GGOV622 – COMPLEXITY AND GLOBAL GOVERNANCE
Winter 2015

Time: Tuesdays, 9:30-12:20; Location: BSIA 131
Instructor: Thomas Homer-Dixon
Office: BSIA 312; Email address: tad@homerdixon.com
Office Hours: Tuesday, 2-4 pm (please make an appointment)

An advanced seminar consisting of two major components: 1. an introduction to key concepts, theories, and empirical findings in complexity science, and 2. a review of the implications of our emerging knowledge about complex systems in three governance domains—economics, climate, and security. The first component surveys the major branches of thought about complexity in physics, biology, ecology, geography, information theory, technology studies, and economics. The second component highlights practical applications of complexity science in global governance, emphasizing research findings with clear policy implications. The course includes some exposure to computational methods of modeling complex phenomena and visualizing complex data.

SCHEDULE

1. 6 January	Complexity: What is it, and why are human systems exhibiting more of it?
2. 13 January	Energy: Open systems, thermodynamics, and energy gradients
3. 20 January	Causation: Interactions, feedbacks, chaos, self-organized criticality, INUS sets, path dependence, and emergence
4. 27 January	Connectivity: Networks, information, synchronization, and cascading failures
5. 3 February	Nonlinearity: Critical transitions, catastrophes
6. 10 February	Complex-adaptive systems: Schemas, (co)evolution, fitness landscapes, and innovation
7. 24 February	Societal collapse
8. 3 March	Normative implications: Risk vs. uncertainty; prudence, precaution, and resilience
9. 10 March	Global governance
10. 17 March	Economics
11. 24 March	Climate
12. 31 March	Security

GRADING

Weekly questions	10%
Research essay, proposal	10%
Methods assignment	10%
Research presentation	20%
Research essay	40%
Attendance and participation	10%

ASSIGNMENTS

Weekly questions: Each week (starting in the seminar's second week), each student will prepare one question relevant to the coming week's topic, with an additional paragraph discussing the question, which may take the form of a provisional answer. **Due: no later than 8 pm on the Sunday preceding each week's class, starting Sunday, January 11. Please distribute to all seminar members.**

The instructor will call upon one or two students each week to raise and discuss their questions.

Research essay, proposal: Students will each submit a 2-page outline of the topic of their research paper, stating its central argument, outlining the paper's structure, and identifying supporting literatures and sources of evidence. **Due: February 3, at beginning of class.**

Methods assignment: Students will explore the NetLogo website (http://ccl.northwestern.edu/netlogo/), including its sample models (http://ccl.northwestern.edu/netlogo/models/index.cgi) , tutorials (see the bottom of the page at http://ccl.northwestern.edu/netlogo/resources.shtml) and research results (http://ccl.northwestern.edu/netlogo/models/community/index.cgi), and write a 4-page (1,000 word) reflection on what they discover and its relevance to their particular interests.
Due: March 10, at beginning of class.

Before beginning, students should read this paper: Shiflet and Shiflet, 2014, "An Introduction to Agent-based Modeling for Undergraduates," *Procedia Computer Science* 29 (2014): 1392-1402, available at: http://www.sciencedirect.com/science/article/pii/S1877050914003032.

Research presentation: Each student will prepare and present a 20-minute talk (followed by 10 minutes of discussion) on the topic of his/her research essay. **Date: either March 17, 24, or 31.**

Research essay: Each student will write a 20-page essay (maximum 5,000 words) using complexity science to elucidate a topic of his/her choice. Essays exceeding the maximum length will be penalized. **Due: Noon, Tuesday, April 7.**

Participation: In addition to regular seminar participation, each student will declare in the first week his/her particular pragmatic interests in the course's topic; each should then be prepared to comment each week on the relevance of the week's concepts to his/her interests.

DISCUSSION GROUP

From January 13 to March 17, core seminar discussion will take place from 9:30 to 11:20 am. Following a short break, the time from 11:30 to 12:20 will be used to pursue questions and concepts needing further discussion.

From March 17 through the remainder of the course, in order to accommodate research presentations, the discussion group will terminate and the seminar will be extended to 12:30 pm.

LATE PENALTIES

Late submissions will be penalized 10 per cent (of the 100 per cent available for that particular assignment) for each day or part thereof that they are late. Submissions will not be accepted after seven days have elapsed. Exceptions will be made only in extraordinary circumstances, usually related to medical emergencies supported by documentation. As soon as the student realizes that his or her assignment may be submitted late, he or she should contact the instructor.

ACADEMIC INTEGRITY

In order to maintain a culture of academic integrity, members of the University of Waterloo are expected to promote honesty, trust, fairness, respect and responsibility.

A student is expected to know what constitutes academic integrity, to avoid committing academic offences, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (for example, plagiarism), should seek guidance from the course instructor.

When misconduct has occurred, disciplinary penalties will be imposed under Policy 7—Student Discipline. See: http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm.

See also the Academic Integrity website: https://uwaterloo.ca/academic-integrity/

Finally, for those still in the dark, we can thank David Welch for this very amusing link: http://www.youtube.com/watch?v=Mwbw9KF-ACY

READINGS, VIDEOS, AND SUPPLEMENTARY MATERIALS

Students should peruse the website of the Waterloo Institute for Complexity and Innovation (www.wici.ca). Of special value will be the "Complexity Reading List" (http://wici.ca/new/resources/complexity-reading-list/), the Occasional Paper series (http://wici.ca/new/resources/occasional-papers/), and the many videos of past lectures (by some of the world's leading complexity thinkers) under the "Events" tab on the home page.

Also worth investigating are the websites of the Santa Fe Institute (www.santafe.edu; see especially the Working Papers at http://santafe.edu/research/working-papers/) and of the Center for the Study of Complex Systems at the University of Michigan (http://www.lsa.umich.edu/cscs/).

This map of the evolution of complexity science is useful: http://www.art-sciencefactory.com/complexity-map_feb09.html.

1. *January 6 What is it, and why are human systems exhibiting more of it?*

Gell-Mann, Murray, "The Simple and the Complex," chapter 1 in *Complexity, Global Politics, and National Security,* eds. David Alberts and Thomas Czerwinski (Washington, D.C.: National Defense University, 1997), pp. 3-28.

Homer-Dixon, Thomas, "Complexity Science," *Oxford Leadership Journal* 2, no. 1 (January 2011): 1-15.

Arthur, Brian, "On the Evolution of Complexity," in Complexity: Metaphors, Models, and Reality," G. Cowan, D. Pines, and D. Meltzer, eds. Santa Fe Institute Studies in the Sciences of Complexity, Proceedings Vol. 19 (Reading, Massachusetts, 1994), pp. 65-78. Republished as SFI Working Paper: 1993-11-070.

von Bertalanffy, Ludwig, "An Outline of General System Theory," *The British Journal for the Philosophy of Science* 1, no. 2 (Aug., 1950), pp. 134-165, excerpts.

Strongly recommended:

Gell-Mann, Murray, "What is Complexity?" *Complexity* (John Wiley, 1995), pp. 16-9.

von Bertalanffy, Ludwig. "The History and Status of General Systems Theory." *The Academy of Management Journal* 15, no. 4 (December 1972): 407–426.

2. *January 13 Energy: Open systems, thermodynamics, and energy gradients (Guest: Sander van der Leeuw)*

Homer-Dixon, Thomas, "A Keystone in Time," chapter 2 of *The Upside of Down: Catastrophe, Creativity, and the Renewal of Civilization* (Toronto: Knopf, 2006), read pp. 31-56, plus endnotes; and "Disintegration," chapter 10 of *The Upside of Down*, read pp. 235-250 (to the subsection "Holland Times Ten"), skim pp. 251-261.

Hall, Charles, et al., "Hydrocarbons and the Evolution of Human Culture," *Nature* 426, No. 6964 (November 20, 2003): 318–22.

Tainter, Joseph, et al., "Resource Transitions and Energy Gain: Contexts of Organization," *Conservation Ecology* 7, no. 3 (2003), available at http://www.ecologyandsociety.org/vol7/iss3/art4/print.pdf.

Odum, Howard T., "Self-Organization, Transformity, and Information," *Science* 242, no. 4882 (Nov. 25, 1988): 1132-1139

Strongly recommended:

Van der Leeuw, Sander, and Bert de Vries, "Empire: The Romans in the Mediterranean," chapter 7 in Bert de Vries and Johan Goudsblom, eds., *Mappae Mundi: Humans and Their Habitats in a Long-Term Socio-Ecological Perspective: Myths, Maps and Models* (Amsterdam: RIVM, Amsterdam University Press, 2002), pp. 209-256.

White, Leslie, "Energy and the Evolution of Culture," *American Anthropologist* 45, no. 3 (July-September, 1943): 335-356.

Schrödinger, Erwin, "Order, Disorder and Entropy," chapter 6 in *What Is Life?* (Cambridge: Cambridge University Press, 1944), pp. 672–80.

3. *January 20 Causation: Interactions, feedbacks, chaos, self-organized criticality, INUS sets, path dependence, and emergence*

Jervis, Robert, "Complex Systems: The Role of Interactions," chapter 3 in *Complexity, Global Politics, and National Security*, pp. 45-72.

Crutchfield, James, J. Doyne Farmer, and Norman Packard, "Chaos," *Scientific American* 255, no. 6 (December 1986): 46-57.

Ishii, Hiroshi , Scott Page, and Niniane Wang, "A Day at the Beach: Human Agents Self-Organizing on the Sand Pile," *Advances in Complex Systems* 2, No. 1 (1999): 37-63.

Pierson, Paul, "Positive Feedback and Path Dependence," Chapter 1 in *Politics in Time: History, Institutions, and Social Analysis* (Princeton: Princeton University Press, 2004), pp. 17-53.

de Haan, J., "How Emergence Arises," *Ecological Complexity* 3 (2006): 293-301.

Strongly recommended:

Mahoney, James, Erin Kimball, and Kendra L. Koivu, "The Logic of Historical Explanation in the Social Sciences," *Comparative Political Studies* 42 (2009): pages 114-28 on different meanings of "causation."

Sawyer, Keith, "Emergence in Sociology: Contemporary Philosophy of Mind and Some Implications for Sociological Theory," *American Journal of Sociology* 107, no. 3 (November 2001): 551-85.

4. *January 27* *Connectivity: Networks, information, synchronization, and cascading failures*

Barabási, Albert-László, "Scale-Free Networks: A Decade and Beyond," *Science* 325 (24 July 2009): 412-413.

Barabási, Albert-László, "Luck or Reason," *Nature* 489 (27 September 2012): 507-508.

Onnela, Jukka-Pekka, and Felix Read-Tsochas, "Spontaneous Emergence of Social Influence in Online Systems," *Proceedings of the National Academy of Sciences* 107, no. 43 (26 October 2010): 18357-18380.

Horgan, John, "Profile: Claude Shannon," *Scientific American* (January 1990): 22-22B.

Strogatz, Steven, TED talk on synchronization, 2004:
http://www.ted.com/talks/steven_strogatz_on_sync

Helbing, Dirk, "Globally Networked Risks and How to Respond." *Nature* 497 (2013):51-59.

Strongly recommended:

Papadopoulus, Fragkiskos, et al., "Popularity versus Similarity in Growing Networks," *Nature* 489 (27 September 2012): 537-540.

Granovetter, Mark, "The Strength of Weak Ties," *American Journal of Sociology* 78, no. 6 (May, 1973), pp. 1360-1380.

5. *February 3 Nonlinearity: Critical transitions, catastrophes*

Schelling, Thomas, "Simple Models of Segregation," *Micromotives and Macrobehavior* (New York: Norton, 1978), pp. 147-165.

Scheffer, Marten, video of WICI lecture on early warning signs for critical transitions: http://wici.ca/new/2011/07/early-warning-signs-for-critical-transitions/.

Scheffer, Marten, et al. "Anticipating Critical Transitions," *Science* 338 (2012): 344-48.

Neuman, Yair, Ophir Nave, and Eran Dolev, "Buzzwords on Their Way to a Tipping Point: A View from the Blogosphere, *Complexity* 16, no. 4 (2010): 58-68.

Strongly recommended:

Scheffer, Marten, "Alternative Stable States," chapter 2, and "Lakes," chapter 7 in *Critical Transitions in Nature and Society* (Princeton: Princeton University Press, 2009), pp. 11-36 and pp. 109-138.

6. *February 10 Complex-adaptive systems: Schemas, (co)evolution, fitness landscapes, and innovation*

Holland, John, "Complex Adaptive Systems," *Daedalus* 121 (1992): 17-30.

Kauffman, Stuart, "High-Country Adventures," chapter 8 in *At Home in the Universe: The Search for Laws of Self-Organization and Complexity* (Oxford: Oxford University Press, 1995), pp. 149-89.

Beinhocker, Eric, "Evolution as Computation: Integrating Self-Organization with Generalized Darwinism," *Journal of Institutional Economics* (2011).

Strongly recommended:

Holland, John, *Hidden Order: How Adaptation Builds Complexity* (Reading, Massachusetts: Addison-Wesley, 1995).

Wright, Sewall, "The Roles of Mutation, Inbreeding, Crossbreeding and Selection in Evolution," *Proceedings of the Sixth International Congress on Genetics* 1 (1932): 356-66.

7. *February 24 Societal collapse*

Tainter, Joseph, "The Study of Collapse," chapter 3, and "Understanding Collapse: The Marginal Productivity of Sociopolitical Change," chapter 4 in *The Collapse of Complex Societies* (Cambridge: Cambridge University Press, 1988), pp. 39-90 and pp. 91-126.

Holling, C.S., **"**Understanding the Complexity of Economic, Ecological, and Social Systems**,"** *Ecosystems* 4 (2001): 390–405.

Peterson, S. Carpenter, and W. Brock, "Uncertainty and the Management of Multistate Ecosystems: An Apparently Rational Route to Collapse," *Ecology* 84, no. 6 (2003); 1403-1411.

Yaneer Bar-Yam, "Human Civilization II: A Complex(ity) Transition," chapter 9 in *Dynamics of Complex Systems* (Reading, MA: Addison-Wesley, 1992), pp. 782-825.

Strongly recommended:

Gill, Richardson, "Summary and Discussion," chapter 13 in *The Great Maya Droughts: Water, Life, and Death* (Mexico City: University of New Mexico Press, 2000), pp. 363-80.

8. *March 3 Normative implications: Risk vs. uncertainty; prudence, precaution, and resilience*

Axelrod, Robert, "Evolving New Strategies," chapter 1, and "Promoting Norms," and chapter 3 in *The Complexity of Cooperation* (Princeton: Princeton University Press, 1997), pp. 10-29 and pp. 40-68.

Helbing, Dirk, Wenjian Yu, Karl-Dieter Opp, and Heiko Rauhut, "Conditions for the Emergence of Shared Norms in Populations with Incompatible Preferences," *PLOS One* 9, no. 8 (August 2014).

Holton, Glyn, "Defining Risk," *Financial Analysts Journal* 60, no. 6 (2004): 19-25.

Walker, W. E., et al., "Defining Uncertainty: A Conceptual Basis for Uncertainty Management in Model-Based Decision Support," *Integrated Assessment* 4, no. 1 (2003): 5-17.

Folke, Carl, et al., "Resilience Thinking: Integrating Resilience, Adaptability, and Transformability," *Ecology and Society* 15, no. 4 (2010).

Strongly recommended:

Pindyck, Robert, "The Climate Policy Dilemma," NBER Working Paper 18205 (July 2012).

9. March 10 Global governance:

Cederman, Lars-Erik, "Modeling Actors in World Politics," chapter 2 in *Emergent Actors in World Politics: How States and Nations Develop and Dissolve* (Princeton, NJ: Princeton University Press, 1997), pp. 14-36.

Ravetz, Jerome, "Post-Normal Science and the Complexity of Transitions towards Sustainability," *Ecological Complexity* 3 (2006): 275-284.

Helbing, Dirk, "System Risks in Society and Economics" (9 November 2009).

Young, Oran, et al., "The Globalization of Socio-Ecological Systems: An Agenda for Scientific Research," *Global Environmental Change* 16 (2006): 304-316.

Meadows, Donella, *Leverage Points: Places to Intervene in a System* (Hartland, Vermont: The Sustainability Institute, 1999).

Strongly recommended:

Bernstein, Steven, Richard Ned Lebow, Janice Gross Stein, and Steve Weber. 2000. "God Gave Physics the Easy Problems: Adapting Social Science to an Unpredictable World." *European Journal of International Relations* 6, No. 1 (March 2000): 43-76.

10. March 17 Economics

Arthur, Brian, "Complexity Economics: A Different Framework for Economic Thought," *Complexity Economics* (Oxford: Oxford University Press, 2013).

Vitali, Stefania, James Glattfelder, and Stefano Battiston, "The Network of Global Corporate Control," *PLOS One* 6, no. 10 (October 2011).

Haldane Andrew and Robert May, "Systemic risk in banking ecosystems," *Nature* 469 (2011):351-355.

Schweitzer, Frank, et al., "Economic Networks: The New Challenges," *Science* 325 (24 July 2009): 422-425.

11. March 24 Climate

Lenton, Timothy, et al., "Tipping Elements in the Earth's Climate System," Proceedings of the National Academy of Sciences 105, no. 6 (12 February 2008): 1786-1793.

Dakos, Vasilis, et al., "Slowing Down as an Early Warning Signal for Abrupt Climate Change," *Proceedings of the National Academy of Sciences* 105, no. 38 (23 September 2008): 14308-14312.

Barnosky, Anthony, et al., "Approaching a State Shift in Earth's Biosphere," *Nature* 486 (7 June 2012): 52-58.

Westley, Frances, et al., "Tipping Towards Sustainability: Emerging Pathways of Transformation," *Ambio* 40 (2011): 762-780.

12. March 31 Security (Guest: Jack Goldstone)

Cederman, Lars-Erik, "Modeling the Size of Wars: From Billiard Balls to Sandpiles," *American Political Science Review* 97, no.1 (2003): 135-150.

Epstein, Joshua, "Modeling Civil Violence: An Agent-Based Computational Approach," *Proceedings of the National Academy of Sciences* 99 (14 May 2002): 7243-50.

Saperstein, Alvin, "Complexity, Chaos, and National Security," chapter 5 in *Complexity, Global Politics, and National Security*, pp. 101-34.

Beyerchen, Alan, "Clausewitz, Nonlinearity, and the Importance of Imagery," chapter 7 in *Complexity, Global Politics, and National Security*, pp. 153-70.

Schmitt, John, "Command and (out of) Control: The Military Implications of Complexity Theory," chapter 9 in *Complexity, Global Politics, and National Security*, pp. 219-46.