Fall 9-1-2022

BIOS 532.01: Fundamentals of Ecosystem Ecology

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Fundamentals of Ecosystem Ecology
(BIOS 532 -Fall 2022)

Instructor: Dr. Cory Cleveland
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Zoom link: https://umontana.zoom.us/my/cory.cleveland
UM Box Course Link: https://umt.box.com/s/htpghlnr1nuryw7nw8g1smfswdnr95sx
Office Hours: By appointment via email
Lecture Time and Location: M/W 10:00 – 11:20 AM, Health Sciences 411
Reading Recitation Time and Location: Monday 8:00 – 9:00 AM, CHCB 426 (Terra Room)

Course Description & Learning Outcomes:

In this course students will consider the defining principles of ecosystem ecology. Ecosystem ecology is somewhat unique in that it considers the flow of both energy and materials through living (*e.g.,* plants, animals, microbes, humans) and non-living (*e.g.,* lithosphere, hydrosphere, atmosphere) components of environments. As such, the course includes material ranging from biophysical and chemical to biological. Using the framework developed by G. Evelyn Hutchinson in his book, *The Ecological Theater and the Evolutionary Play*, we will begin by examining the "abiotic stage" (*e.g.,* ecosystem water and energy balance, climate, geology and soils) on which the major ecological players perform some truly incredible roles (e.g., primary production, decomposition, nutrient cycling and nutrient use). We will consider a number of fundamental concepts in the field (*e.g.,* succession, disturbance, ecological stoichiometry), then turn our attention to the major element cycles (carbon, nitrogen, phosphorus), what drives them, how element fluxes vary in space and time, and what that means for the planet, and we will consider some strategies for managing and sustaining ecosystems. Along the way, we will use some specific case studies from the primary literature to help synthesize the information we are covering.

The overall goal of this course is help students develop an understanding the relationships between ecosystem structure and the way they function. Through the semester, I hope to weave logical connections between ideas, and to demonstrate how complex processes can be understood from basic principles. Most of the course will be lecture-based, but we will have plenty of group discussion of concepts and primary literature. Everyone will take exams, and homework may be assigned periodically to help reinforce concepts. Participation in class discussions will also be a significant part of the course grade, and will be assessed, in part, via quizzes covering the assigned readings. In addition, students will be responsible for completing a short independent project (ecological synthesis, review, or meta-analysis) that addresses an ecosystems-related question in an ecosystem of interest. Finally, all students will be responsible for preparing and delivering presentations summarizing the information from their independent projects in an *Ecosystem Ecology Symposium* held at the end of the semester.

Required Textbook:

Chapin, FS, Matson, PA, Vitousek, PM. 2011. Principles of Terrestrial Ecosystem Ecology. Springer, New York.

Course Schedule (Fall 2022):

Class#	Date	Topic	Required Reading	Recommended Reading
1	8/29	Course Introduction/Ecosystem Ecology and the Ecosystem Concept	Ch 1	Gorham (1991); Pickett and Cadenasso (2002)
2	8/31	The State Factor Approach to Ecosystems – Hawaii as a case study	Vitousek et al. (1997)	
3	9/5	**Labor Day – No class**		
4	9/7	The Atmosphere, Climate and Ecosystems, Part 1	Ch 2	
5	9/12	Climate & Ecosystems, Part 2	Ch 2	
6	9/14	Geology & Soils, Part 1	Ch 3	
7	9/19	Geology & Soils, Part 2	Ch 3	
8	9/21	Energy & Water	Ch 4	Wright et al. (2017)
9	9/26	Global C Cycle: Overview **Project Prospectus DUE**	Ch 14: pp. 407 - 414	Friedlingstein et al. (2021) https://doi.org/10.5194/essd-14-1917-2022
10	9/28	C Cycle 1 – Photosynthesis & GPP	Ch 5	Chapin et al. (2006)
11	10/3	C Cycle 2 – GPP/NPP	Ch 6	Cleveland et al. (2015)
12	10/5	**No Class**		
13	10/12	C Cycle 3 – NPP & Decomposition	Ch 5/6	Cleveland et al. (2014); Wickings et al. (2012)
14	10/17	**Midterm 1**		
15	10/19	Ocean Biogeochemistry	Falkowski et al. (2000)	Blain et al. (2015)
16	10/24	Nutrients & Nutrient Acquisition	Ch 8	Lambers et al. (2008)
17	10/26	Nutrient Use	Ch 8	
	10/31	Nutrient Cycling - Nitrogen	Ch 9; Galloway et al. (2008)	Laliberte et al. (2012)
18		Nutrient Cycling - Phosphorus		
19	11/2	Project meetings		
20	11/7	Nutrient Cycling	Ch 9	Schindler et al. (2008)
21	11/9	Trophic Dynamics	Ch 10	
22	11/14	**Exam 2**		
23	11/16	Ecosystem Dynamics & Succession	Ch 12; Odum (1969)	Vitousek & Reiners (1975)
24	11/21	Species Effects on Ecosystems	Ch 11	
25		Biodiversity Case Studies	Tilman & Downing 1994 Maron et al. (2010)	Vitousek et al. (1987)

26	11/23	**Travel Day – No Class**		
27	11/28	Ecosystems & Global Change	Ch. 14	
28	11/30	Ecosystems Symposium	Presentations	
29	12/5	Ecosystems Symposium	Presentations	
30	12/7	Ecosystems Symposium	Presentations	

Note: "Ch" refers to chapters in the Chapin et al. textbook. Recommended reading is just that, but I encourage you to read these papers as well, as time allows.

Course Details, Guidelines, and Policies:

Required Assignments and Proportion of Grade

Midterm 1:	25%
Midterm 2:	25%
Final Project (written):	25%
Symposium Presentation:	10%
Participation/Homework:	15%

Reading Group

The course includes a required reading group. This additional meeting will allow us to read and discuss some of the most important studies that address the topics we cover in lecture in more detail. Prior to each discussion, students should read the assigned papers carefully and come to class prepared to discuss them. Prior to each session, I will ask for two volunteers to co-lead the discussion, and encourage them to prepare a set of questions or a short assignment to help guide the conversations. Each person can expect to lead two discussions. I have already assembled a list of papers, and PDFs of all reading are available on the course UM Box folder. However, I am open to other suggestions should individual group leads prefer to discuss another paper. The discussion section will count towards your participation grade in the course.

Unless otherwise informed and as conditions allow, we will plan to meet TBD. I would encourage you to bring a laptop/tablet to class, if possible, so that you can all access course materials as needed.

Students with Disabilities

The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and Office for Disability Equity. If you think you have a disability that adversely affects your academic performance, and you have not already registered with Disability Equity, please contact Disability Equity in Aber Hall (1st Floor) or call 406.243.5330. I will work with you and Disability Equity to provide an appropriate modification.

Academic Honesty

All students must practice academic honesty. Academic misconduct is subject to an academic penalty by the course instructor and/or a disciplinary sanction by the University. All students need to be familiar with the Student Conduct Code. Academic misconduct includes plagiarism. Don't plagiarize someone else's work, period.

Health and Safety

COVID is still with us, but we are learning to live with it. As such, in most cases, we will meet in person for both lecture and reading group, but will all follow all relevant UM safety protocols.

In the unlikely event that we are forced to temporarily transition to remote instruction, I will provide instructions on how that will unfold. While we are in class, I would encourage everyone to wear masks. Not required, and I may not always wear a mask while lecturing, but I would hope everyone will do their best to ensure the safety of others. If you do not feel well for any reason, please do not come to class. I will upload all my lecture materials to the course UM Box folder, so you should be able to keep up, even if you miss a lecture or two. please contact DSS for either an accommodation to be completely remote for the semester or for any safety protocol modification you may need (*depending on the needs we may or may not be able to accommodate the modification without requesting that you complete the class remotely*). If, at any point, students decide not to follow all safety protocols, I will immediately adjust any existing F2F activities and commit to full remote learning for the entire class for the remainder of the semester. More information and updates to UM's Healthy Fall plan can be found on the UM website.

UM COVID Guidance

The university encourages COVID-19 vaccines and boosters, which are offered for both students and employees at the Health Services Pharmacy inside Curry Health Center.

Masks are only required inside Curry Health Center and in some medical/research laboratories on campus. This requirement will be clearly posted. Required or not, we respect those choosing to wear a mask to reduce the spread of respiratory viruses.

COVID testing for students is available at Curry Health Center. For employees, contact your primary care provider or visit a walk-in clinic. Free at-home tests can be ordered online or there may be tests available through the Health Services Pharmacy, call 243-5171.

Students who test positive need to isolate and not attend in-person classes for at least five days. (Please see link for CDC guidelines referring to isolation).

As with any other illness, please work to accommodate student absences. Consider ways to make course content available in the event of multiple student absences.

Refer to this page for additional resources and guidance on supporting students who miss classes due to illness.

Drop/Add Deadlines

The UM website contains all relevant information on drop/add deadlines. Please read them carefully.

Additional Course Reading (Available on UM Box)

Blain, S. et al. (2007). Effect of natural iron fertilization on carbon sequestration in the Southern Ocean. Nature, 446(7139), 1070–1074. https://doi.org/10.1038/nature05700.

Chapin, F. S. et al. 2006. Reconciling carbon-cycle concepts, terminology and methods. Ecosystems 9:1041-1050.

Cleveland, C. C., Reed, S. C., Keller, A. B., Nemergut, D. R., O'Neill, S. P., Ostertag, R., & Vitousek, P. M. (2014). Litter quality versus soil microbial community controls over decomposition: A quantitative analysis. Oecologia, 174(1), 283–294. http://doi.org/10.1007/s00442-013-2758-9

Cleveland, C.C., P. Taylor, K.D. Chadwick, K. Dahlin, C.E. Doughty, Y. Malhi, W.K. Smith, B.W. Sullivan, W.R. Wieder and A.R. Townsend. 2015. A comparison of plot-based, satellite and Earth system model estimates of tropical NPP. Global Biogeochemical Cycles 29, doi:10.1002/2014GB005022.

Falkowski, P. et al. (2000). The global carbon cycle: a test of our knowledge of earth as a system. *Science 290*, 291–296.

Friedlingstein, P. et al. (2021). Global Carbon Budget 2021. Earth Syst. Sci. Data, 14, 1917–2005, 2022
https://doi.org/10.5194/essd-14-1917-2022

Galloway, J. N. et al. (2008). Tranformations of the nitrogen cycle: Recent trends, questions and potential solutions. Science, 320, 889–892.

Gorham, E. (1991) Biogeochemistry: Its origins and development. Biogeochemistry 13:199-239.

Laliberte, E. et al. (2012). Experimental assessment of nutrient limitation along a 2-million-year dune chronosequence in the south-western Australia biodiversity hotspot. Journal Of Ecology, 100, 631–642.

Maron, J., M. Marler, J. Klironomos, C. Cleveland. 2010. Soil pathogens contribute to the positive plant diversity-productivity relationship. Ecology Letters doi: 10.1111/j.1461-0248.2010.01547.x

Odum, E. P. 1969. The strategy of ecosystem development. Science 164:262-269.

Pickett, S. T. A., & Cadenasso, M. L. (2002). The ecosystem as a multidimensional concept: Meaning, model, and metaphor. Ecosystems, 5(1), 1–10. https://doi.org/10.1007/s10021-001-0051-y

Schindler, D. W. et al. (2008). Eutrophication of lakes cannot be controlled by reducing nitrogen input: results of a 37-year whole-ecosystem experiment. Proceedings of the National Academy of Sciences of the United States of America, 105(32), 11254–8. http://doi.org/10.1073/pnas.0805108105

Tilman, D. and J. A. Downing. 1994. Biodiversity and stability in grasslands. Nature 367:363-365.

Vitousek, P. and W. Reiners. 1975. Ecosystem succession and nutrient retention: A hypothesis. BioScience 25:376-381.

Vitousek, P. M. et al. 1997. Soil and ecosystem development across the Hawaiian Islands. GSA Today 7: 1-8.

Vitousek. P.M. et al. (1987) Biological invasion by Myrica faya alters ecosystem development in Hawaii. Science 238:802-804.

Wickings, K. et al. (2012). The origin of litter chemical complexity during decomposition. Ecology Letters, 15(10), 1180–1188. http://doi.org/10.1111/j.1461-0248.2012.01837.x

Wright, J. S. et al. (2017). A rainforest-initiated wet season over the southern Amazon, 114(32), 8481–8486. http://doi.org/10.1073/pnas.1621516114

Some other potentially useful references:

Aber, J.D. and J. M. Melillo (1991) Terrestrial Ecosystems. Saunders College Publishing, Philadelphia, PA.

Likens, G.E. and F.H. Bormann (1995) Biogeochemistry of a Forested Ecosystem. Springer-Verlag, New York.

Sala, O.E., R.B. Jackson, H.A. Mooney and R.W. Howarth. (2000) Methods in Ecosystem Science. Springer, New York.

Schlesinger, W.H., Bernhardt, E.S. (2013) Biogeochemistry: An Analysis of Global Change. Academic Press, San Diego, CA

Sterner, R. W. and J. J. Elser. (2002). Ecological Stoichiometry: The Biology of Elements from Molecules to the Biosphere. Princeton University Press, Princeton, NJ.

Vitousek, P.M. (2004) Nutrient Cycling and Limitation. Princeton University Press, Princeton, NJ.

Waring, R.H. and S.W. Running. (1998) Forest Ecosystems: Analysis at Multiple Scales. Academic Press, New York.

Wetzel, R.G. (2001). Limnology, 3rd Edition: Lake and River Ecosystems. Academic Press, New York.

Reading group schedule

Week	Date (week of)	Topic	Required Reading	Discussion Leaders
1	8/29	Introduction to Ecosystem Science	Gorham, E. (1991) Biogeochemistry: Its origins and development. Biogeochemistry 13:199-239. Pickett, S. T. A., & Cadenasso, M. L. (2002). The ecosystem as a multidimensional concept: Meaning, model, and metaphor. Ecosystems, 5(1), 1–10. https://doi.org/10.1007/s10021-001-0051-y	Cory
2	9/5	The State Factor Approach; The Ecosystem Concept	Amundson, R. & H. Jenny. 1997. On a state factor model of ecosystems. *BioScience* 47:536-543. Reiners, W. A. (1986). Complementary models for ecosystems. *The American Naturalist*, *127*, 59–73.	Cory
3	9/12	Climate & Ecosystems	Meir, P., Cox, P. M., & Grace, J. (2006). The influence of terrestrial ecosystems on climate. *Trends in Ecology and Evolution*, *21*, 254–260. Molles, M.C. & Dahm, C. N. (1990). A perspective on El Niño and La Niña: Global implications for stream ecology. *Journal of the North American Benthological Society*, 9, 68 – 76.	
4	9/19	Geology & Soils	Richter, D., & Markewitz, D. (1995). How deep is soil? *BioScience*. https://doi.org/10.2307/1312764 Chadwick, O. A. et al. (1999) Changing sources of nutrients during four million years of ecosystem development. *Nature*, 397, 491-497.	
5	9/26	Ecosystems Metabolism	Falkowski, P. G. et al. (2008). The microbial engines that drive Earth's biogeochemical cycles. *Science*, 320, 1034 – 1039. Jannasch, H. W., & Mottl, M. J. (1985). Geomicrobiology of Deep-Sea Hydrothermal Vents. *Science, 229*(4715), 717–725.	
6	10/3	**No Recitation**		
7	10/10	Primary Production	Clark, D. A., S. Brown, D. W. Kicklighter, J. Q. Chambers, J. R. Thomlinson, and J. Ni. 2001. Measuring net primary production in forests: concepts and field methods. Ecological Applications 11:356-370. Running, S. W. et al. (2004). A Continuous Satellite-Derived Measure of Global Terrestrial Primary Production. *Bioscience*, 54, 547 – 560.	
8	10/17	Decomposition /NEP	Couteaux, M. -M. et al. (1995). Litter decomposition, climate and litter quality. Trends in Ecology and Evolution, 10, 63-66. Goulden, M. L., Mcmillan, A. M. S., Winston, G. C., Rocha, A. V., Manies, K. L., Harden, J. W., & Bond-Lamberty, B. P. (2011). Patterns of NPP, GPP, respiration, and NEP during boreal forest succession. *Global Change Biology*, *17*(2), 855–871.	

9	10/24	Nutrient Cycling	Vitousek, P. M. and R. W. Howarth. 1991. Nitrogen limitation on land and sea: How can it occur. Biogeochemistry 13:87-115. Vitousek, P. M., & Farrington, H. (1997). Nutrient limitation and soil development: Experimental test of a biogeochemical theory. *Biogeochemistry*, *37*, 63–75.	
10	10/31	Nutrient Limitation	Elser, J. J., et al. (2007). Global analysis of nitrogen and phosphorus limitation of primary producers in freshwater, marine and terrestrial ecosystems. *Ecology Letters*, *10*, 1135–1142. Vitousek, P. M., Porder, S., Houlton, B. Z., & Chadwick, O. A. (2010). Terrestrial phosphorus limitation: Mechanisms, implications, and nitrogen-phosphorus interactions. *Ecological Applications*, *20*(1), 5–15. https://doi.org/10.1890/08-0127.1	
11	11/7	Hypotheses, Inference, and Scientific Inquiry	Lawson, A. E. (2000). The generality of hypothetico-deductive reasoning: Making scientific thinking explicit. *The American Biology Teacher,* 62, 482 – 495. Hutto, R. L. (2012). Distorting the process of scientific inquiry. *Bioscience,* 62, 707- 708.	
12	11/14	Trophic Dynamics	Pastor, J. et al. (1988). Moose, Microbes, and the Boreal Forest. *Bioscience 38*(11), 770–777. Walsh, J. R. et al. (2016). Invasive species triggers a massive loss of ecosystem services through a trophic cascade. *Proceedings of the National Academy of Sciences*, *113*(15), 201600366.	
13	11/21	Thanksgiving Break	No Recitation	
14	11/28	Ecosystem Succession	Seidl, R., and M.G. Turner. 2022. Post-disturbance reorganization of forest ecosystems in a changing world. Turner, M.G. (2010). Disturbance and landscape dynamics in a changing world. Ecology 91: 2833 – 2849.	
15	12/5	A Social Contract for Science	Lubchenco, J., & Rapley, C. (2020). Our Moment of Truth: The Social Contract Realized? Environmental Research Letters, https://doi.org/10.1088/1748-9326/abba9c Lubchenco, J., & Nin, E. (1998). Entering the Century of the Environment: A New Social Contract for Science, *279*, 491-497.	