ES250: Introduction to Sustainability Science

DRAFT ONLY - Updated 6/29/12

When: Friday 1:30 -3:45
Where: TBD

Prof. Tracey Holloway (taholloway@wisc.edu)
Office Hours: Wed./Thurs. 1:30 – 2:30
201A SAGE (Nelson Institute Center for Sustainability and the Global Environment)
Enzyme Institute, 1710 University Ave.

TA: TBD

Course Objectives:
This course aims to develop a solutions-oriented understanding of environmental and energy issues, and to empower students to take actions toward resource sustainability. To advance these goals, **the course introduces basic quantitative analysis methods and builds these skills by solving problems inspired by real-world sustainability issues**.

With a "tool-kit" of analysis methods, students can evaluate how actions affect environmental systems. For example, what changes to dorm-room electricity use would most significantly reduce CO_2 emissions? Is long-distant travel by train, plane, or car most sustainable? Paper or plastic? These types of questions will motivate homework problem sets and in-class project-based learning.

In particular the course has the following as learning outcomes:
- Development of a **conceptual framework** for understanding complex systems
- **Empowering students** to evaluate real-world conservation, technology, and lifestyle choices.
- Linking **quantitative problem-solving skills** – especially drawing on mathematics, engineering, atmospheric science, and physical geography – to problems of personal relevance to students
- Basic understanding of how **human and natural systems interact**, especially the major issues connecting electricity, transportation, materials and waste, and food with climate change, land use, water, and air quality.
- **Increased curiosity** about environmental science and engineering, ideally motivating advanced scientific study (whether or not students major in a STEM discipline).

Each week, students will be introduced to a concept or application area through readings, video, and/or podcasts, and solving problems using a related quantitative method with the use of a workbook and materials developed by Prof. Holloway. These original materials, referenced in the syllabus below, draw from a range of published and original problems, inspired by the graduate-level texts "Consider a Spherical Cow" by John Harte and "Should We Risk It?" by Daniel Kammen and David Hazzenzahl (to which Prof. Holloway served as a contributor).

The overarching objective of the course is to stimulate imagination and creativity, learning how to ask questions, seek answers, and advance solutions.

Grading:

30% Attendance & Daily Participation
(Participation will be measured with the iClicker Student Response System)
30% Homework
10% 1st Mid-Term
10 % 2nd Mid-Term
20 % Final Exam

The grading system will be implemented through cumulative points, with some extra credit points available.

Other Information

- Academic misconduct is not tolerated at the University of Wisconsin. Please review University policy at http://students.wisc.edu/saja/misconduct/UWS14.html
- Homework will be accepted up until 1:30 pm on the due date. Turn in assignments at the beginning of lecture, or to your T.A.s mailbox (Located in the basement of Science Hall) Homework will be graded on a "check, check-plus, check-minus, zero" basis
- Make-up exam policy: Students are expected to take the exam at the scheduled time and date. If a student must miss an exam due to illness or a family emergency he or she must contact their T.A. prior to the beginning of the exam and take a make-up exam within one week.
- Missed classes or missed/late homework cannot be made up for any reason. However, students can use extra credit points to help compensate for missed class work.

Required Texts & Related Materials

- ES250 Text Book + online supplement (T. Holloway et al.); unless otherwise noted, readings refer to this text. All linked materials should be included in reading assigment.
- iClicker (http://comets.wisc.edu/clickers/), $35.00 ($26.50 used) from the University Bookstore
- Access to Stella Systems Modeling Software (e.g. purchase of v. 9.1 6-month Student license for $59; also available for free in the SAGE computer lab during fixed usage time periods) (http://www.iseesystems.com/softwares/education/stellasoftware.aspx),
- Microsoft Excel (standard Windows Office software; freely available on University computers)

Week 1 – Introduction to Sustainability from UW to the World – Jan. 25

- Overview of class goals and format, discuss the meaning of "sustainability," and "sustainability science" as it has come to be defined in scholarship, practice, and everyday life; (unconfirmed) Guest lecture by Faramarz Vakili, Co-Director of UW-Madison Office of Sustainability; Founder of the We Conserve
- **Learning Goals**: Back-of-the-envelope problem-solving; Unit conversion; build intuition on scales; articulate a definition of sustainability
- **Homework**:
    - Reading Ch. 1 (Building a Sustainable World)
    - Problem 1.1 (global population); 1.2 (food supply)

Week 2 – Electricity Production – Feb. 1

- Class fieldtrip to Campus Power Plant Charter Street and/or West Campus Cogen
- **Learning Goals**: Familiarity with sources of electricity; difference between model and measurements (electricity context); Concepts of electricity supply and demand
- **Homework**:
    - Reading Ch. 2 (Ways of Knowing/Measurements and Models)
    - Reading Ch. 3 (Energy Sources and Impacts)
    - Problem 2.1 (Kaya identity); Problem 2.2 (working with an electricity model: MyPower); Problem 3.1 (MyPower: UW-Madison's Impact on the Grid)

Week 3 – Buildings and Energy – Feb. 8

- Interactive lecture and discussion about Week 2 tours and homework. Introduction to LEED as a sustainability metric for buildings; (unconfirmed) Guest lecture by Andrew Fieber, Project Manager Boldt Construction and LEED AP
- **Learning Goals**: Familiarity with building energy demand, comparing energy and sustainability metrics, problem solving on building energy conservation
- **Homework**:
    - Reading Ch. 4 (Energy Demand and Conservation)
    - Problems 2.2 (energy metrics); 3.2 (back-of-the-envelope energy planning) 4.1 (MyPower: Planning an Energy Future)

Week 4 – Green Buildings - Feb. 15

- Class fieldtrip to LEED certified facilities (e.g. Fieber home + Fire Station #12; Union Church; Madison Children's Museum) + air quality monitoring
- **Learning Goals**: Quantifying resource use (beyond energy); basic understanding of air emissions; introduction to remote sensing
- **Homework**:
    - Reading Ch. 5 (Air Quality and Emissions Regulation)
    - Problem 4.2 (MyPower: National Energy Strategies and Emissions); 5.1 (air pollution)

Week 5 – Resource Use, Waste, and Emissions - Feb. 22

- Discussion of field trip, and employing environmental metrics to quantify system inputs, outputs. Distinction between emissions and ambient concentrations
- Review for Mid-Term #1

- **Learning Goals**: Understanding why multiple metrics are used for sustainability analysis; summarize learning to date; basic understanding of air quality issues
- **Homework**:
    - Study for Mid-Term #1

Week 6 – Air Quality in the U.S. and Around the World – March 1

- Mid-Term #1
- Interactive lecture on air pollution successes, advances, and challenges
- **Learning Goals**: Clarify understanding of models vs. measurements; build a context for electricity emissions seen in MyPower simulations.
- **Homework**:
    - Ch. 6 (Climate Change Science and Solutions)
    - Problems 5.2 (air pollution); 6.1 (back-of-the-envelope impact of Earth radiative balance); 6.2 (historic + future CO2)

Week 7 – Climate Change Challenges and Solutions – March 8

- Q & A on climate science based on Ch. 6 reading, follow-up discussion and interactive lecture.
- ½ class field trip to SSEC/CIMSS to visit climate research facilities (ice core analysis, Antarctic weather, satellite data, Science on a Sphere, etc.)
- **Learning Goals**: Basic understanding of climate science; difference between adaptation and mitigation strategies; exposure to research approaches
- **Homework**:
    - Chapter 7 (Climate Impacts)
    - Problems 6.3 (evaluating climate solutions); 6.4 (innovating on climate); 7.1 (sea level rise)

Week 8— Climate Impacts and Risk – March 15

- Introducing non-linear systems and feedbacks; prediction methods; broad thinking on natural and human system dependencies on weather and climate; Stella tutorial and overview.
- **Learning Goals**: Familiarity with Stella modeling software; prediction methods; basic understanding of weather vs. climate
- **Homework**:
    - Chapter 8 (Land Use and Land Cover)
    - Problems 7.2 (climate change and air quality); 7.3 (forest fires); 8.1 (footprint calculation)

Week 9 – The Changing Surface of the Earth – March 22

- How do we measure land use, and why does land use change matter?
- **Learning Goals**: Understanding connection between land cover and climate; human drivers of land use change; ecosystems services
- **Homework**:
    - Chapter 9 (Renewable Resources)
    - Problems 8.2 (carbon cycle basics); 8.3 (Earth from space); 9.1 (regeneration times); 9.2 (biofuels); 9.3 (bamboo)

Spring Break – March 29

Week 10 – What is a renewable resource? – April 5

- How long does it take for forest regrowth? How does the regeneration time affect the sustainability of a resource? + Review for Mid-Term #2
- **Learning Goals**: Calculating regeneration times, budgeting resources
- **Homework**:
  - Chapter 10 (Water)
  - Study for Mid-Term #2

Week 11 – Water – April 12

- Mid-Term #2
- Regional differences in water availability, use, and conservation options
- **Learning Goals:** Connect knowledge on climate, risk, regeneration, and land cover in the context of water; evaluate where and when water is a resource concern
- **Homework**:
  - Chapter 11 (Transportation)
  - Problems 10.1 (Stella for water systems); 10.2 (closed loop water systems); 10.3 (options for conserving water); 11.1 (calculating VMT)

Week 12 – Transportation - April 19

- What makes transportation a sustainability issue? What does smart transportation mean?
- **Learning Goals**: Apply systems thinking to transportation; connect with energy, emissions, air quality, climate, land use
- **Homework**:
  - Chapter 12 (Garbage & Recycling)
  - Problems 11.2 (comparing emissions from cars, buses, and trains); 11.3 (freight); 12.1 (per household garbage use); 12.2 (energy and recycling)

Week 13 – Garbage and Recycling – April 26

- Tracing waste streams to landfills, recycling, repurposing, evaluating the pros and cons of alternatives, including waste-to-energy combustion.
- **Learning Goals**: Systems thinking, life-cycle analysis
- **Homework**:
  - Chapter 13 (Food)
  - Problems 12.3 (Food waste); Problem 13.1 (measuring garbage); Problem 13.2 (waste reduction)

Week 14 – What Makes Food Sustainable?– May 3

- A simple trip to the grocery store encapsulates a wide range of sustainability issues: paper vs. plastic, local food, meat vs. vegetables, etc.
- **Learning Goals**: Systems thinking, life-cycle analysis
- **Homework**:
  - Chapter 14 (What is a Sustainable Future?)

- Problems 14.1 (sustainable cities); Problem 14.2 (health and life expectancy); Problem 14.3 (education and action)

Week 15 – Last Class – May 10

- "Sustainability Scavenger Hunt" where students spend class in teams looking for examples of resource use, conservation, new technology, and environmental impacts, and explaining how these examples fit into sustainability frameworks. Goal of exercise is to help students link in-class learning with everyday experiences (e.g. "take a photo of a natural gas bus and calculate the carbon use per mile of natural gas vs. a diesel bus?"; "Get the signature of a vegetarian – why did this person opt not to eat meat?")
- Wrap-up and Review for Final Exam