EN 101 Sustainability Science: Environment, Society, and Technology

Spring 2010: Monday and Wednesday 12:00-1:15, Sackler Science Building S321

Professor: Jennie C. Stephens, Environmental Science and Policy (ES&P) Program
Department of International Development, Community, & Environment (IDCE)
Email: jstephens@clarku.edu Office: IDCE 303, 10 Hawthorne Street

Lab/Discussion Sessions: Thursdays 9-10:50 and 2:50-4:40 (S223)

Course TA: Kate Hanley khanley@clarku.edu

Course Description

Sustainability science, an emerging field focused on the dynamic interactions between people and the environment, is defined by the problems it addresses rather than the disciplines it employs. As risks associated with climate change, biodiversity loss, deforestation, and other types of environmental degradation are increasingly threatening human well-being, destabilizing human society's and disrupting the earth's systems, calls for a societal transition toward sustainability are increasing. The complexity and varying scales of the multiple interconnected human-environment systems limit society's capacity for social and technical change to confront these problems and transition toward sustainability. This transdisciplinary course examines this complexity by adopting a socio-technical systems approach to examining linkages among environmental science, technological development, and social attempts to reduce environmental impacts. The course is structured around three basic human needs: energy, food, and water - and three critical biogeochemical cycles: carbon, nitrogen and water. In each of these three areas, an inquiry based case-study approach enables students to explore in depth current controversial questions at the intersection of environmental science and policy. A required lab/field-trip/discussion section provides students with opportunities for observing and applying sustainability science challenges in and around the Clark/Worcester community.

Course Learning Goals

(1) Understand fundamental science associated with anthropogenic disruption in three critical biogeochemical cycles (carbon, nitrogen, and water), while gaining an appreciation for complex systems science

(2) Explore the complexities associated with sustainability science challenges including technology and policy designed to reduce anthropogenic disruption of these biogeochemical cycles

(3) Integrate and synthesize information from different perspectives, disciplines, and scales to evaluate sustainability science problems and potential solutions

(4) Gain the capacity to apply the theoretical framework of socio-technical systems to a broad array of environmental challenges

(5) Develop both oral and written communication skills to facilitate systematic analysis and effective consideration of these complex issues

Course Philosophy

This course is designed as a collective endeavor in which the instructor will facilitate student engagement with the major themes of the course and the course materials. Lectures and required readings will provide necessary background and context, while student-driven active learning and inquiry will be encouraged through individual and group assignments inside and outside of class including role playing, problem-solving, and student presentations. The success of the course depends on students preparing for each class session, being ready to participate fully in all course activities, and taking responsibility for their learning.

Course Structure: Energy, Food, and Water - Three basic human needs, three interconnected biogeochemical cycles disrupted by human activity, and, with all three, technology is both a critical contributor to the disruption and offers valuable potential solutions. Applying a socio-technical systems approach, each unit will revolve around a policy question that requires an integration of technical and social knowledge and understanding to consider.

Energy – Carbon (C), the carbon cycle disrupted by anthropogenic carbon dioxide (CO_2) emissions is resulting in climate change.
Policy Question with both technical and social components: Can a transition to a 100% carbon-free renewable energy system solve the climate-energy challenge?

Food - Nitrogen (N), the nitrogen cycle transformed by humans to enhance global food production has contributed to an increase in population
Policy Question with both technical and social components: Can a transition to an organic agricultural system solve nitrogen pollution and feed the world?

Water - Hydrogen and oxygen (H_2O), the hydrologic cycle altered by human development.
Policy Question: In the final unit students will be asked to integrate and apply what they have learned from the carbon and nitrogen units to develop their own policy question with both technical and social components, and research and write a paper addressing that question.

Required Readings
EN 103 Course Pack (available at the Clark Copy Center, basement of UC)
Shiva, Vandana. 2000. Stolen Harvest. Cambridge, MA. South End Press.
Shiva, Vandana. 2002. Water Wars, Privatization, Pollution and Profit. Cambridge, MA.South End Press.
Recommended but not required reference book – on reserve at the Goddard Library
Kaufmann and Cleveland. 2008. Environmental Science. McGraw-Hill Companies. ISBN 0073311863

Course Learning Activities and Assessment
Participation (including attendance and preparedness) (15%) All students are expected to attend every class session and be prepared to participate in every class. This class is not a lecture-only class; class sessions will be interactive and students are required to engage and contribute during class, because interaction and participation will be a critical component of student learning. Occasional assignments that students will work on individually or in small-groups inside or outside of class may also contribute to the participation grade.

Laboratory/Discussion (20%) The weekly lab/discussion session is designed to provide students with a diversity of hands-on, local, community-based experiences that foster the exploration of the themes, topics, materials and issues addressed in the course. The lab/discussion section is an integral part of the course, so full attendance and participation is required. Some of the lab activities will require pre-lab reading or preparation or a post-lab assignment that will be evaluated by the course TA.

Presentations (15%) Each student will be involved in 3 group presentations reporting to the rest of the class on the research they have done for each of the three units.

Papers (40%): Students will write four papers throughout the semester. Each of these papers will correspond with and relate to each of the four units of the course.

Quizzes (10%): Students will take two in-class quizzes on the technical and scientific details of the course.

Unit 1 Sustainability Theoretical Frameworks

1/20 Wednesday Sustainability Science & Course Expectations

Required Reading

- Kates, R. W. et al. 2001. "Sustainability science." Science **292**(5517): 641-642.
- Hawken, Paul. 2009 "The Earth is Hiring" Commencement speech to the Class of 2009 at the University of Portland.

Come to class prepared to address the following questions based on the required readings:
(1) How is "sustainability science" different than other "scientific" disciplines?
(2) Review the 7 core questions of sustainability science listed in the Kates et al article, and identify which of these 7 questions would you focus on if you were asked to write a research paper about some aspect of sustainability science?
(3) What kinds of knowledge and skills related to sustainability do you want to learn before you graduate from Clark?
(4) How do you balance your own feelings of pessimism and optimism when considering the environmental/sustainability challenges facing humans and the earth?

1/21 Th - Lab/Discussion Ecological Footprint & Library Coaching Session.

1/25 Monday Sustainability Framing and Policy

Required Reading

- Reread Kates et al 2001 and Hawken 2009 (if you did not read before the first class session)
- Marshall, J. D. and M. W. Toffel, 2005. "Framing the Elusive Concept of Sustainability: A Sustainability Hierarchy." Environmental Science & Technology **39**(3): 673-682.

Come to class prepared to address the following questions based on the required readings:
(1) Considering the sustainability hierarchy, identify examples of each level from your own experience. (2) Apply the explanation for the policy void on issues of sustainability to one specific proposed environmental policy that you are familiar with that has not been made into law.

1/27 Wednesday Socio-Technical Systems and Transitions

Required Reading

- Geels, F. W. 2005. "The dynamics of transitions in socio-technical systems: A multi-level analysis of the transition pathway from horse-drawn carriages to automobiles (1860-1930)." Technology Analysis & Strategic Management **17**(4): 445-476.

Come to class prepared to address the following questions:
(1) What are the most important technical factors that have contributed to the evolution of the automobile's importance in our society? (2) What are the most important social factors? (3) Do the complexity and the interconnections surprise you?

1/28 Th - Lab/Discussion Who killed the Electric Car?

As you watch this film, apply the socio-technical systems perspective to your interpretation of the story being told. What social and technical factors limited the technology's transition from niche to mainstream? Can you predict the indirect future influences of what happened in California with these vehicles?

Unit 2 Energy-Carbon. Can a transition to a 100% carbon-free renewable energy system solve the climate-energy challenge?

2/1 Monday Wrap-up of Sustainability Frameworks Unit and Intro to Energy-Carbon Unit

There is no required reading for this class session. Students are required to bring a hard copy of their first paper to the class session because during class we will be doing some peer-review of your papers. We will also be brainstorming about what we want to learn to consider the question for the Unit 2.

2/3 Wednesday Transitioning Energy Systems: Fossil-fuel based vs. renewable based.

Required Reading

- Jacobson, M. Z. and M. A. Delucchi 2009. "A Path to Sustainable Energy by 2030." Scientific American 301(5): 58-65.

Come to class prepared to address the following questions based on the required readings:
Why is demand projected to be lower with a renewable-based energy system? Have the authors convinced you that the obstacles are surmountable? What else do you want to know to consider whether you agree with authors' analysis? What factors have the authors not included?

2/4 Th – Lab/Discussion Campus Energy Systems

Required Reading (in course reader)

- DeCarolis, J. F., R. L. Goble, et al. 2000. "Searching for Energy Efficiency on Campus, Clark University's 30-Year Quest." Environment 42(4): 9-20.

2/5 Friday Final Draft of Integration paper #1 Due. Post on Cicada.

2/8 Monday Carbon Cycle & Climate Change Science

Required Reading

- McKeown, A. & G.Gardner. 2009. Climate Change Reference Guide. Worldwatch Institute.

Come to class prepared to address the following questions based on the required reading:
(1) What pollutants and associated human activity are contributing to climate change? (2) How does the carbon cycle presented in this document relate to carbon transformations related to humans and other animals? (3) Review the key terms for understanding climate change - which of these terms are most unfamiliar to you? (4) What do you notice about the global distribution of causes and impacts of climate change?

2/10 Wednesday Scaling Up Renewables

Required Reading

- Pacala, S. and R. Socolow 2004. "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies." Science 305(5686): 968-972.
- Ausubel, J. H. 2007. "Renewable and nuclear heresies." International Journal of Nuclear Governance, Economy and Ecology 1(3): 229-243.

Come to class prepared to address the following questions based on the required reading: (1) Why is the wedge concept helpful to considering carbon reductions? (2) What perspectives are not discussed in the stabilization wedge article, and why do you think these perspectives are not included? (3) Are you convinced of the limitations of renewable by the information presented in the Ausubel article? (4) What additional information would you like to learn about after reading the Ausubel article?

2/11 Th - Lab/Discussion Wedge Game: Technological Options for CO_2 Stabilization & Quiz #1

2/15 Monday Electric Grid Industry Presentation

Required Reading

- Spring, N. 2009. "The Smart Grid and Generation". Power Engineering. 44-50.
- Apt and Fischoff. 2006. Power and People. The Electricity Journal. Vol 19, No. 9, p. 17-25

2/17 Wednesday Solar and Wind Industry Presentation

Required Reading

- Komor, Paul. 2009. "Wind and Solar Electricity: Challenges and Opportunities" Pew Center on Global Climate Change.

2/18 Th – Lab/Discussion Wind Farm Game

2/22 Monday Coal Industry Presentation

Required Reading

- MIT. The Future of Coal – Options for a Carbon Constrained World. Summary Report. 2007. An Interdisciplinary MIT Study.

2/24 Wednesday US Department of Energy Presentation

Required Reading

- Holdren, J.P. 2006. "The Energy Innovation Imperative, Addressing Oil Dependence, Climate Change, and Other 21st Century Energy Challenges." Innovations, Technology, Governance & Globalization **1**(2): 3-23.

2/25 Th – Lab/Discussion Climate Modeling Lab

3/1 Monday Peer Review of Integration Paper #2

No required reading for this class session. Students are to bring hard copy of paper #2 for peer review during the class session. We will also follow up on the group presentations from the previous week.

3/3 Wednesday Energy, Carbon, Renewables, Wrap-up Debate – Mid-term Evaluation

Final session of the energy-carbon unit will focus on debating the original question that framed this unit.

3/4 Th - Lab/Discussion Energy Efficiency Lab

3/5 Friday Integration Paper #2 Due on Cicada by midnight

SPRING BREAK

Unit 3 – Food-Nitrogen: Can an organic agricultural system solve nitrogen pollution & feed the world?

3/15 Monday Scaling up Organic Food and Nitrogen Pollution

Required Reading

- Badgley, C. and I. Perfecto (2007). "Can organic agriculture feed the world?" Renewable Agriculture and Food Systems **22**(2): 80-85.
- Socolow, R. H. (1999). "Nitrogen management and the future of food: Lessons from the management of energy and carbon." Proceedings of the National Academy of Sciences **96**(11): 6001-6008.

Come to class prepared to address the following questions based on the required reading: Badgley and Perfecto (2007): (1) What are the most important differences between organic and conventionally grown food? (2) Are you convinced by the authors' arguments about organic food? (3) What additional perspectives and information would you like to learn? (4) Reflecting on the analogy between carbon and nitrogen, energy and food, and renewable and organic, what are some distinct systemic differences between these two systems?

3/17 Wednesday Other Food System Controversies

Required Reading

- Shiva, V. (2000). Stolen Harvest, The Hijacking of the Global Food Supply. Cambridge, MA, South End Press.

Come to class prepared to address the following questions based on the required reading:

(1) Of the main controversies highlighted in Shiva's book, which of these are you most concerned about or would you prioritize as most critical? (2) Reflecting on both the content as well as her writing style, what additional information or perspectives does Shiva's book make you want to learn about?

3/18 Th – Lab/Discussion Watch Youth Grow Video and Research Team Work

3/22 Monday Food System Controversies and Nitrogen Discussion

Required Read

- Shiva, V. (2000). Stolen Harvest, The Hijacking of the Global Food Supply. Cambridge, MA, South End Press.
- Kaiser, J. (2001). "Environmental policy - The other global pollutant: Nitrogen proves tough to curb." Science 294(5545): 1268-1269.

Come to class prepared to continue the discussion on Vandana Shiva's perspective and the concerns raised in her book. Also: Why is nitrogen pollution difficult to manage? Is it more or less difficult to manage than carbon? Or other pollutants?

3/24 Wednesday Nitrogen and Nitrogen Fixation

Required Reading (Available on Cicada – not in reader)

- Vitousek, Peter M., John D. Aber, Robert W. Howarth, Gene E. Likens, Pamela A. Matson, David W. Schindler, William H. Schlesinger, David G. Tilman. 1997. Human Alteration of the Global Nitrogen Cycle: Sources and Consequences. Ecological Applications. P. 737-750.

Come to class prepared to answer the following questions: (1) Identify at least two critical interactions between human disruption of the nitrogen cycle and the carbon cycle. (2) Notice that this article was written in 1997 – what do you think may have changed since then that may change the state of the science, and in the management options? (3) What are the differences in the three N species included in Figure 3?

3/25 Th – Lab/Discussion Food, Inc. Quiz #2

3/29 Monday Scientists Presentation Relating to Genetic Engineering & Organic Agriculture Industry

Required Reading

- Gurian-Sherman, D. & Gurwick, N. 2009. No Sure Fix – Prospects for reducing Nitrogen Fertilizer Pollution Through Genetic Engineering. Union of Concerned Scientists.

3/31 Wednesday International Fertilizer Industry Presentations

Required Reading

- Browse the International Fertilizer Association (IFA) website paying particular attention to the sections on climate change and sustainability http://www.fertilizer.org/ifa/Home-Page/ABOUT-IFA

4/1 Th – Lab/Discussion Youth Grow Visit – till the soil! (wear work clothes)

4/5 Monday Organic Farmers Presentations

Required Reading (on Cicada)

- Easton, Thomas A.(ed) 2009. "Is a Large-Scale Shift to Organic Farming the Best Way to Increase World Food Supply?" In Taking Sides. Clashing Views on Environmental Issues. Thirteenth Edition. P. 270-287

4/7 Wednesday International Agriculture Corporations Presentations (ADM, Monsanto)

Required Reading (on Cicada)

- Easton, Thomas A. (ed) 2009. "Is a Large-Scale Shift to Organic Farming the Best Way to Increase World Food Supply?" In Taking Sides. Clashing Views on Environmental Issues. Thirteenth Edition. P. 270-287

4/8 Th – Lab/Discussion Food Choice and Local Availability – Artichoke Food Co-op

4/ 12 Peer Review of Paper #3
No required reading for this class session. Bring hard copy of paper #3 for peer review during class.

4/14 Wednesday Wrap-up Debate and Discussion

4/15 Th – Lab/Discussion Blackstone River Watershed

4/16 Friday Integration Paper #3 due on Cicada by midnight

Unit 4 Self-designed Inquiry on Socio-Technical Challenges of the Hydrologic Cycle
In this final unit students will be asked to integrate and apply what they have learned from the carbon and nitrogen units to develop their own policy question with both technical and social components, and research and write a paper addressing that question. Given that water challenges are geographically diverse and very location-specific, students are required to situate their question within a specific region of the world. The student presentations will be clustered based on geographic region of the world.

4/19 Monday Water Controversies
Required Reading
- Shiva, V. (2002). Water Wars, Privitization, Pollution, and Profit. Cambridge, MA. South End Press. Chapter 1-3
- Imhof, A. and G. R. Lanza (2010). "Greenwashing Hydropower." WorldWatch **Jan/Feb**: 8-14.

4/21 Wednesday Water Controversies Continued
Required Reading
- Shiva, V. (2002). Water Wars, Privitization, Pollution, and Profit. Cambridge, MA. South End Press. Remaining Chapters
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4/22 Th – Lab/Discussion Campus Food and Water Systems

4/26 Monday Student Presentations

4/28 Wednesday Student Presentations

4/29 Th – Lab/Discussion Bottled Water Waste Stream Analysis, Tour Recycling Center

5/3 Monday – Last Class Course Wrap-up, Peer Review of Paper #4

5/7 Final Integration Paper #4 due on Cicada by midnight

EN 101: Environment, Society, and Technology
Spring 2010, Laboratory Sessions.
Thursdays 9-10:50 and 2:50-4:40 (Sackler S223)
Lab/Discussion Instructor: Kate Hanley khanley@clarku.edu

Laboratory Schedule

Objectives: The weekly lab/discussion session is designed to provide students with a diversity of hands-on, local, community-based experiences that foster the exploration of the themes, topics, materials and issues addressed in the course. The lab/discussion section is an integral part of the course, so full attendance and participation is required. Some of the lab activities will require pre-lab reading or preparation or a post-lab assignment that will be evaluated by the course TA.

Date	Topic/Activity	Notes
Jan 21	Lab introduction, Ecological Footprint, & Library Session	
Jan 28	Who Killed the Electric Car	
Feb 4	Campus Energy System: Cogeneration Plant & Heat Wheel	DeCarolis et al 2000
Feb 11	Wedge Game and Quiz #1	Pacala and Socolow, 2004
Feb 18	Wind Farm Game	Read pre-game materials before
Feb 25	Climate Modeling Lab	Pre-lab Materials
Mar 4	Energy Efficiency Lab – Infrared Camera	
Mar 18	Youth Grow Video and Research Team Work	
Mar 25	Food Inc. Quiz #2	
Apr 1	Youth Grow Visit and Farm Work	Wear good walking shoes
Apr 8	Food Choice and Availability: Artichoke Food Co-op and Conventional Supermarket comparison	
Apr 15	Blackstone River Watershed Tour – Facilitated by Peter Koffin	Blackstone River Coalition
Apr 22	Campus Food and Water Systems	
Apr 29	Bottled Water Waste Stream Analysis, Tour Recycling Center	