. et al. 2009. Nutrient imbalances in agricultural development. *Science* 324: 1519-1520.~~ ***LAB***: Lab handout for Weeks 5 & 6 Gleissman, S.R. 2007. Ch. 15. Species interactions in crop communities, pp. 205-216 *in* Agroecology: the ecology of sustainable food systems, 2nd ed. CRC Press, Boca Raton, FL.

Week 6 (March 15 - 19)

Lecture topics	No class Monday, Wednesday review, **Friday Midterm**
Lab topic	Nitrogen management for sustainable agriculture
Lab activity	Data analysis of nodulation data
Lab location	**Computer labs: W, X, Z — SDL IL3; Y — MBH117**
Lab assignments due / Exams	**Midterm Friday in class**
Reading	***LECTURE***: Review notes, readings from weeks 1-5. ***LAB***: Nodulation lab report and data analysis guidelines Singer, J.W., and W.J Cox. 1998. Agronomics of corn production under different crop rotations in New York. *Journal of Production Agriculture* 11: 462-468.

Week 7 (March 29 – April 2)

Lecture topics	Rain, surface water and aquifers: Natural systems, human modifications.
Lab topic	Water pollution
Lab activity	Water quality and land use study: land use analysis using GIS
Lab location	**Computer labs: W, X, Z — SDL IL3; Y — MBH117**
Lab assignments due / Exams	**Nodulation experiment lab report due April 2, 4p.m. to Marc's office**
Reading	***LECTURE***: TEXT: Ch 12, 13 Broussard, W., and Turner, R.E. 2009. A century of changing land-use and water-quality relationships in the continental U.S. *Frontiers in Ecology and the Environment* 7: 302-307. Diaz, R.J., and R. Rosenberg. 2008. Spreading dead zones and consequences for marine ecosystems. *Science* 321: 926-929. Pimentel, D. et al. 2004. Water resources: agricultural and environmental issues. *BioScience* 54: 909-918. Stokstad, E. 2009. Obama moves to revitalize Chesapeake Bay restoration. *Science* 324: 1138-1139. ***LAB***: Lab handout for Weeks 7-9 Lake Champlain Basin Program. 2008 State of the Lake and Ecosystem Indicators Report-2008. LCBP, Grand Isle, VT. *pages 4-10, 16-17* Page, C. 2009. Lake phosphorus targeted. Burlington Free Press, 28 February 2009. http://www.burlingtonfreepress.com/apps/pbcs.dll Accessed 30 March 2009. Page, C. 2009. Judge to state: act on stormwater. Burlington Free Press, 21 February 2009. http://www.burlingtonfreepress.com/apps/pbcs.dll Accessed 30 March 2009.

Week 8 (April 5 - 9)

Lecture topics	The hydrologic cycle, air and water resources.
Lab topic	Water pollution
Lab activity	Water quality and land use study — water sampling
Lab location	**VAN PICKUP LOCATION**
Lab assignments due / Exams	
Reading	***LECTURE***: TEXT : Ch. 12, 13 (cont) Kerr, R.A. 2009. Northern India's groundwater is going, going, going … *Science* 325: 798. Service, R.F. 2009. California's water crisis: worse to come? *Science* 323: 1665. ***LAB:*** Lab handout for Weeks 7-9 Kelly, J.M. et al. 2007. Phosphorus uptake during four years by different vegetative cover types in a riparian buffer. *Nutrient Cycling in Agroecosystems* 78: 239-251.

Week 9 (April 12 - 16)

Lecture topics	Toxic organic compounds, environmental toxicology. No class Friday (Student Research Symposium)
Lab topic	Water pollution
Lab activity	Data analysis of water and land use data
Lab location	**Computer labs: W, X, Z — SDL IL3; Y — MBH117**
Lab assignments due / Exams	
Reading	***LECTURE:*** TEXT: Ch 10. Cristol, D.A. et al. 2008. The movement of aquatic mercury through terrestrial

	foodwebs. *Science* 320: 335. Additional reading TBA. ***LAB***: Water quality and land use study lab report and data analysis guidelines Zedler, J.B. 2003. Wetlands at your service: reducing impacts of agriculture at the watershed scale. *Frontiers in Ecology* 1: 65-72.

Week 10 (April 19-23)

Lecture topics	Ecosystem components, functions, services
Lab topic	Sustainable forest management
Lab activity	Exploring forest management
Lab location	**VAN PICKUP LOCATION**
Lab assignments due / Exams	**Water quality and land use lab report due April 23, 4p.m. to Marc's office**
Reading	***LECTURE***: TEXT : Ch 3 (pp. 57-59), Ch 4, Ch 5. Barbier, E.B. et al. 2008. Coastal ecosystem-based management with non-linear functions and values. *Science* 319: 321-323. Rey Benayas, J.M. et al. 2009. Enhancement of biodiversity and ecosystem services by ecological restoration: a meta-analysis. *Science* 325: 1121-24. Tallis, H. et al. 2008. An ecosystem services framework to support both practical conservation and sustainable development. *Proceedings of the National Academy of Sciences* 105: 9457-9464. ***LAB***: Lab handout for Weeks 10 & 11 Montreal Process. 1999. excerpts from: What is the Montreal Process? <http://www.mpci.org/rep-pub/1999/broch_e/html> Accessed 9/11/2006. Lindenmayer, D.B., J.F. Franklin, and J. Fischer. 2006. General management principles and a checklist of strategies to guide forest biodiversity conservation. *Biological Conservation* 131: 433-445.

Week 11 (April 26 - 30)

Lecture topics	Biodiversity, invasive species, biodepletion and extinction
Lab topic	Forests and the carbon cycle
Lab activity	Forest carbon sampling
Lab location	**VAN PICKUP LOCATION**
Lab assignments due / Exams	
Reading	***LECTURE***: TEXT: Ch 4, Ch 5 (cont), Ch 8 Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: general synthesis. Pages ii-24. http://www.millenniumassessment.org/documents/document.356.aspx.pdf ***LAB***: Lab handout for Weeks 10 & 11 TBA… North East State Foresters Association. 2002. Carbon sequestration and its impacts on forest management in the northeast. <http://www.nefainfo.org/publications/carbonsequestration.pdf> Accessed 3 December 2008.

Week 12 (May 3 - 7)

Lecture topics	Natural science, environmental policy and management of natural resources: selected case studies.
Lab topic	Ecosystem functions and services
Lab activity	Wetland functions
Lab location	**MEET AT BASEBALL FIELD on South Street**
Lab assignments due / Exams	**Forest carbon lab report due, May 7, 4p.m. to Marc's office**
Reading	***LECTURE***:

	TBA… ***LAB***: Lab handout for Week 12 Vermont Wetland Rules [1-page excerpt] Thompson, E. H., Sorenson, E. R. 2000. Wetland, Woodland, Wildland. The Nature Conservancy and Vermont Department of Fish and Wildlife, Montpelier, VT. [excerpt]

Week 13 (May 10)

Lecture topics	Review, question and answer for final. Classes end Monday 4:15
Lab topic	No lab
Lab activity	
Lab location	
Lab assignments due / Exams	Exam period begins Weds May 12.
Reading	***LECTURE***: Re-familiarize yourself with reading materials from the semester.

Finals Period (May 12-18)

Lab assignments due / Exams	Final exam: 3 hour take-home exam

How to Write a Reading Report

For an article or a pair of articles to be announced as the semester proceeds, you will be required to submit a reading report for the lecture portion of the class. **Due dates will be announced in class**.

What is in a report?

- Your name, followed by a blank line.
- The citation for the reading, using the correct style (see below), followed by a blank line.
- The first author's professional affiliation, i.e. where they work (e.g., Department of Biology, Middlebury College, U.S. Fish and Wildlife Service), followed by a blank line.
- In a separate paragraph, summarize the main points of the reading.
- In another separate paragraph, describe (a) the major strengths of the paper's arguments, (b) the major weaknesses of the paper's arguments, and (c) your overall evaluation of the reading in 2-3 sentences each. In other words, critically analyze the authors' arguments. Be sure your writing **clearly** distinguishes the strengths, weaknesses, and overall evaluation.
- In a final separate paragraph, state why you think the reading was assigned. In other words, summarize what you think this article contributes to your education in this course.

What is the format for a report? Printed, single-spaced, normal margins, normal font size, normal font type. Use proper English. No summaries should be more than can fit on one printed page (double-sided if necessary).

How will they be graded? On a scale of 0 to 4, based on content, style, grammar, proofreading, and adherence to specifications:

0 = unacceptable job (= not showing evidence of actually having read the article carefully)
1 = inadequate job (= incomplete or **not meeting the specifications [I'm serious about this so you should read the "What is in a report?" section very carefully]**)
2 = acceptable job (= basically complete but nothing special)
3 = very good job (= complete, generally well written, with some evidence of critical thinking)
4 = excellent job (= complete, very well written, and clear evidence of very good critical thinking)

Reading reports turned in late for any reason will automatically be penalized one point, with additional penalties of one point for each subsequent day it is late.

Correct style for a Reading Report citation

The following are examples of the proper style for citing a journal article. Note the correct use of initials, punctuation, and capitalization.

Kates, R.W., and T.M. Parris. 2003. Long-term trends and a sustainable transition. Proceedings of the National Academy of Sciences 100: 8062-8067.

Vitousek, P.M., H.A. Mooney, J. Lubchenko, and J.M. Melillo. 1997. Human domination of earth's ecosystems. Science 277: 494-499.