**EVSC 4250 Ecosystem Ecology Syllabus – Fall Semester 2022**

**Location:** Clark Hall 101

**Time**: 10:00-10:50 Monday/Wednesday/Friday

**Instructor: Michael Pace**
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**Course Description**: An ecosystem is a spatially defined unit inclusive of all organisms along with the abiotic environment within its boundaries. In this course, we will learn about the flows of materials and energy through ecosystems through various processes including primary and secondary production. The central role of mass balance and the cycling of elements will be a focus along with how ecosystems change in relation to external and internal forces. We will study how interactions among organisms such as predation and disease influence ecosystems. We will consider the critical contributions of ecosystems to human well-being and the sustainability of life. We will think about and project possible trends in ecosystems to visualize alternative possibilities for the future.

**Learning Objectives**: By the end of the course, you will be able to: 1) understand the general attributes of ecosystem structure and function, 2) analyze mass balance, cycling, and elemental stoichiometry in relation to questions about ecosystems, 3) understand how ecosystems are changing, 4) appreciate the services provided by ecosystems and the relation of ecosystems to human well-being, 5) consider and evaluate future scenarios for ecosystems, 6) read and evaluate general and technical articles about ecosystems.

**Activities:** The course is organized into one-week topics which represent key ecosystem processes, dynamic attributes, and human-ecosystem interactions. The weekly schedule will typically include a lecture to introduce the subject, discussion of readings, evaluations of problems, and short presentations where students summarize an ecosystem service they have researched. Toward the end of the course, we will consider scenarios of human and ecosystem dynamics in the form of model projections and stories that help reveal possible futures.

**Readings**: The text is *Fundamentals of Ecosystem Science*, 2nd Edition. An important feature of the course are the assigned papers which we will discuss. All readings are available on Collab.

Students are required to post a question for each paper (not the book chapters). These questions must be posted by Friday morning (8 AM) each week. We will use these questions as part of our discussion. Questions can be uploaded on the course Collab site under the 'Assignments" tab. There are 40 papers and hence you will be expected to post 40 questions over the course of the semester. Each question posted on time will be worth 1 point.

**Grading Scheme:** Course grades will be determined from your combined, weighted scores on a series of tests, assignments, and class participation as follows:

Tests: Three tests will be given to assess your learning. Each test will account for 20% of your final grade. Tests will be posted on Collab on the following dates: September 30, October 28, December 7 (highlighted in yellow below). You will have an 84-hour window within which you must take the test and one and a half hours to complete test once you start. Tests will be closed book.

Questions: As described above, 15% of grade.

Lead discussant: Each student will lead the discussion of one of the readings and this activity will account for 10% of your final grade.

Ecosystem Services Presentation: Each student will research an ecosystem service, prepare a short powerpoint presentation, and give a 10-minute talk on their work to the class. This project is described separately. We will schedule presentations throughout the course and this activity will account for 10% of your final grade.

Class participation: Attendance and contributions in class will be monitored and constitute 5% of your final grade.

Course grades are assigned based on your final scores on a 100-point scale:
>97 = A+, 93-97 = A, 90-93 = A-, 87-90 = B+, 83-87 = B, 80-83 = B-, 77-80 = C+, 73-77 = C, 70-73 = C-, 60-70 = D, < 60 = F

**Attendance Policy**: Attending class is required except for University sponsored trips or illness. Please notify the Instructor or TA if you are going to miss class.

**Late Work Policy**: The class is designed to provide a number of graded assessments to help you keep up and to prevent too much grading emphasis on a single item. Please complete all assignments and tests by the deadlines indicated so we can keep on track. If you have a special reason for needing additional time (e.g., illness), please discuss accommodation with the Instructor.

**Academic Integrity Policy**: The Instructor starts from a position of trust and openness with all in the class. I will carefully lay out guidelines and indicate what work is to be done individually and "pledged". Please be sure you understand the guidelines before engaging in assignments and tests. Do not hesitate to ask for clarification.

**Accessibility:** Materials will be made available on Collab. If you have difficulties with accessing course materials, have special needs, or have technical issues, please notify us. We will work with you to accommodate needs and resolve technical problems.

Week 1 – August 24 and 26: Introduction to Course and the Ecosystem Concept

*What is the ecosystem concept? What is ecosystem structure and function? What approaches and concepts do ecosystem scientists use? What are ecosystem services? What are complex adaptive systems?*

Text Chapters 1 and 10

Levin, S. A. 1998. Ecosystems and the biosphere as complex adaptive systems. Ecosystems 1: 431-436.

Bar-On, Y. M., R. Phillips, and R. Milo. 2018. The biomass distribution on Earth. Proceedings of the National Academy of Sciences doi/10.1073/pnas.1711842115

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Week 2 – August 29, 31 and September 2: Primary Production

*How is energy formed and dissipated in ecosystems? What controls primary production and why do ecosystems differ in production? What are the rates of primary production in different ecosystems? How is the primary production of ecosystems and the planet changing?*

Text Chapter 2

Hamilton J.G., E.H. DeLucia, K. George, S.L. Naidu, A.C. Finzi, and W.H. Schlesinger. 2002. Forest carbon balance under elevated $CO_2$**.** Oecologia 131: 250-260.

Knapp, A.K., P. Ciais, and M. D. Smith. 2017. Reconciling inconsistencies in precipitation-productivity relationships: implications for climate change. New Phytologist 214: 41-47.

Wilkinson, G.M., J.A. Walter, C.D. Buelo, and M.L. Pace. 2022. No evidence of widespread algal bloom intensification in hundreds of lakes. Frontiers in Ecology and Environment 20: 16-21.
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Week 3 – September 5, 7, and 9: Secondary Production

*What is secondary production? How do consumers affect ecosystem processes like primary production? How are consumers regulated by the availability of resources? What factors control food chains and food webs in ecosystems?*

Text Chapter 3

Street, G.M. and G.G. McNickle. 2019. A global estimate of terrestrial net secondary production of primary consumers. Global Ecology and Biogeography 28: 1763-1773.

Post, D.M., M.L. Pace, N.G. Hairston, Jr. 2000. Ecosystem size determines food-chain length in lakes. Nature 405: 1047-1049.

Eddy, T. D. 2021. Energy flow through marine ecosystems: confronting transfer efficiency. Trends in Ecology and Evolution 36: 77-84.

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## Week 4 – September 12, 14, and 16: Decomposition and Cycles

*What controls the degradation of materials in ecosystems? What are biogeochemical cycles? How do ratios of elements (stoichiometry) influence ecosystems dynamics?*

Text Chapters 4 and 6

Gu, B., J. Chang, Y. Min, Y. Ge, Q. Zhu, J. N. Galloway, and C. Peng. 2013. The role of industrial nitrogen in the global nitrogen biogeochemical cycle. Scientific Reports 3: article 2579

Bradford, M.A., B. Berg, D.S. Maynard, W.R. Wieder, and S.A. Wood. 2016. Understanding the dominant controls on litter decomposition. Journal of Ecology 104: 229-238.

Sterner, R. W., and J. J. Elser. 2009. Ecological stoichiometry. The Princeton Guide to Ecology

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## Week 5 – September 19, 21 and 23: Carbon

*How do ecosystems form, cycle, dissipate, and store carbon? What is the structural composition of ecosystems in terms of carbon? What regulates carbon cycling? How is carbon cycling related to climate change? How might ecosystem carbon cycling change in the future?*

Text Chapter 7

Mitchard, E.T.A. 2018. The tropical forest carbon cycle and climate change. Nature 559: 527-534.

Macreadie, P. I. et al. 2019. The future of blue carbon science. Nature Communications doi/10.1038/s41467-019-11693-w

Solomon, C.T. et al. 2015. Ecosystem consequences of changing inputs of dissolved organic matter to lakes: current knowledge and future challenges. Ecosystems 18: 376-389.

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## Week 6 – September 26. 28 and 30: Nitrogen and Phosphorus
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*How do nutrients limit ecosystems? What are the key attributes of nitrogen and phosphorus inputs and cycling? How does nutrient limitation vary among freshwater, marine, and terrestrial ecosystems?*

Text Chapters 8 and 9

Elser, J.J., M.E.S. Bracken, E.E. Cleland, D.S. Gruner, W.S. Harpole, H. Hillebrand, J.T. Ngai, E. W. Seabloom, J.B. Shurin, and J.E. Smith. 2007. Global analysis of nitrogen and phosphorus limitation of primary producers in freshwater, marine and terrestrial ecosystems**.** Ecol. Lett. 10: 1135-1142.

Levy-Varon, J.H., S.A. Batterman, D. Medvigy, X. Xu, J.S. Hall, M. van Breugel, and L.O. Hedin. 2019. Tropical carbon sink accelerated by symbiotic dinitrogen fixation. Nature Communications 10: article 5637.

Fay, P. A. et al. 2015. Grassland productivity limited by multiple nutrients. Nature Plants 1: doi:10/1038/NPLANTS.2015.80

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September 30 Test 1

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No Class October 3 Fall Break

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## Week 7 – October 5 and 7: Heterogeneity of Ecosystems in Space and Time

*How is spatial and temporal heterogeneity important?*

Text Chapter 11

McClain, M. E. et al. 2003. Biogeochemical hot spots and hot moments at the interface of terrestrial and aquatic ecosystems. Ecosystems 6: 301-312

Schindler, D. E., J. B. Armstrong, and T. E. Reed. 2015. The portfolio concept in ecology and evolution. Frontiers in Ecology and the Environment 13: 257-263.

Levine, N.M., K. Zhang, M. Longo, and P.R. Moorcraft. 2016. Ecosystem heterogeneity determines the ecological resilience of the Amazon to climate change. Proceeding of the National Academy of Sciences USA 113: 793-797.

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## Week 8 – October 10, 12, and 14: Ecosystem Controls

*How are ecosystems regulated by internal and external processes? What is the importance of feedback? How are ecosystem processes regulated at different scales?*

Text Chapter 12

Harris, L. I. et al. 2022. The essential carbon service provided by northern peatlands. Frontiers in Ecology and Environment 20: 222-230.

Schmitz, O.J., J.H. Grabowski, B.L. Peckarsky, E.L. Preisser, G.C. Trussell, and J.R. Vonesh. 2008. From individuals to ecosystem function: toward an integration of evolutionary and ecosystem ecology. Ecology 89: 2436-2445.

Pugnaire, F. I., J. A. Morillo, J. Penuelas, P. B. Reich, R. D. Bardgett, A. Gaxiola, D. A. Wardle, and W. H. van der Putten. 2019. Climate change effects on plant-soil feedbacks and consequences for biodiversity and ecosystem functioning of terrestrial ecosystems. Science Advances 5: eaaz1834

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## Week 9 – October 17, 19 and 21: Predators

*How do predators regulate ecosystems?  What are the impacts of predators and what happens when predators are lost or restored?*

Estes, J.A. et al.  2011. Trophic downgrading of planet earth. Science 333: 301-306.

Croll, D.A., J.L. Maron, J.A. Estes, E.M. Danner, G.V. Byrd.  2005. Introduced predators transform subarctic islands from grasslands to tundra. Science 307: 1959-1961.

Prugh, L.R., C.J. Stoner, C.W. Epps, W.T. Bean, W.J. Ripple, A.S. Laliberte, and J.S. Brashares. 2009. The rise of the mesopredator. BioScience 59: 779-791.

Hammerschlag, N., O.J. Schmitz, A.S. Flecker, K.D. Lafferty, A. Sih, T.B. Atwood, A.J. Gallagher, D.J. Inschick, R. Skubel, and S.J. Cooke. Ecosystem function and services of aquatic predators in the Anthropocene. Trends in Ecology and Evolution 34: 369-383.

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## Week 10 – October 24, 26 and 28: Ecosystems and Disease

*How do diseases impact ecosystems? How does ecosystem structure promote or inhibit disease risk? Can ecosystems be managed to moderate disease?*

Text Chapter 14

Yates, T.L. and others. 2002. The ecology and evolutionary history of an emergent disease: hantavirus pulmonary syndrome.  BioScience 52: 989-998.

Lamb, J. B. et al. 2017. Seagrass ecosystems reduce exposure to bacterial pathogens of humans, fishes, and invertebrates. Science 355: 731-733.

Harvel, C. D. et al. 2019. Disease epidemic and a marine heat wave are associated with the continental-scale collapse of a pivotal predator (*Pycnopodia helianthoides*). Science Advances 5: eeau7042.

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Test 2 October 28

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## Week 11 – October 31, November 2 and 4: Ecosystem Dynamics

*What factors are driving ecosystem change? How are human and natural systems coupled? What are regime shifts? How can regime shifts be detected and avoided?*

Edburg, S.I. et al. 2012. Cascading impact of bark beetle-caused tree mortality on coupled biogeophysical and biogeochemical processes. Frontiers in Ecology and Environment 10: 416-424.

Sankaran, M. et al. 2005. Determinants of woody cover in African savannas. Nature 438: 846-849.

Turner, M. G. et al. 2020. Climate change, ecosystems and abrupt change: science priorities. Philosophical Transactions of the Royal Society of London B 375: doi/10.1098/rstb.2019.0205

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## Week 12 – November 7, 9, and 11: Ecosystems and Human Well Being, Ecosystem Stewardship

*How are ecosystems related to human well being? How are ecosystem services changing? How can ecosystems be managed?*

Millennium Ecosystem Assessment: Living beyond our means: natural assets and human well being.

Nystrom, M. et al. 2019. Anatomy and resilience of the global production ecosystem. Nature 575: 98-108.

Lynch, A. J. et al. 2021. Managing for RADical ecosystem change: applying the Resist-Accept-Direct (RAD) framework. Frontier in Ecology and Environment 19: 461-469.

Chapin et al. 2022 Earth stewardship: Shaping a sustainable future through interacting policy and norm shifts. Ambio **https://doi.org/10.1007/s13280-0220-01721-3**

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## Week 1 3 – November 14, 16, and 18: Scenarios and the Future of Ecosystems

*How can ecosystem change be considered when assessing the future? What is the future of the Yahara River Watershed? What is the impact of ecosystem change on humans? What is the response of humans to ecosystem change? What is scenario planning?*

Yahara 2070 Scenario 1: Abandonment and renewal
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Yahara 2070 Scenario 2: Accelerated innovation

Yahara 2070 Scenario 3: Connected communities

Yahara 2070 Scenario 4: Nested watersheds

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Week 14 – November 21 Scenarios Cont'd

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No Class November 23 and 25 Thanksgiving

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Week 15 – November 28, 30 and December 2: Frontiers

*What are the key directions and challenges in ecosystem science? How is ecosystem science changing?*

Text Chapter 17

Hughes, T. P., S. Carpenter, J. Rockstrom, M. Scheffer, and B. Walker. 2013. Multiscale regime shifts and planetary boundaries. Trends in Ecology and Evolution 28: 389-395.

Bennett, E.M. 2017. Research frontiers in ecosystem service science. Ecosystems 20: 31-37.

Pace, M. L., and J. A. Gephart. 2017. Trade: a driver of present and future ecosystems 20: 44-53.

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Week 16 – December 5: Synthesis and Review

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Review, Catch-up, Synthesis

Test 3 December 7

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