Program in Urban Planning and Policy Development, Rutgers University, Revised 8/30/16

34:970:571 Industrial Ecology

Tuesdays 9:50 am to 12:30 pm
Fall 2016
Civic Square Building, Room CSB 112
Office Hours: Tuesdays 2-5 pm

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Class Sakai Site: http://sakai.rutgers.edu 34:970:571:01 F16

This graduate seminar course explores the powerful industrial ecology metaphor, testing the field's claim that it is a framework for implementing sustainable development. Industrial ecology takes a systematic view of the use and environmental implications of materials, energy, and products in industrial societies. It attempts, in practical terms, to bridge the disciplines of economics and ecology. It exploits the ecological analogy by placing industrial activity in its environmental context and by drawing on nature as a model. It relies on modern microeconomics for a theory of agency and to explain the behavior of actors in industrial ecosystems. We will evaluate five aspects of current research and practice in industrial ecology:

- **Individuals**: At the micro level, what motivates individual humans? Why do they create firms and governments? Why do they consume, pollute, or stop polluting?
- **Organizations**: At the organizational level, what motivates individual firms? Which survival strategies do they employ? How do organizations work? How do/ought they transform materials and energy?
- **Structure**: At the community and sector levels, what is the structure of each web of industrial actors? What actors are present and what are their roles? Are there vacant ecological niches?
- **Space**: At the industrial ecosystem level, what do the flows of materials and energy look like? Is there any waste? Is the system sustainable? How does the picture differ between local and larger-scale perspectives?
- **Time**: How quickly do human activities and environmental conditions change? How do we gracefully manage these transitions?

The course employs a research seminar-practicum format, in which the instructor provides a conceptual overview of the day's topic, and then students apply the concepts to a specific case or volunteers take responsibility for leading discussion on the application of the concepts. Thus each class will address both conceptual and practical issues.

Learning objectives are that after taking this course the student will be able to explain the industrial ecological analogy to others; apply systems thinking to problems in environmental

planning, management, and policy; comfortably discuss and investigate selected scientific and technological aspects environmental issues; incorporate knowledge of human agency and social structure into the development of environmental solutions; and confront emerging environmental problems in a balanced and realistic way. No special disciplinary or mathematical background is required but students will be encouraged to use whatever they have.

Course requirements include active participation in classroom cases/exercises and discussions (5% of grade); leading the classroom discussion of one or more practicum topics depending on the size of the class (15%); preparing a 500-word (+/-) written reflection on the readings for each of Parts I, II, III, IV, V, and VI of the course (5% each) *except* the part(s) in which you lead the practicum; and a final paper on an approved topic proposed by the student with a length of about 5,000 words excluding tables, figures and references (55%). No exams.

Rutgers' academic integrity policy will be strictly enforced in this course. Failure to comply with this policy can result in severe sanctions up to and including expulsion from the University. See the full text at http://academicintegrity.rutgers.edu. The following excerpt serves as a reminder that the student must:

- properly acknowledge and cite all use of the ideas, results, or words of others
- properly acknowledge all contributors to a given piece of work
- make sure that all work submitted as his or her own in a course or other academic activity is produced without the aid of unsanctioned materials or unsanctioned collaboration
- obtain all data or results by ethical means and report them accurately without suppressing any results inconsistent with his or her interpretation or conclusions
- treat all other students in an ethical manner, respecting their integrity and right to pursue their educational goals without interference. This requires that a student neither facilitate academic dishonesty by others nor obstruct their academic progress
- uphold the canons of the ethical or professional code of the profession for which he or she is preparing.

Readings:

All of the assigned readings are stored in electronic form as pdf files on the class Sakai site. There is no required textbook. Readings are divided into ***Required*** readings that all students must complete prior to the class day for which they appear in this syllabus, and ***Recommended*** readings which interested students (especially Ph.D. students) may read to learn more about a topic. Not all of the ***Recommended*** readings are on Sakai, so it may be necessary to visit the library or see the instructor. Finally, all students are required to read the *Journal of Industrial Ecology* throughout the semester.

Schedule of Classes

WEEK	DATE	LECTURE TOPIC
		Part I Background
1	Sept. 9*	Introduction and Overview (FRIDAY!)
2	Sept. 13	Metabolism of the Anthroposphere
		Part II Individual Agency
3	Sept. 20	Consumer, Producer, and Citizen Behavior
4	Sept. 27	Sustainable Consumption
		Part III Organizational Actors
5	Oct. 4	Organizational Behavior and Functions
6	Oct. 11	Green Supply Chain Management
7	Oct. 18	Business Strategy
		Part IV Structure
8	Oct. 25	Morphology of Industrial Ecosystems
9	Nov. 1	Environmental Implications of Economic Globalization
		Part V Urban Applications
10	Nov. 8	Urban Metabolism
11	Nov. 15	Urban Footprints: The Grand Nutrient Cycles
	Thanksgiving Break	
12	Nov. 29	Urban Residues: Toxics Today and Tomorrow
		Part VI Toward the Future
13	Dec. 6	Transition Management
14	Dec. 13	Final Student Presentations

Schedule of Topics, Readings, and Assignments

Part I Background

September 9 Introduction and Overview

Introduction and course overview, the ecological analogy, central issues and perspectives

Practicum: Develop ecological analogies and ways to test their appropriateness in class discussion.

Required Reading:

Socolow, R.H. (1994) "Six perspectives from industrial ecology," pp. 3-16 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Lifset, R., and T.E. Graedel. (2002) "Industrial ecology: Goals and definitions," pp. 3-15 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Cheltenham, UK.

Lifset, R. (2014) "Speaking industrial ecology," *Journal of Industrial Ecology* 18(6): 785-6. DOI: 10.1111/jiec.12218

September 13 Metabolism of the Anthroposphere

Metabolic phenomena at several scales of human activity; metabolic design

Practicum: Become a metabolic designer, that is, apply metabolic concepts to re-imagine aspects of human activity. Chapter 5 of the Baccini & Brunner book discusses three such design challenges: phosphorus management, urban mining, and waste management. Three volunteers will each prepare and hand out a short (1 page) summary of one of these design challenges, briefly present their findings to the class (10 minutes), and lead a short discussion.

Required Reading:

Baccini, P., and P.H. Brunner (2012) "Metabolic phenomena in the anthrposphere," chapter 2 (pp. 21-80) in *Metabolism of the Anthroposphere: Analysis, Evaluation, Design*, 2nd edition. Cambridge, MA: MIT Press.

Marshall, J.D., and M.W. Toffel. (2005). "Framing the elusive concept of sustainability: A sustainability hierarchy," *Environmental Science and Technology* 39(3): 673-682.

Recommended Reading:

Baccini, P., and P.H. Brunner (2012) "Designing metabolic systems," chapter 5 (pp. 281-361) in *Metabolism of the Anthroposphere: Analysis, Evaluation, Design*, 2nd edition. Cambridge, MA: MIT Press. *Practicum students should read the portion of the chapter that relates to their assigned design problem.*

Part II Individual Agency

September 20 Consumer, Producer, and Citizen Behavior

Theory of agency for industrial ecology; individual choices; multiple roles of individuals as consumers, producers, and citizens

Practicum: Evaluate the efficacy of efforts to promote green consumerism and citizenship toward the built environment, including eco-labels, public information programs (e.g., energy efficiency), and regulatory or incentive programs (e.g., recycling). Three volunteers will each prepare and hand out a short (1 page) summary of one of these topics, briefly present their findings to the class (10 minutes), and lead a short discussion. Each presentation should draw on one or more articles in the *Journal of Industrial Ecology*. Feel free to supplement the *JIE* articles with your own sources.

1st reflection on readings due on Sakai the night before class (11:59 pm Sept. 19th)

Required Reading:

Andrews, C.J. (2001) "Building a micro foundation for industrial ecology." *Journal of Industrial Ecology*, 4(3): 35-51.

Frankel, C. (1998) *In Earth's Company: Business, Environment, and the Challenge of Sustainability*, New Society Publishers, Gabriola Island, BC, pp. 135-148.

Stern, P. (2002) "Changing behavior in households and communities: What have we learned?" pp. 201-211 in T. Dietz and P.C. Stern, eds., *New Tools for Environmental Protection: Education, Information, and Voluntary Measures*, National Academy Press, Washington, DC. Available online at http://www.nap.edu/books/0309084229/html/.

Recommended Reading:

Kleindorfer, P.R. (1999) "Understanding individuals' environmental decisions: A decision science approach," pp. 37-56 in K. Sexton, A.A. Marcus, K.W. Easter, and T.D. Burkhardt, eds., *Better Environmental Decisions: Strategies for Governments, Businesses, and Communities*, Island Press, Washington, DC.

Lutzenhiser, L. (2002) "Marketing household energy conservation: The message and the reality," pp. 49-66 in T. Dietz and P.C. Stern, eds., *New Tools for Environmental Protection: Education, Information, and Voluntary Measures*, National Academy Press, Washington, DC. Available online at http://www.nap.edu/books/0309084229/html/.

Schultz, P.W. (2002) "Knowledge, information, and household recycling: The knowledge-deficit model of behavior change," pp. 67-82 in T. Dietz and P.C. Stern, eds., *New Tools for Environmental Protection: Education, Information, and Voluntary Measures*, National Academy

Press, Washington, DC. Available online at http://www.nap.edu/books/0309084229/html/.

Stead, W.E. and J.G. Stead. (1992) *Management for a Small Planet: Strategic Decision Making and the Environment*. Newbury Park CA: Sage Publications, pp. 143-165 (ch. 8: The Green Stakeholders).

Thøgersen, J. (2002) "Promoting "green" consumer behavior with eco-labels," pp. 83-104 in T. Dietz and P.C. Stern, eds., *New Tools for Environmental Protection: Education, Information, and Voluntary Measures*, National Academy Press, Washington, DC. Available online at http://www.nap.edu/books/0309084229/html/.

September 27 Sustainable Consumption

Contrasting perspectives of consumption and marketing, potential system effects

Practicum: Critically examine the potential for sustainable consumption to bring about systemic changes in production systems. Three volunteers will each prepare and hand out a short (1 page) summary of one of the articles in the 2010 special issue of the *Journal of Industrial Ecology* on this topic, briefly present their findings to the class (10 minutes), and lead a short discussion. Feel free to supplement the *JIE* articles with your own sources.

Submit one-page proposal for your final project on Sakai by 11:59 pm Sept. 26th)

Required Reading:

Andrews, C.J. (2013) Policy Perspectives: Empowering sustainable consumption. *IEEE Technology and Society Magazine*, Fall 2013, 32(3): 8–9.

Tukker, A., Cohen, M. J., Hubacek, K. and Mont, O. (2010), The Impacts of Household Consumption and Options for Change. *Journal of Industrial Ecology*, 14: 13–30. doi: 10.1111/j.1530-9290.2009.00208.x

Hertwich, E. G. (2005), Consumption and the Rebound Effect: An Industrial Ecology Perspective. *Journal of Industrial Ecology*, 9: 85–98. doi: 10.1162/1088198054084635

Weidema, B. P., Suh, S. and Notten, P. (2006), Setting Priorities within Product-Oriented Environmental Policy. *Journal of Industrial Ecology*, 10: 73–87. doi: 10.1162/jiec.2006.10.3.73

Recommended Reading:

Journal of Industrial Ecology 14(1) (2010), special issue on sustainable consumption and production.

Heller, M.C., and Keoleian, G.A. (2015) Greenhouse gas emission estimates of U.S. dietary choices and food loss. *Journal of Industrial Ecology* 19(3): 391-401. DOI: 10.1111/jiec.12174.

Freeman, R., Yearworth, M., and Preist, C. (2016) Revisiting Jevons' paradox with system dynamics: Systemic causes and potential cures. *Journal of Industrial Ecology* 20(2): 341-353. DOI: 10.1111/jiec.12285.

Part III Organizational Actors

October 4 Organizational Behavior and Functions

Internal workings of the firm, relationship of internal organization and the behavior of firms, principal-agent problems, conspiring to reform large organizations, environmentally important functions of the firm, accounting and finance issues, product and process design issues

Practicum: Share case studies of three different organizations that have attempted to reduce their environmental impacts. Three volunteers will each prepare and hand out a short (1 page) summary of an organization, and briefly present their findings to the class (10 minutes), and lead a short discussion. Each presentation should draw on one or more articles in the *Journal of Industrial Ecology*. Feel free to supplement the *JIE* articles with your own sources.

2nd reflection on readings due on Sakai the night before class (11:59 pm Oct. 3rd)

Required Reading:

Andrews, C.J. (2008) "Changing a firm's environmental performance from within," Ch. 7 in M. Ruth & B. Davidsdottir, eds., *Changing Stocks, Flows, and Behaviors in Industrial Ecosystems*, Aldershot, UK: Edward Elgar, pp. 82–100.

Nelson, K. (1994) "Finding and implementing projects that reduce waste," Pp. 371-382 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Ochsner, Michelle, Caron Chess, and Michael Greenberg. 1996. "Pollution prevention at the 3M Corporation: Case study insights into organizational incentives, resources, and strategies." *Waste Management*. 15(8): 663-672.

Todd, Rebecca. (1994). "Zero-Loss Environmental Accounting Systems." Pp. 191-200 in Braden Allenby & Deanna Richards, eds. *The Greening of Industrial Ecosystems*. Washington, DC: National Academy Press.

Recommended Reading:

Allenby, Braden R. 1997. "Environmental constraints and the evolution of the private firm." Pp. 101-113 in Deanna J. Richards, ed., *The Industrial Green Game*. Washington, DC: National Academy Press.

Graedel, T., I. Horkeby, and V. Norberg-Bohm. (1994) "Prioritizing impacts in industrial ecology," Pp. 359-370 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Scientific Applications International Corporation. 2006. Life Cycle Assessment: Principles and Practice. Report EPA/600/R-06/060 prepared for the U.S. Environmental Protection Agency, Washington, DC. 88 pp.

Pfahl, R.C., Jr. "Design for environment: an R&D manager's perspective." In B.R. Allenby and D.J. Richards, eds. *The Greening of Industrial Ecosystems*. Washington DC: National Academy Press, 1994, pp. 208-213.

Panayotou, T., and C. Zinnes. (1994) "Free-lunch economics for industrial ecologists," Pp. 383-397 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Kleindorfer, P.R., H.C. Kunreuther and P.J. Schoemaker. *Decision Sciences: An Integrative Perspective*. Cambridge: Cambridge University Press, 1993, pp. 289-343 (ch. 8: organizational decision making).

Smart, B., ed. *Beyond Compliance: A New Industry View of the Environment*. Washington DC: World Resources Institute, 1992, pp. 83-120, 139-149 (ch. 4, 5, 7).

Young, L.H. "The claimants for influence with the corporation." In W.R. Dill, ed., *Running the American Corporation*. Englewood Cliffs, NJ: Prentice-Hall, 1978, pp. 38-57.

Diwekar, U., and M.J. Small. (2002) "Process analysis approach to industrial ecology," pp. 114-137 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

Shepherd, W.G. *The Economics of Industrial Organization*. Englewood Cliffs NJ: Prentice-Hall, 1979, pp. 75-107 (chapter on the nature of the firm).

Smart, B., ed. *Beyond Compliance: A New Industry View of the Environment*. Washington DC: World Resources Institute,1992, pp. 121-138 (ch. 6).

Steen, B. (2002) "Impact evaluation in industrial ecology," pp. 149-161 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

U.S. Congress, Office of Technology Assessment. *Green Products by Design*. OTA-E-541. Washington DC: U.S. Government Printing Office, 1992, pp. 23-63 (ch. 2-4). Available online at http://radburn.rutgers.edu/andrews/courses/9221.pdf

Udo de Haes, H.A. (2002) "Industrial ecology and life cycle assessment," pp. 138-148 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

October 11 Green Supply Chain Management

Guest lecture by Prof. Kevin Lyons (Rutgers Business School): Microeconomic basis for industry structures, environmental implications, greening the supply chain

Practicum: Investigate ways to reduce environmental impacts given a more sophisticated view of industrial organization, via (1) third party certification (e.g., ISO 14001), (2) vertical restructuring, and (3) extended producer responsibility. Three volunteers will each prepare and hand out a short (1 page) summary of one of these topics, briefly present their findings to the class (10 minutes), and lead a short discussion. Each

presentation should draw on one or more articles in the *Journal of Industrial Ecology*. Feel free to supplement the *JIE* articles with your own sources.

Required Reading:

Guile, B., and J. Cohon. (1997) "Sorting out a service-based economy," Pp. 76-90 in M.R. Chertow and D.C. Estey, eds., *Thinking Ecologically: The Next Generation of Environmental Policy*, Yale University Press, New Haven, CT.

Nahlik, M.J., Kaehr, A.T., Chester, M.K., Horvath, A., and Taptich, M.N. (2015) "Goods movement life cycle assessment for greenhouse gas reduction goals," *Journal of Industrial Ecology* 20(2): 317-328. DOI: 10.1111/jiec.12277.

Shugart, W.F., II. (1990) *The Organization of Industry*. Boston: BPI-Irwin, pp. 44-64.

Seuring, S. (2004) "Integrated chain management and supply chain management comparative analysis and illustrative cases," *Journal of Cleaner Production* 12: 1059-1071.

Recommended Reading:

Andrews, C.J. (1994) "Policies to encourage clean technology," Pp. 405-422 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Gertsakis, J., N. Morelli and C. Ryan. (2002) "Industrial ecology and extended producer responsibility," pp. 521-529 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

October 18 Business Strategy

Guest lecture by Dr. Jennifer Senick (Rutgers Center for Green Building): Strategic decision-making in firms, influence of public policy and other factors, innovative strategies

Practicum: Share case studies of the business strategies adopted by three different organizations that play in the "green" space—do they pursue a triple bottom line, eco-efficiency, service delivery orientation, greenwashing, or some other strategy? Three volunteers will each prepare and hand out a short (1 page) summary of an organization and its strategy, briefly present their findings to the class (10 minutes), and lead a short discussion. Each presentation should draw on one or more articles in the *Journal of Industrial Ecology*. Feel free to supplement the *JIE* articles with your own sources.

3rd reflection on readings due on Sakai the night before class (11:59 pm Oct. 17th)

Required Reading:

Andrews, C.J. and D. DeVault. (2009) "Green Niche Market Development: A Model with Heterogeneous Agents," *Journal of Industrial Ecology* April, 13(2): 326-345, special issue on complexity.

Delmas, M.A., and M.W. Toffel. (2008) "Organizational responses to environmental demands: Opening the black box," *Strategic Management Journal* 29: 1027–1055.

Graedel, T.E., Y. Kakizawa, and M. Jensen. (2002). "Industrial ecology and automotive systems," pp. 432-444 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

MacLean, R. (2005). "Map your value proposition," *Managers Notebook* (July/August). http://www.eponline.com

Recommended Reading:

Andrews, C.J. (1998) "Environmental business strategy: Corporate leaders' perceptions," *Society and Natural Resources* 11: 531-540.

Bunker, S. (1994) "The political economy of raw materials extraction and trade," Pp. 437-450 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Paton, B. (1994) "Design for environment: A management perspective," Pp. 349-358 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Piasecki, B. "Industrial ecology: an emerging management science." Colloquium paper. *Proceedings of the National Academy of Sciences USA*. 89 (February 1992): 873-875.

Stahel, Walter. (1994). "The Utilization-Focused Service Economy: Resource Efficiency and Product-Life Extension." Pp. 178-190 in Braden Allenby & Deanna Richards, eds. *The Greening of Industrial Ecosystems*. Washington, DC: National Academy Press.

Part IV Structure

October 25 Morphology of Industrial Ecosystems

Community ecology, morphological analysis methods, applications to industrial ecosystems, life cycle analysis, industrial symbiosis, structure of industrial ecosystems

Practicum: Evaluate the success of industrial symbioses in (1) North America, (2) Europe, and (3) Asia. Three volunteers will each prepare and hand out a short (1 page) summary of one of these topics, briefly present their findings to the class (10 minutes), and lead a short discussion. Each presentation should draw on one or more articles in the 2012 special issue of *Journal of Industrial Ecology* on industrial symbiosis (vol. 16, no. 1) or others. Feel free to supplement the *JIE* articles with your own sources.

Required Reading:

Frosch, R., and N. Gallopoulos. (1989) "Strategies for Manufacturing," *Scientific American*. 261(3):144-152. *This is the article that launched the field of industrial ecology!*

Chertow, M.R. (2000) "Industrial symbiosis: literature and taxonomy," *Annual Review of Energy and Environment* 25: 313–37.

Chertow, M. & Ehrenfeld, J. (2012). Organizing self organizing systems – towards a theory of industrial symbiosis. *Journal of Industrial Ecology* 16(1), 13-27.

Lombardi, D. R. & Laybourn, P. (2012). Redefining industrial symbiosis – crossing academic-practitioner boundaries. *Journal of Industrial Ecology* 16(1), 28-37.

Recommended Reading:

Allenby, Braden R. and William E. Cooper. 1994. "Understanding industrial ecology from a biological systems perspective." *Total Quality Environmental Management*. Spring: 343-354.

Ehrenfeld, John, and Nicholas Gertler. 1997. "Industrial ecology in practice: The evolution of interdependence at Kalundborg." *Journal of Industrial Ecology*. 1(1) Winter: 67-79.

Graedel, Thomas E. 1996. "On the concept of industrial ecology." *Annual Review of Energy and Environment*. 2:69-98.

Desrochers, P. (2004) "Industrial symbiosis: The case for market coordination," *Journal of Cleaner Production* 12: 1099-1110.

Heeres, R.R., W.J.V. Vermeulen and F.B. de Walle. (2004) "Eco-industrial park initiatives in the USA and the Netherlands: first lessons," *Journal of Cleaner Production* 12: 985-995.

Mirata, M. (2004) "Experiences from early stages of a national industrial symbiosis programme in the UK: Determinants and coordination challenges," *Journal of Cleaner Production* 12: 967-983.

Roberts, B.H. (2004) "The application of industrial ecology principles and planning guidelines for the development of eco-industrial parks: An Australian case study," *Journal of Cleaner Production* 12: 997-1010.

Yang, P.P., and O.B. Lay. (2004) "Applying ecosystem concepts to the planning of industrial areas: A case study of Singapore's Jurong Island," *Journal of Cleaner Production* 12: 1011-1023.

Tsai, C.L., and U. Krogmann. (2012). "Material Flows and Energy Analysis of Glass Containers Discarded in New Jersey, USA," *Journal of Industrial Ecology* (preprint): 1-21.

McGraw-Hill Co. (2002) BioCourse.com online tutorials. Browse content on ecosystems at http://www.biocourse.com/.

November 1 Environmental Implications of Economic Globalization

Income and products accounts; regional economic analysis; global financial flows and their environmental implications.

Practicum: Investigate the net environmental effects of globalization on three countries: United States, Vietnam, and Kenya. Three volunteers will each prepare and hand out a short (1 page) summary of one of these topics, briefly present their findings to the class (10 minutes), and lead a short discussion. Each presentation should draw on one or more

articles in the *Journal of Industrial Ecology*. Feel free to supplement the *JIE* articles with your own sources, including the relevant chapters in the Mol book.

Required Reading:

Mol, A.P.J. (2001) *Globalization and Environmental Reform: The Ecological Modernization of the Global Economy*, MIT Press, Cambridge, MA, ch. 2-4 (pp. 17-93).

Haas, W., Krausmann, F., Wiedenhofer, D., and Heinz, M. (2015) How circular is the global economy? An assessment of material flows, waste production, and recycling in the European Union and the World in 2005. *Journal of Industrial Ecology* 19(5): 765-777. DOI: 10.1111/jiec.12244.

Bartelmus, P. (2002) "Environmental accounting and material flow analysis," pp. 165-176 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

Hansen, A., Nielsen, K.B., and Wilhite, H. (2016) Staying cool, looking good, moving around: Consumption, sustainability and the 'rise of the South,' *Forum for Development Studies* 43(1): 5-25. http://dx.doi.org/10.1080/08039410.2015.1134640

Recommended Reading:

Mol, A.P.J. (2001) *Globalization and Environmental Reform: The Ecological Modernization of the Global Economy*, MIT Press, Cambridge, MA, remainder of book. *Go to library or borrow from Prof. Andrews*.

Chen, R.S. (1994) "The human dimension of vulnerability," Pp. 85-105 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Dietz, T., and E.A. Rosa. (1997) "Effects of population and affluence on CO_2 emissions," *Proceedings of the National Academy of Sciences* 94: 175-179.

Huq, S. (1994) "Global industrialization: A developing country perspective," Pp. 107-113 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Nordhaus, W.D. "The ecology of markets." *Proceedings of the National Academy of Sciences of the USA*. 89 (February 1992): 843-850.

Part V Urban Applications

November 8 Urban Metabolism

Evolution of cities and their environmental impacts, sustainable city systems, managing complexity

Practicum: Contrast the urban metabolisms of three cities, one megacity from the developing world, one megacity in the developed world, and a smaller city in, say, New Jersey. Three volunteers will each prepare and hand out a short (1 page) summary of the

urban metabolism of one of these cities, briefly present their findings to the class (10 minutes), and lead a short discussion. Each presentation should draw on one or more articles in the *Journal of Industrial Ecology* (especially recommended is the 2012 special issue on sustainable urban systems) or your own sources.

4th reflection on readings due on Sakai the night before class (11:59 pm November 7th)

Required Reading:

Andrews, C.J. (1999) "Putting industrial ecology into place: Evolving roles for planners," *Journal of the American Planning Association* 65(4): 364-375.

Angel, S., with J. Parent, D.L. Civco, and A.M. Blei. (2011) *Making Room for a Planet of Cities*. Policy Focus Report. Lincoln Institute of Land Policy, Cambridge, MA. ***Read executive summary, skim the rest.***

Boone, C.G., and A. Modarres. (2006). "Urban morphology and the shaping of an urban ideal," chapter 1 (pp. 1-37) in *City and Environment*, Temple University Press, Philadelphia, PA.

Handi Chandra Putra, Jing Chen, Clinton J. Andrews, "Eco-evolutionary pathways toward industrial cities," *Journal of Industrial Ecology*, special issue on complexity, March 2015, 19(2). DOI: 10.1111/jiec.12234.

Glaeser, E. (2011) "Introduction" and "Chapter 1—What Do They Make in Bangalore?," chapters in *Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier*, Penguin Books, London.

Russell, J.S. (2011) "Climate Change in the Landscapes of Speculation," chapter 1 in *The Agile City: Building Well-being and Wealth in an Era of Climate Change*, Island Press, Washington, DC.

Recommended Reading:

Journal of Industrial Ecology, 2012 special issue on sustainable urban systems.

Beatley, T., ed. (2012). *Green Cities of Europe*, Island Press, Washington, DC. ***Case studies of innovative cities.***

Bristow, D., and Kennedy, C. (2015) Why do cities grow? Insights from nonequilibrium thermodynamics at the urban and global scales. *Journal of Industrial Ecology* 19(2): 211-221. DOI: 10.1111/jiec.12239.

McGranahan, G., and D. Satterthwaite. (2003). "Urban centers: An assessment of sustainability," *Annual Review of Environment and Resources* 28:243–74.

Powers, C.W., and M.R. Chertow. (1997) "Industrial ecology: Overcoming policy fragmentation," pp. 19-36 in M.R. Chertow and D.C. Estey,

eds., *Thinking Ecologically: The Next Generation of Environmental Policy*, Yale University Press, New Haven.

Gordon, J., and J. Coppock. (1997) "Ecosystem management and economic development," pp. 37-48 in M.R. Chertow and D.C. Estey, eds., *Thinking Ecologically: The Next Generation of Environmental Policy*, Yale University Press, New Haven.

Shahrokni, H., Arman, L., Lazarevic, D., Nilsson, A., and Brandt, N. (2015) Implementing smart urban metabolism in the Stockholm Royal Seaport. *Journal of Industrial Ecology* 19(5): 917-929. DOI: 10.1111/jiec.12308.

November 15 Urban Footprints: Disruption and Repair of the Grand Nutrient Cycles

Human impacts on carbon, nitrogen, phosphorus, and sulfur cycles; efforts to reduce human perturbations of these cycles; energy policy; agricultural policy

Practicum: How can we manage these problems? tHREE volunteers, one each for C, N, and S, will each prepare and hand out a short (1 page) summary of a proposal, and briefly present their findings to the class (10 minutes), and lead a short discussion. Draw on articles in the *Journal of Industrial Ecology* and elsewhere.

Required Reading:

Naassen, J., Andersson, D., Larsson, J., and Holmberg, J. (2015) Explaining the variation in greenhouse gas emissions between households: Socioeconomic, motivational, and physical factors. *Journal of Industrial Ecology* 19(3): 480-489. DOI: 10.1111/jiec.12168.

De Bruyn, S. (2002) "Dematerialization and rematerialization as two recurring phenomena of industrial ecology," pp. 209-222 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

Pacala, S. and R.H. Socolow (2004) "Stabilization wedges: Solving the climate problem for the next 50 years with current technologies," *Science* 305 (13 August): 968-972.

Smil, V. (2002) "Global biogeochemical cycles," pp. 249-259 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

Hoornweg, D., L. Sugar, and C.L.T. Gomez. (2011). "Cities and greenhouse gas emissions: moving forward," *Environment and Urbanization* (April): 1-21.

Mayor's Office of Long-Term Planning & Sustainability. (2012). *New York City Local Law 84 Benchmarking Report*, PlaNYC, New York, NY. *Read executive summary and skim the rest.*

Recommended Reading:

Patterson, B.T. (2012). "DC, come home: DC microgrids and the birth of the "Enernet"," *IEEE Power & Energy Magazine* 10(6): 60-69.

Allenby, B.R. (2000/2001) "Earth systems engineering and management," *IEEE Technology and Society Magazine* 19(4): 10-24.

Keith, D.W. (2000/2001) "The Earth is not yet an artifact," *IEEE Technology and Society Magazine* 19(4): 25-28.

Soka, L., R. Antikainen and P. Kauppi. (2004) "Flows of nitrogen and phosphorus in municipal waste: a substance flow analysis in Finland," *Progress in Industrial Ecology* 1 (1/2/3): 165-186.

Auld, G., B. Burlica, A. Mallett, F. Nolan-Poupart, and R. Slater. (2011). *When do climate policies work?* Network for Business Sustainability, Waterloo, ONT, Canada.

November 22 **NO CLASS—THANKSGIVING BREAK (Rutgers Thursday class schedule)**

November 29 **Urban Residues: Toxics Today and Tomorrow**

Impacts of xenobiotic or man-made materials; efforts to reduce these impacts; materials accounting data and techniques

Practicum: How should we deal with contaminants of emerging concern? This is a question facing the Science Advisory Board of the New Jersey Department of Environmental Protection. Three volunteers will each prepare and hand out a short (1 page) summary of one of the following emerging contaminants (nanomaterials, endocrine disruptors, antidepressants), briefly present their findings to the class (10 minutes), and lead a short discussion. Draw on articles in the *Journal of Industrial Ecology* and your own sources.

5th reflection on readings due on Sakai the night before class (11:59 pm Nov. 28th)

Required Reading:

Wiedenhofer, D., Steinberger, J.K., Eisenmenger, N., and Haas, W. (2015) Maintenance and expansion: Modeling material stocks and flows for residential buildings and transportation networks in the EU25. *Journal of Industrial Ecology* 19(4): 538-551. DOI: 10.1111/jiec.12216.

Wenzlik, M., Eisenmenger, N., and Schaffartzik, A. (2015) What drives Austrian raw material consumption? A structural decomposition analysis for the years 1995 to 2007. *Journal of Industrial Ecology* 19(5): 814-824. DOI: 10.1111/jiec.12341.

Rupasingha, A., S.J. Goetz, D.L. Debertin, and A. Pagoulatos. (2004). "The environmental Kuznets curve for US counties: A spatial econometric analysis with extensions," *Papers in Regional Science* 83: 407–424.

Rogich, D.G., and G.R. Matos. (2002) "Material flow accounts: The USA and the world," pp. 260-287 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

Thomas, V., and T. Spiro. (1994) "Emissions and exposure to metals: Cadmium and lead," pp. 297-318 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M.

Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Berkhout, F. (1994) "Nuclear power: An industrial ecology that failed?," pp. 319-330 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Recommended Reading:

Guinée, J.B., and E. van der Voet. (2002) "Risks of metal flows and accumulation," pp. 382-390 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

Stigliani, W.J., P. Jaffe, and S. Anderburg. (1994) "Metals loading of the environment: Cadmium in the Rhine Basin," pp. 287-296 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Part VI Toward the Future

December 6 Transition Management

Understanding and inducing transitions, legitimating change, innovation diffusion processes, component vs. system evolution, technological vs. behavioral solutions.

Practicum: Evaluate the prospects for graceful management of sustainability transitions in energy, mobility, and urban settlements. Three volunteers will each prepare and hand out a short (1 page) summary of one of these topics, briefly present their findings to the class (10 minutes), and lead a short discussion. Each presentation should draw on one or more articles in the 2010 special issue of *Research Policy* on sustainability transitions. Feel free to supplement these articles with your own sources.

6th reflection on readings due on Sakai the night before class (11:59 pm Dec. 5th)

Required Reading:

Smith, A., J.-P. Voß, J. Grin. (2010). "Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges," *Research Policy* 39(4): 435-448.

Elzen, B., and A. Wieczorek. (2005) "Transitions toward sustainability through system innovation," *Technological Forecasting and Social Change* 72: 651-661.

Beatley, T. (2012). "Green cities of Europe as compelling models," chapter 9 (pp. 215-224) in T. Beatley, ed., *Green Cities of Europe*, Island Press, Washington, DC.

Ehrlich, P.R., and A.H. Ehrlich. 2012. Can a collapse of global civilization be avoided? *Proceedings of the Royal Society B* 280: 20122845.

Matthews, J.H., and F. Boltz. 2012 The shifting boundaries of sustainability science: Are we doomed yet? *PLoS Biology* 10(6):1-4.

Recommended Reading:

From the 2010 special issue of *Research Policy* on sustainability transitions:

Späth, P., and H. Rohracher. (2010). "'Energy regions': The transformative power of regional discourses on socio-technical futures," *Research Policy* 39(4): 449-458.

Cohen, M.J. (2010). "Destination unknown: Pursuing sustainable mobility in the face of rival societal aspirations," *Research Policy* 39(4): 459-470.

Shove, E., and G. Walker. (2010). "Governing transitions in the sustainability of everyday life," *Research Policy* 39(4): 471-476.

Hodson, M. and S. Marvin. (2010). "Can cities shape socio-technical transitions and how would we know if they were?, *Research Policy* 39(4): 477-485.

Lauridsen, E.H., and U. Jørgensen. (2010). "Sustainable transition of electronic products through waste policy," *Research Policy* 39(4): 486-494.

Geels, F.W. (2010). "Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective," *Research Policy* 39(4): 495-510.

Others:

Andrews, C.J. (2007). "Rationality in policy decision making," chapter 12 (pp. 161-171) in F. Fischer, G.J. Miller & M.S. Sidney, eds., *Handbook of Public Policy Analysis*, NY: CRC Press.

Graedel, T.E., R. Barr, C. Chandler, T. Chase, J. Choi, L. Christoffersen, E. Friedlander, C. Henly, C. Jun, N.T. Nassar, D. Schechner, S. Warren, M. Yang, and C. Zhu. (2012). "Methodology of Metal Criticality Determination," *Environmental Science and Technology* 46: 1063−1070.

Nassar, N.T., R. Barr, M. Browning, Z. Diao, E. Friedlander, E. M. Harper, C. Henly, G. Kavlak, S. Kwatra, C. Jun, S. Warren, M. Yang, and T. E. Graedel. (2012) "Criticality of the Geological Copper Family," *Environmental Science and Technology* 46: 1071−1078.

Chen, M.K. (2012). "The effect of language on economic behavior: Evidence from savings rates, health behaviors, and retirement assets," Cowles Foundation Discussion Paper #1820. Yale University, New Haven, CT.

Valente, T.W. (2012). "Network interventions," *Science* 337(6 July): 49-53.

December 13 Final Student Presentations

Present results of student projects in class; solicit feedback

Each student should prepare a short (2-3 slides max) Powerpoint presentation about their project, upload it to Sakai, present it briefly (5 minutes max) to the class, and use the feedback received to improve their final paper.

Final paper due at 11:59 pm on Monday, December 19th via Sakai/Assignments