**ECOL 8580** **SYSTEMS ECOLOGY**
Fall 2005 Instructor: Dr. Bernard C. Patten

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# NOMINAL SYLLABUS

*This course has 4 main objectives …*

1. Learn a quantitative systems approach to holistically analyzing and interpreting ecological processes and relationships.
2. Learn the elements of *system theory*, *modeling*, *simulation*, and ecological *systems analysis* employing the computer software STELLA (for dynamics) and MATLAB (for statics).
3. Become familiar with systems ecology literature through assignments and quizzes on selected readings. [not implemented this year]
4. Become oriented to environmental systems as "systems", through …

*a textbook …* White, I. D., Mottershead, D. N., and Harrison, S. J. 1992. *Environmental Systems*, 2nd Edition. Chapman & Hall, London. 616 pp. (out of print; copies on reserve).

*2 field trips …* Weekend camping excursions: Great Smoky Mountains National Park, October 7-9, and Okefenokee National Wildlife Refuge and Cumberland Island National Seashore, November 4-6. Student participation required.

*4 projects …*

Project 1. Envirograms
Project 2. Modeling
Project 3. Simulation
Project 4. Systems analysis

***Key dates:***

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| Sep 8 | Readings Quiz 1 |
| Sep 29 | Readings Quiz 2 |
| Oct 6 | Project 1 written report due |
| Oct 7–9 | Field trip, Smokies |
| Oct 11 | Midterm marker (no exam) |
| Oct 20 | Readings Quiz 3 |
| Oct 27 | Fall break |
| Nov 4–6 | Field trip, Okefenokee/Cumberland Island |
| Nov 17 | Readings Quiz 4 |
| Nov 24 | Thanksgiving |
| Dec 12-16 | Final exam period |
| Dec 12 | Final exam, Ecology Seminar Room 3:30-6:30 p.m. |
| Dec 14 | Projects 2–4 written reports due |
| Dec 16 | Course party—Project 1–4 oral reports |

| WEEK | DATES | TOPICS |
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| **1** | **Aug 18** | Course organization<br>Introduction: Why Systems Ecology?<br>Elements of Systems Ecology; six premises (text, pp. 8-9)<br>Mathematics in ecology: book of nature (Galileo); four causes (Aristotle)<br>Field Systems Ecology<br>Holoecology: 13 cardinal hypotheses<br><br>Text reading: *Preface* (pp. ix–x); *Part A Prologue* (pp. 1–2); *Chapter 1*: Sections 1.1–1.2 (pp. 6–10); Sections 1.3–1.5 (pp. 10–20) |
| **2** | **Aug 23 & 25** | What is a system?—class discussion<br>Reductive (parts-based) Definition I; are there alternative definitions?<br>Hierarchical systems: scale hierarchies; origins (bond strength—Simon); examples<br>Fundamental forces: $10^{64}$ eV energy span; basis for ~$10^{24}$ levels of hierarchical organization<br><br>Text reading: *Chapter 2* (pp. 21–41), Part B prologue (pp. 43–45) |
| **3** | **Aug 30 & Sep 1** | Background items:<br>Hierarchical systems (continued)—*Powers of Ten* (video)<br>Websites:<br>http://www.powersof10.com/<br>http://www.wordwizz.com/pages/1uexp-13.htm/<br>http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/<br>Matter & force particles<br>Zero and Nonzero Sumness (PowerPoint):<br>Bond types—transactions & relations<br>Necessary & sufficient conditions—Ecology's AWFUL Theorem<br>STELLA simulation of behavior—demonstrations:<br>Water basins sequence (start)<br><br>Assignment: Explore *Powers of Ten* websites; STELLA self instruction—Getting Started with STELLA<br><br>Text reading: *Chapter 3* (pp 48–58 through solar energy cascade, Section 3.2) |
| **4** | **Sep 6 & 8** | STELLA simulation models (continued):<br>Water basins sequence (end)<br>Classical population models — Malthusian exponential growth; Pearl–Verhulst logistic growth<br><br>**Readings Quiz #1**: Sep 8 (assigned reading Weeks 1–3)<br><br>Text reading: *Chapter 3* (pp 58–72 through geothermal energy cascade, Section 3.6) |

Additional reading: *Systems thinking*: High Performance Systems, Inc. 1992–1997. An Introduction to Systems Thinking. Part 1: Chapter 1, pp. 1-1 – 1-21; Chapter 2, pp. 2-1 – 2-14

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| **5** | **Sep 13 & 15** | Conceptual modeling with STELLA<br>Envirograms<br><br>Text reading: *Chapter 10* (Catchment System: pp. 236–257)<br><br>Assignment: **Project 1**. Life-cycle envirograms— conceptual & simulated; **written report due Oct 6** |
| **6** | **Sep 20 & 22** | STELLA simulation models (continued):<br>Classical population models— Lotka–Volterra competition<br>Compartment models—black bear<br><br>Text reading: *Chapter 11* (Weathering System: pp. 258-284) |
| **7** | **Sep 27 & 29** | STELLA simulation models (continued):<br>Management model—Patagonia coastal zone (start)<br>ISEE Systems (http://www.hps-inc.com/)<br>STELLA-based "Stories of the Month" (http://www.hps-inc.com/community/SOTM/default.aspx)<br>Creative Learning Exchange: Systems thinking in primary and secondary education (http://www.clexchange.org/)<br><br>**Readings Quiz #2**: Sep 29 (assigned reading, Weeks 4–6)<br><br>Assignment: Explore cited websites; **Project 2** (Modeling), **Task 2.1** (Conceptual (Sub)models)<br><br>Text reading: *Chapter 12* (Slope System: pp. 285-305) |
| **8** | **Oct 4 & 6** | STELLA simulation models (concluded):<br>Management model—Patagonia coastal zone (end)<br>Progressive definitions of a system: I. Reductive (parts-based), II. Holistic (environment-based), III. Behavioral (dynamics-based)<br>State-space dynamical system theory (start): determinacy; determinate "objects"; epistemic mediation; determinate "subjects"; modeling definition of life<br>Origin of systems: interactive coupling; identity constraints of coupling<br><br>Field trip orientation<br><br>**Project 1**. Life-cycle envirograms (written report due date, Oct 6)<br><br>Assignment: **Project 2** (Modeling), **Task 2.2** (Compartment Modeling with STELLA)<br><br>Text reading: *Chapter 13* (Fluvial System: pp. 306-323) |

**Field Trip—Smokies** (Oct 7–9)

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| **9** | **Oct 11 & 13**<br>**Mid-term Oct 11**<br>(no exam) | Origin of systems: interactive coupling; identity constraints of coupling<br>State-space system theory (continued): from "Propagation of Cause" paper—Zadeh's consistency conditions for system input–output determinacy; bundling and the role of present state in determining future dynamic behavior<br><br>Text reading: *Chapter 15* (Aeolian System: pp. 344-356)<br><br>Additional reading: *State-space system theory* (start)<br>Patten, B.C., Bosserman, R.W., Finn, J.T., and Cale, W.G. 1976. Propagation of cause in ecosystems. Read pp. 458-471 in Patten, B.C. (ed.), Systems Analysis and Simulation in Ecology, vol. 4. Academic Press, NY. pp. 457-579. |
| **10** | **Oct 18 & 20** | State-space system theory (conclusion): from "Propagation of Cause" paper— Zadeh's consistency conditions for system input–output determinacy; bundling and the role of present state in determining future dynamic behavior<br>What is environment? (start)—class discussion<br>Concepts of environment<br>Holon-centered environments<br><br>**Readings Quiz #3**: Oct 20 (assigned reading, Weeks 7–9)<br><br>Assignment: **Project 3A** (Simulation)<br>Note: Project 3B (Composite Model) will not be done<br><br>Text reading: *Chapter 16* (Coastal System: pp. 357-375)<br><br>Additional reading: *State-space system theory* (continued)<br>Patten, B.C., Bosserman, R.W., Finn, J.T., and Cale, W.G. 1976. Propagation of cause in ecosystems. Read pp. 471-482 in Patten, B.C. (ed.), Systems Analysis and Simulation in Ecology, vol. 4. Academic Press, NY. pp. 457-579. |
| **11** | **Oct 25**<br>**Fall break**<br>**Oct 27** | What is environment? (conclusion)<br>Epistemic mediation—holons as objects vs. subjects<br>Worldlines & light cones<br>Environs<br>Example environs: Okefenokee water model, oyster reef energy-flow model<br>Final thoughts on "What is a System?": recap progressive definitions of a system: I. Reductive (parts-based), II. Holistic (environ-based), III. Behavioral (state-space based)<br><br>Assignment: MATLAB self instruction—Getting Started with MATLAB |

Text browsing: *Chapters 4* (Global Systems: Atmosphere), *5* (Lithosphere), and *6* (Hydrosphere): review pp. 76–156 for background and context

Text reading: *Chapter 7* (Ecosphere: pp. 158-173 through Section 7.4)

**12** **Nov 1 & 3**

Introduction to *Holoecology*—13 cardinal hypotheses (CH)
Introduction to *Network Environ Analysis* (NEA)—five methods

**NEA–1. Pathway analysis**
Paths & walks; five-mode model; modes in environs
*CH #1. Network pathway proliferation*

Field trip orientation

Assignment: **Project 4** (Systems Analysis); explore MATLAB and NEA software

Text reading: *Chapter 7* (Ecosphere: pp. 174-195 through Section 7.7)

**Field Trip—Okefenokee/Cumberland Island** (Nov 4–6)

**13** **Nov 8 & 10**

**NEA 2. Throughflow analysis**
Mapping boundary flows to throughflows
**NEA 3. Storage analysis**
Mapping boundary flows to stocks
Integration of throughflow and storage NEA's
Stock- and flow-based cardinal hypotheses:
*CH #2. Network nonlocality*
*CH #4. Network homogenization*
*CH #5. Network (interior) amplification*
Network trophic dynamics
*CH #6. Network unfolding*
*CH #11. Network enfolding*
Network thermodynamics
*CH #9. Network aggradation*
*CH #10. Network boundary amplification*

Text reading: *Chapter 18* (The Ecosystem: pp. 388-416)

**14** **Nov 15 & 17**

Case studies of NEA applications
EIA—salt-dome environmental impact assessment in the Strategic Petroleum Reserve
CNEA (comparative NEA)—case study of nitrogen dynamics in the Neuse River Estuary

**Readings Quiz #4**: Nov 17 (assigned reading Weeks 10–13)

Text browsing: review for background and context *Chapters 19* (The Primary Production System: pp. 417-446), *20* (The Grazing–Predation System: pp. 447-456), *21* (The Detrital System: pp. 457-469), and *22* (The Soil System: p. 470-486)

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| **15** | **Nov 22**<br>**Thanksgiving**<br>**Nov 24** | **Thanksgiving recess:** Nov 23-25<br><br>**NEA 4. Utility analysis**<br>Mapping boundary flows into internal benefits > costs, and ecological interaction types positive > negative<br>*CH #7 Network synergism*<br>*CH #8 Network mutualism*<br>Community modules—structural vs. parametric determination of interaction assembly rules<br><br>Text browsing: review for background and context *Chapters 23* (Change in Environmental Systems: pp. 490-494), *24* (Change in Physical Systems: pp. 497-520), *25* (Change in Living Systems: pp. 522-548), and *26* (Human Modification of Environmental Systems: pp. 552-584) |
| **16** | **Nov 29**<br>**& Dec 1** | **NEA 5. Distributed control analysis**<br>Basis: limiting-factor vs. resource-supply control<br>NEA control methodology<br>*CH #2. Network distributed control*<br>Case study—proximate vs. ultimate control of nitrogen dynamics in the Neuse River Estuary<br>Cybernetic control—open- vs. closed-loop<br>Case study—flying the North American Adirondack whitetail on instruments<br><br>Text reading: *Chapter 27* (Systems Retrospect & Prospect) |
| **17** | **Dec 6 & 8** | Handwaving time ...<br>Genotypes, phenotypes and "envirotypes"<br>*CH #13. Network holoevolution*<br>Ecosystem cosmography: 21 "remarkable properties"<br>Valediction: "Hard Choices for Ecology"<br><br>Assignment: Prepare final written and oral reports |
| | **Dec 12-16** | University final exam period<br>**Course final exam** as scheduled |
| | **Dec 14** | **Written reports** due: Projects 2–4 |
| | **Dec 16** | Course party<br>**Final oral reports**: Projects 1–4 |