The Centre for Environment

ENV1004/ENV431

A Joint Graduate/4th year Undergraduate Course on URBAN SUSTAINABILITY AND ECOLOGICAL TECHNOLOGY

Wednesday 10–12:00, ESC 1042

Ecological technology or green infrastructure, in a limited sense, encompasses those technologies that incorporate ecosystems to replace mechanical or non-living components in a machine or a piece of infrastructure. These technologies might include green roofs, green walls, bioswales, raingardens, breathing walls and living machines. As cities grow and as densities increase, green space often decreases, leading to a number of consequences, some expected and some unexpected. On the other hand, can green infrastructure provide a means to take advantage of suburban spatial structure to address environmental, social and economic issues?

What are ecological technologies, how does their design differ from other green technologies, how we might evaluate their performance and how ecological technologies contribute to urban sustainability are ongoing themes of this course. Some of the questions that are addressed in the course involve the role of green spaces, climate change, water quality, emergency response and food security. Can ecological technologies replace the green spaces, in terms of area and function, within a city? Can they function as a green infrastructure, replacing hard infrastructure Can these technologies be used as adaptation strategies to climate change? Do these technologies provide means of enhancing food security in urban areas?

As both cities and ecosystems are complex systems on their own, the interaction between them can also be expected to be complex. Through a series of texts, students will gain an understanding of language and concepts complex systems theory and how these might be applied in the urban context. These concepts include emergence, bifurcation, feedbacks, attractors and chaos. In addition, to the language of complexity, concepts from second-law thermodynamics, exergy and entropy, provide a theoretical understanding of how ecosystems can contribute to urban sustainability and a basis from which to evaluate green infrastructure or ecological technologies.

The course will use complex systems theory and second-law thermodynamics as a template to explore concepts of urban sustainability and the role of ecological technology in this context. From the theoretical, the course will move onto water,

looking at the infrastructure that handles water, where it is, how it can be integrated with green infrastructure and how it can be replaced. This part of the class will focus on identifying opportunities on the landscape for greening infrastructure, daylighting underground streams and utllizing living walls as a replacement infrastructure. Green roofs and living walls will be used as an infrastructure models to illustrate how green infrastructure works, how it is designed and how it can be implemented in urban areas.

The benefits green roof infrastructure, green walls and breathing walls and the opportunities for utilizing unconventional spaces as part of the city's green infrastructure will be utilized to assess the role of ecological technologies in promoting urban sustainability. Students will have the opportunity to look at green roof design on a small-scale, grow food on a green roof, work with a breathing wall or work on the design and/or construction of a green wall.

The course will meet for two hours each week. Course participants will be expected to complete the assigned readings, participate in the weekly discussions on the readings and complete the following three assignments:

1. Choose one of the following projects:
    a. Using a simulation model, explore the linkages between urban form and complexity and between urban form and the city's resource base OR
    b. Development of a stormwater runoff educational activity with green roofs
2. A book review of a relevant text (list to be provided)
3. A team project based selected from a design, measurement, education, planning or research issue or a design issue including a team presentation.

In addition, each student will be expected to complete the readings and participate in discussions.

Previous team assignments drew from a range of applications:

- addressing the gaps in a business plan to preserve urban natural heritage areas from industrial encroachment.
- the design of a food production system for a school cafeteria based on a green wall to address to food quality for lower income neighbourhoods, develop opportunities in the green economy and help revitalize a city hit hard by a hurricane in New Orleans.
- the development and application of measures of sustainability based on complexity to a neighbourhood in Toronto.
- Development of material on green infrastructure, particularly trees that can be accessed elementary school age children or teachers via the web.
- Updating spreadsheet on embodied energy
- Designing a green roof to meet specific objectives for specific buildings

Current possibilities for new assignments include:

- Extending assignment 1 (simulation) with climate change & disease
- Design of an off-grid energy source for pumping water.
- Develop and test guidelines for raising moss indoors
- Simulating the emergence of antibiotic-resistant bacteria and the role of green infrastructure as an adaptation measure
- Assess regulations that restrict the use of ecological technologies to harvest rainwater and use wastewater
- Assess the feasibility and modify the design of a living wall for use in emergency situations for providing food and water.
- Develop the database for a simulation of a breathing wall and test the performance of the model for different types of ecosystems.

Teams will have the opportunity to propose an original design, policy or research project.

The course will take place on the St. George campus, in ESC1042/(a larger space depending on enrollment), Wednesdays from 10:00 – 12:00 in the Fall 2010 semester. The in-class lectures and discussions may be supplemented with a computer lab, guest speakers and/or visits to buildings or sites in the city of relevance to the course. The first half of the course will be based on the assigned readings, videos, in-class lectures and discussions. In the second half of the course, more time will be devoted to the issues that will arise in each project, and may be supplemented by readings or lectures. This will provide an opportunity for each student to participate in each project.

The course is taught by Brad Bass, a member of the Adaptation & Impacts Research Section located within the Centre for Environment. Dr. Bass has been conducting research in the benefits of ecological technologies (green roofs and walls and living machines) since 1996, he is the Chair of the North American Green Roof Research Committee and is also the leader of the COBWEB project.

Participation is important in assessing your final grade. Participation will be graded on the basis of attendance and active participation in seminar discussions. In assessing participation, quality of contributions will matter as much as quantity. All students should ensure that they have an e-mail account, as important course announcements will be sent by email.

Grade Distribution:

Assignment 1	20%
Assignment 2	25%
Team project	40%
Participation	10%
Quizzes on Readings	5%

A field trip to Cawthra Woods and/or the Sheridan sub-watershed may be scheduled for September or October, the purpose of which is to discover opportunities for reintroducing green infrastructure.

The course is a joint graduate/undergraduate course, open to 4th year undergraduate students in any discipline with permission of the instructor. Although there are no formal prerequisites for the course, students should be comfortable with reading scientific as well as less formal literature, lively discussion and debate, experimentation and written communication.

Questions about the seminar can be directed to Brad Bass by phone at 416-978-6285 or 905-828-5298 or by email at brad.bass@utoronto.ca or brad.bass@ec.gc.ca. Undergraduate students interested in this seminar should also contact David Powell at david.powell@utoronto.ca.

Readings:
Green Infrastructure: Projects, Performance and Policies This is a manual published by the Green Infrastructure Foundation

Readings on complexity, urban form and benefits of green infrastructure in Course Reader.

DIY Guide to Green Roofs (2009) Available from livingroofs.org This guide is a short introduction to the design and construction of small-scale green roofs.

Bass, B et al. (2011) *Course Manual for the Design and Construction of Vertical Integrated Biofilters* This manual is based on training course conducted by Robert Cameron and Brad Bass at Penn State University in July 2010.

Optional Readings:
Clive Doucet (2008) *Urban Meltdown* Part autobiographical text and part commentary on urban sprawl and climate change written by a City of Ottawa councilor Clive Doucet (yes he is related to local musician Luke Doucet). This provides an "in-house" perspective on the economic and environmental costs of urban sprawl in Canada.

Salingaros N.A. (2005) Principles of Urban Structure. Amsterdam, The Netherlands: Techne Press Chapters 1 and 4. Salingaros uses concepts of complexity to derive a new basis for urban planning based on first principles. Although he may not have been entirely successful, his book does formalize and goes beyond many of the ideas raised by Jane Jacobs in her first book on the *Decline of American Cities*.

Stafford Beer, *Designing Freedom*, available on Blackboard

Schedule of Topics and Readings

Date	Topic	Reading
Week 1 Sept 14	Introduction to Urban Sustainability, Green Infrastructure and the language of complexity	
Week 2 Sept 21	Complexity and Urban Sustainability Intro to assignments 1 & 2	Beer,Ch 1 – 4 Abler, Adams & Gould (Reader) Krugman Part 1 (Reader) James Kay (Reader)
Week 3 Sept 28	Density & sustainability: Land use theory, urban heat islands and green infrastructure Select text for assignment 2	Abler, Adams & Gould (Reader) Krugman Part 1 (Reader)
Week 4 Oct 5	Water & Climate Change; Water in the Urban Environment, Aggregates and Water Quality and Integrated Water Management Assignment 1 due	GI Manual 1.4, Appendix A Bass et al. Ch 1 & 3
Week 5 Oct 12	The Benefits of Green Infrastructure	Rowe (Course Reader) GI Manual Ch. 2
Week 6 Oct 19	Introduction to Green Roofs, plants and growing media Introduction to Team Projects	DIY Green Roof Guide GI Manual 3.6
Week 7 Oct 26	Design and construction of vertical biofilters, Designing Ecosystems for low and high nutrient inputs Assignment 2 Due	Bass et al. Ch 1 & 3 GI Manual 3.3-3.5, 3.7 Optional: Vertical Farm – http://www.verticalfarm.com/ Ken Yeang – *Ecodesign: A Manual for Ecological Design* (pp. 133-60, 254-61, 280-7, 294-7) Architecture & Robarts NA2542.35

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Week 8 Nov 2	Integrated Water Management	Optional Readings: *ACE Wetland Manual, Achieving Water Independence in Buildings, Greywater guidebook,* Stumpf, *Treatment Wetland Design Manual*, USDA, *Virginia Rainwater Harvesting Manual*
Week 9 Nov 9	The language of complexity, second-law thermodynamics Thermodynamics & biodiversity	Rosen. M. Exergy Analysis Winter, C-J. Energy efficiency, no: It's exergy efficiency!
Week 10 Nov 16	Designing for biodiversity	GI Manual 3.1 – 3.5 Currie & Bass – *Using Green Roofs to Enhance Biodiversity in the City of Toronto*
Week 11 Nov 23	Implementing Green Infrastructure	GI Manual 5.2, Appendices B & C
Week 12 Nov 30	Team Projects Presentations Team Projects Due	

Coffman RR (2007) Comparing Wildlife Habitat and Biodiversity across Green Roof Type. Presented at *Greening Rooftops for Sustainable Cities, Minneapolis*. Toronto, ON: Green Roofs for Healthy Cities.

Gedge D and Kadas G (2005).Green roofs and biodiversity. *Biologist*, pp 161-169 http://www.iob.org/userfiles/File/biologist_archive/Biol_52_3_Kadas.pdf

Kadas G (2006). Rare Invertebrates Colonizing Green Roofs in London *Journal of Urban Habitats* 4:66-86.

Rosen, M (2007) Exergy Analysis. *Encyclopedia of Energy Engineering*

Winter, C-J (2007) Energy efficiency, no: It's exergy efficiency! *International Journal of Hydrogen Energy* 32: 4109 – 4111.

Yeang, Ken. *Ecodesign: A Manual for Ecological Design*, New York: Wiley, 2006

Achieving Water Independence in Buildings – http://www.google.ca/url?sa=t&source=web&ct=res&cd=2&ved=0CA0QFjAB&url=http%3A%2F%2Filbi.org%2Fresources%2Fresearch%2Fwater%2FAchieving_Water_Independence_in_Buildings.pdf&rct=j&q=%22achieving+water+independence+in+buildings%22&ei=KGYdS_aHIITT8Qauo8TdAw&usg=AFQjCNEApiY7uBP3etrhSrwHpLKr0xX60w

Greywater Guidebook – http://www.doh.wa/gov/ehp/ts/WW/GreywaterFact.PDF

Virginia Rainwater Harvesting Manual –
http://www.dcr.virginia.gov/documents/stmrainharv.pdf