Instructor

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Meeting time and location:
Tuesday/Thursday 1:30 – 3:00 pm in Biodiversity 224
September 8 – October 6

Think ecosystem ecology is all about nitrogen cycling? Think again! Ecosystem ecology is the most holistic ecological discipline, explicitly considering ecological systems and all their parts. In this course we consider ecosystems as stocks and fluxes of energy and matter. We review papers and concepts to understand what measurements of nutrients, carbon and biomass can tell us about the movement and transformation of energy/matter how ecosystems and more broadly how ecosystems operate and change through time. We will consider contemporary topics, including biodiversity and ecosystem function, concepts of homeostasis and stability, and discuss how ecosystems have changed over geological time.

Learning objectives

- Explain the fundamental concepts in ecosystem ecology, their historical development and contemporary application
- Describe ecological systems in terms of flows of energy and matter.
- Critically assess evidence-based arguments in ecosystem ecology.

Lecture schedule and format

Each class period will focus on a set of learning goals. Lectures will provide background and context, while discussions focus on the papers read by students before class.

Sept 8: Introduction to ecosystem concepts, components, and processes
Sept 13: Succession and development of ecosystem ecology
Sept 15: Microbial contributions to biogeochemical cycling
Sept 20: Carbon cycle and trophic ecology
Sept 22: Nitrogen limitation and forest nutrient cycling
Sept 27: Phosphorus cycle and eutrophication; Project discussion
Sept 29: Ecosystem resilience and alternative states
Oct 4: Biodiversity and Ecosystem Function
Oct 6: Feedback and revisions on project

Assessment:

Class contributions: 30% (attendance, contributing through activities, questions and discussion)
Pre-reading assignments: 30% (Due at 1:00 pm before each class on Canvas)
Final project: 40% (Due October 7th on Canvas)

Workload:

This is a compressed course and we will cover a lot of ground. I expect that you will spend about 3 hours outside of class for every 1.5 hour class; This is the general expectation at UBC. Suggested breakdown:

- Background reading: you are responsible for reading the textbook chapters listed in the readings section prior to class (occasional the background will be a paper instead).
    - Required Textbook: Chapin FS, Matson PA, Vitousek PM, Chapin MC. 2011. Principles of Terrestrial Ecosystem Ecology, 2nd edition. Springer.
    - Available online through the UBC library (free, CWL required), or in the bookstore.
- Primary paper and writing assignment: Each student is responsible for reading and summarizing ONE paper per class period.
    - Readings online through the EZProxy library website, links posted on Canvas
    - Students with last names starting [A-M] will summarize the first paper listed, and students with last names starting with [N-Z] will summarize the second paper.
    - Each student will prepare a short writing assignment (1 paragraph) that highlights key ideas introduced and how they changed our understanding of ecosystem ecology.
    - *Summary due on Canvas by 13:00 on the day of class.*
    - Total time suggested for reading + summary = 90 minutes
    - Then you will teach the contents of the paper to your classmates.
- **Skim** the other paper (~10 min).
- Before each class, plan to spend some time on your annotated bibliography (brainstorming, outlining, drafts).

Final project: Annotated Bibliography
The annotated bibliography will a) identify a research question in ecosystem ecology that addresses how ecosystems work and is specifically connected to their thesis research, b) provide context for why the question is important, c) review previous efforts to answer the question. Most often, students will investigate questions that are taken as assumptions or used to justify broader relevance of a research topic in population or community ecology. This is an opportunity to interrogate these background assumptions explicitly and critically.

The project consists of an abstract, paper summaries, and a reflection.

1. Abstract: The abstract should lay out the thesis research, the research question in ecosystem ecology, and explain the connection.

2. Paper summaries: Students will select 5-8 papers from the primary literature. At least one paper should be by an author from a historically underrepresented group in ecology or should explicitly address a relevant environmental inequity; state which paper(s) meet this criterion. Students will identify the hypotheses and main objectives of published studies, summarize findings, and connect findings to the ecosystem ecology question.

3. Conclusion: Briefly explain what you learned. How did these papers address your research question in ecosystem ecology?

Schedule and readings:

Lecture 1: Introduction to ecosystem concepts, components, and processes

- Odum EP. 1969. The strategy of ecosystem development. *Science* 164: 262-270
- Levin S. 1998. Ecosystems and the Biosphere as Complex Adaptive Systems. Ecosystems 1: 431–436
- *Background:* Chapin et al 2011. Chapter 1: The Ecosystem Concept.
- *Optional:* Doolittle WF and Inkpen SA. 2018. Processes and patterns of interaction as units of selection: An introduction to ITSNTS thinking. PNAS (115) 4006-4014

Lecture 2: Succession and development of ecosystem ecology

- Tansley AG. 1935. The use and abuse of vegetational concepts and terms. *Ecology* 16: 284-307.
- Currie WS. 2011. Units of nature or processes across scales? The ecosystem concept at age 75. *New Phytologist* 190 1:21-34.
- *Background:* Chapin et al 2011. Chapter 1: The Ecosystem Concept.

Lecture 3: Geological evolution and biogeochemical cycling

- Falkowski PG, Fenchel T, Delong EF. 2008. The microbial engines that drive Earth's biogeochemical cycles. *Science* (320):1034 -1039.
- Judson O. 2017. The energy expansions of evolution. *Nature Ecology and Evolution* 0138(1): 1-9.
  - https://www.theatlantic.com/science/archive/2017/05/a-grand-unified-theory-for-life-on-earth/525648/
- *Background*: Oren 2008. Microbial Metabolism: Importance for Environmental Biotechnology. In Wang et al (eds) *Environmental Biotechnology*, pp.193-255, Springer Science.

Lecture 4: Carbon cycle and trophic ecology

- Lindeman RL. 1942: The trophic-dynamic aspect of ecology. *Ecology,* 23: 399-418.
- Wilhelm SW and Suttle CA. 1999. Viruses and nutrient cycles in the sea: Viruses play critical roles in the structure and function of aquatic food webs. *Bioscience*. 49(10):781-788
- *Background:* Chapin et al 2011. Chapter 6: Terrestrial Production process; Chapter 7: Terrestrial decomposition; Chapter 11: Trophic Dynamics
- *Optional*: Azam, F., T. Fenchel, J. S. Gray, L. A. Meyer-Reil, and F. Thingstad. 1983. The ecological role of water-column microbes in the sea. *Marine Ecology Progress Series* 10: 257-263.

Lecture 5: Nitrogen limitation and forest nutrient cycling

- Vitousek PM and Farrington H. 1997. Nutrient limitation and soil development: Experimental test of a biogeochemical theory. *Biogeochemistry* 37(1) 63-75.
- Likens GE. et al. 1970. Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook Watershed-Ecosystem. *Ecological Monographs* 40: 23-47

- *Background:* Chapin et al 2011. Chapter 9: Nutrient cycling, Chapter 3. Geology, Soils and Sediments

Lecture 6: Phosphorus cycle and eutrophication

- Schindler DW. 1974. Eutrophication and Recovery in Experimental Lakes: Implications for Lake Management. *Science*. 184:897-899.
- Elser JJ et al. 2007. Global analysis of nitrogen and phosphorus limitation of primary producers in freshwater, marine and terrestrial ecosystems. *Ecology Letters* 10: 1135-1142.
- *Background*: Chapin et al 2011. Chapter 9: Nutrient cycling

Lecture 7: Ecosystem resilience and alternate states

- Holling CS. 1973. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics Vol. 4:1-23
- Knowlton N. 1992. Thresholds and multiple stable states in coral reef community dynamics. American zoologist 32: 674–682.
- *Background:* Chapin et al 2011. Chapter 12: Ecosystem resilience and change
- *Optional:* Scheffer M. et al. 1993. Alternative equilibria in shallow lakes. TREE (8) 275-279.

Lecture 8: Biodiversity and Ecosystem Function

- Tilman D, Wedin D and Knops J. 1996. Productivity and sustainability influenced by biodiversity in grassland ecosystems. *Nature* 379(22): 718
- Hooper et al, 2012. A global synthesis reveals biodiversity loss as a major driver of ecosystem change. *Nature*. 486: 105-109.
- *Background:* Chapin et al 2011. Chapter 11: Species effects on ecosystem processes