A PRIMER IN QUANTITATIVE METHODS FOR STUDYING COMPLEX SOCIAL-ECOLOGICAL SYSTEMS

PhD Programme in Sustainability Science at Stockholm Resilience Centre

James Watson, Maja Schlüter

March 9-20, 2015

Where: Room: 239
When: Lectures: 1100-1200
Workshops 1300-1430
Requirements: an open mind**,** R (http://www.r-project.org/, http://www.rstudio.com/)

Course overview:
10 days over two weeks, one lecture a day (morning), one workshop a day (afternoon), with a guest lecture on the first Wednesday and reading throughout. Lectures will focus on key social-ecological concepts and the language and approaches quantitative scientists use to describe and analyze them. Key point – in the topics listed below, we are not going to teach how things are done. Rather we are looking to make students aware that these approaches exist, and give them the language with which to talk to experts in these approaches.

Core Concepts:
1) Philosophy of quantitative analysis and research design
2) Numbers, data, exploratory data analysis and statistics
3) Dynamical systems (equilibrium, stability, stocks and flows)
4) Complex Adaptive Systems (networks, emergence, self-organization, agent-based modeling)
5) Human Decision Making: optimization, game theory, adaptation and learning

Learning outcomes:
- Understanding of how to conduct quantitative analysis of Social-Ecological Systems (SESs), and how to model (in the broadest sense).
- A vocabulary to talk with researchers doing ecological, economic, social-ecological modeling of SES using statistical, mathematical or computational approaches.
- Overview of quantitative methods available for studying SES, particularly formal modeling, empirical analysis and methods from complexity science.
- Understanding of when and how different approaches can be used, their potentials and limitations (but no technical details on their application).
- Understanding of different conceptualizations of SES, different approaches and their implications (e.g. what do we learn from a theoretical model, from a statistical analysis, etc.)

Reading material:
tbd

Note: This syllabus will likely change the closer the start date is.

Date	Class	Topic
Week 1: Philosophy, Data, Dynamics		
Monday Mar 9, 2015 (James, Maja)	Morning lecture (1100-1200)	<u>Philosophical Foundations</u> Motivation for the course The philosophy of quantitative science. Intro to Complex Adaptive Systems Course purpose, review course material
	Afternoon lecture (1300-1430)	Social Ecological Systems are Complex Adaptive Systems: how do we analyze them? What is modeling? How do I design a quantitative research approach?
Tuesday Mar 10, 2015 (Ingo Fetzer)	Morning lecture (1100-1200)	<u>Introduction to numbers and data</u> Numbers, functions, equations. Introduction to DATA, the various forms it can take. Exploratory data analysis.
	Afternoon workshop (1300-1430)	Introduction to scientific computing with R Perform simple exploratory data analysis on course case study. Give out problem set, based on morning lecture. Give out Wed reading material.
Wed Mat 11, 2015	Morning Lecture (1100-1200)	<u>Guest Lecture I</u> *tbd*
	Afternoon	Read
Thurs Mar 12, 2015 (James)	Morning lecture (1100-1200)	<u>SESs are Dynamical Systems I</u> Introduction to dynamical systems. Relate to causal loops. SES concepts that have roots in dynamics: regime shifts, resilience, early-warning signals.

	Afternoon workshop (1300-1430)	Develop dynamical model of case study, fit using optimization techniques Review previous problem set / Reading Introduce next problem set based on morning lecture
Fri Mar 13, 2015 (James)	Morning lecture (1100-1200)	<u>Dynamical Systems Analysis II</u> Expand on basic dynamics vocab: ODEs, PDEs, LSA… etc Example dynamical systems – Lotka Volterra, Lorentz attractor, and other example from SES Link SES and dynamical concepts: regime shifts = bifurcations for example
(James)	Afternoon workshop (1300-1430)	End of week review
Week 2: Complex Adaptive Systems, Strategy and Game theory, Networks, Agent-based modeling)		
Mon Mar 16, 2015 (Maja)	Morning lecture (1100-1200)	<u>SES as complex adaptive systems</u> Introduction to CAS: complexity, adaptation and selection, emergence, self-organization, variation/heterogeneity. Intro to methods in complexity science, particularly ABM and networks Discuss the issue of scale and mean-field models; bottom-up versus systems-level modelling
(Maja)	Afternoon workshop (1300-1430)	Intro to agent-based modeling using Netlogo. Develop Netlogo implementation Predator Prey system as ABM, comparison with dynamical system version.

Tues Mar 17, 2015 (James)	Morning lecture (1100-1200)	<u>Networks</u> Introduction to connectivity, the different types. Examples from SES: food webs, social networks, metapopulations, cities… etc. Introduction to network theory, Basic concepts from linear algebra (matrixes, vectors, elements)
(Maja)	Afternoon workshop (1300-1430)	Expand on Netlogo implementation of course case-study: social-network of fishing fleet
Wed Mar 18, 2015 (James, Maja)	Morning lecture (1100-1200)	<u>Human Decision Making</u> Introduction to optimization (maximize, minimize) Basic Bioeconomics and Game theory Modeling adaptation and learning
(James)	Afternoon workshop (1300-1430)	Game theory applied to the course case study: how do agents choose their effort levels strategically?
Thurs Mar 19, 2015 (James, Maja)	Morning lecture 1100-1200	<u>Course Review</u> Overview of course material Introduction to modules on advanced topics
	Afternoon workshop	None