EAS 524 Agroecosystem Management: Nutrient Cycles and Soil Fertility

Syllabus- Winter 2022

(*Draft, subject to change*)

Instructor: Dr. Jennifer Blesh
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Office hours: by appointment
Phone: 734.763.2470
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Location: Dana Building 1046

Meeting times: 1 - 2:20PM, Tuesdays and Thursdays; Saturday, March 12th 1pm-4pm

Credits: 3

Course Summary

Global food systems have dramatically altered biogeochemical cycles, contributing to climate change and eutrophication of waterways. Growing concern about agriculture's environmental impacts is increasing demand for citizens, scientists, and policymakers who have in-depth knowledge of more sustainable agroecosystem management approaches. We will focus on how management impacts carbon (C), nitrogen (N), and phosphorus (P) cycles from soil-plant to global scales. The course links theory and practice, and domestic and international examples, to discuss the complex challenges of sustainable food production, with an emphasis on applying ecological principles to soil fertility management. Students will develop skills using this knowledge in applied settings.

Course learning objectives

During this class, students will:

1) Apply ecological theory to the analysis of food systems and agroecosystem management, with a focus on soil C and nutrient cycles

2) Analyze and critique peer-reviewed literature from multiple disciplines examining the ecological processes and outcomes of different food systems

3) Understand organic nutrient management

4) Be able to identify and characterize a range of domestic and international agroecosystem management systems

5) Practice communicating ideas about agroecosystem management, policy, and sustainability in oral presentations to peers in a group setting

6) Engage with stakeholders in classroom and field settings

7) Develop critical thinking and systems thinking skills

8) Engage in collaborative teamwork and problem-solving with those of differing viewpoints and backgrounds

Course competencies

Upon completion of this course, students will be able to:

1) Describe key concepts related to ecological soil management, and impacts of management on soil fertility, and C, N, and P cycles

2) Describe contrasting paradigms for agricultural research and management

3) Apply ecological principles to the analysis and design of more sustainable agroecosystems

4) Apply and synthesize scientific evidence in support of arguments that address soil science and agroecosystem management

5) Communicate clearly and effectively about soil science and agroecology through writing and oral presentations in a professional setting of diverse peers

Textbook and suggested prior coursework

No textbook is required for this course. All required readings will be provided under the "Files" link of the course Canvas site. Students will strongly benefit from having completed one or more of the following courses before joining this class: Soil Ecology (EAS 430), an ecosystem ecology or biogeochemistry course, an agronomy or sustainable agriculture course, or a statistics course. Those with no ecology or soil science background may wish to have a textbook as reference such as M. Begon et al. *Ecology: From Individuals to Ecosystems* (Wiley-Blackwell), or equivalent, and/or Brady, N.C. and R.R. Weil: *The Nature and Properties of Soils* (Prentice Hall).

Teaching philosophy and course format

We all participate in the food system. As such, this course aims to contribute to the education of informed citizens who influence decision-making about how food is produced. Key goals of my instruction are to build students' knowledge of particular content as well as practical skills and experience. To achieve that goal this course will synthesize theoretical and practical knowledge from multiple disciplines, drawing upon mixed teaching formats. The course content will be presented using classroom lectures, reading of the peer-reviewed literature, writing assignments, and cooperative learning through in-class discussion and activities as a large group and in small groups. In addition to textbook readings, students will read foundational literature from the disciplines of ecosystem ecology, agroecology, biogeochemistry, and soil science. Guest speakers will provide various perspectives on agroecosystem and soil fertility management. Students will also interview a farmer to learn more about the approaches farmers are using to meet today's agricultural challenges.

Class schedule in brief

Week	Date	Topic	Assignments due
		UNIT I: CONTEXT- AGRICULTURE AND GLOBAL CHANGE	
1	January 6	Course introduction	
2	January 11	History of agricultural intensification and food system overview	
	January 13	Agroecology and the ecosystem concept	
3	January 18	Overview of management paradigms	
	January 20	Human alteration of global C, N, and P cycles; Issue discussion: Agriculture and global climate change	
		UNIT II: BASIC ECOLOGICAL PROCESSES AND PRINCIPLES	
4	January 25	Key soil science concepts/ soil organic matter	
	January 27	Soil microbial ecology- *Guest Lecture* Kent Connell	
5	February 1	Functional ecology- *Guest Lecture* Etienne Herrick	
	February 3	Soil C, N, and P cycles	
6	February 8	The N cycle and biological N fixation	Choose farmer + questions
	February 10	The P cycle and organic management	
7	February 15	Issue discussion: Dead Zones	Group project outline 1
		UNIT III: AGROECOLOGICAL MANAGEMENT PRACTICES	
7	February 17	Ecologically-based management systems I	
8	February 22	Ecologically-based management systems II- *Guest Lecture* Etienne Herrick	
	February 24	Ecologically-based management systems III	Mid-term exam
9	March 1	**BREAK: NO CLASSES**	
	March 3	**BREAK: NO CLASSES**	
10	March 8	Ecologically-based management systems IV- *Guest Lecture* Jeremy Moghtader	Group project outline 2
	March 10	Ecologically-based management systems V	
	March 12	Saturday Session- Farmer Nutrient Budget Game 1-4pm	
11	March 15	Ecologically-based management systems VI	
	March 17	Ecologically-based management systems VII- *Guest Lecture* Brendan O'Neill	Interview summary
		UNIT IV: SYNTHESIS- POLICY, MANAGEMENT, AND SUSTAINABILITY	
12	March 22	Discussion of farmer interviews	
	March 24	Role of the US Farm Bill	
13	March 29	Farm Bill (cont.)	
	March 31	Student presentations	
14	April 5	Student presentations	
	April 7	Student presentations	Final project paper draft
15	April 12	Policy issue discussion: Agriculture and C sequestration – *Guest Lecture* Kent Connell	
	April 14	No class/ project workday	
16	April 19	No class/ project workday	Final project paper due

Assignments

Readings and discussion questions

Students are expected to complete the assigned readings, and to come to class prepared to critically discuss them. For a minimum of **10 classes**, students are expected to post 1-2 discussion questions on the course Canvas site, based on the readings for that session. I will aim to address as many questions as possible during the class discussions, but will select and prioritize several provocative questions for discussion each class period. Discussion questions must be posted by midnight on the Canvas site on the day before the class for which readings are assigned. Questions might focus on ideas or research results that were particularly confusing or surprising, arguments you agree or disagree with, or connect an outside topic with a given reading. *Questions should demonstrate critical and/or synthetic thinking about a given topic or reading.*

Farmer interview

During the semester students will work with the instructor to identify a farmer (or another agricultural stakeholder) to interview. The primary goals of the interview assignment are: i) to learn directly from practitioners about farming systems and soil fertility management, and ii) to better understand the real-world approaches and challenges to agroecosystem management on working farms. More details regarding the interview assignment will be given during the semester.

Mid-term exam

The course will have one take-home exam covering concepts in Units I and II, worth 25% of the overall grade.

Group project

During the term, small groups will work together on a research project. Groups will develop a research question that addresses relationships between agricultural management practices, policy, and the environmental and social impacts of a given agroecosystem. Groups will present their findings during a class session in Unit IV. A final report will also be due on the last day of class (5-7 pages, single spaced, 12-point font). Students will receive further details regarding this group project during the semester.

Grading

Participation & attendance:	15 points
Discussion questions:	10 points
Farmer interview:	20 points
Mid-term exam:	25 points
Group project:	30 points
Total points possible:	**100 points**

Letter grades will be assigned based on the following cut-offs:

A+	97% or greater
A	93-96.9%
A-	90-92.9%
B+	87-89.9%

B	83-86.9%
B-	80-82.9%
C+	77-79.9%
C	73-76.9%
C-	70-72.9%

A Rubric for Evaluation of Participation

A significant portion of your grade for this class (15%) is based on your participation in class discussions, activities, and group project. Participating in this class does not necessarily mean talking a great deal. An important part of satisfactory participation in this class is your active role in creating, and engaging in, a community of learners. It entails your building on and synthesizing comments and contributions from others, and on showing appreciation for others' involvement. Some of the most helpful things you can do are to bring a new resource to the classroom, or highlight something interesting and compelling you witness in others. There are multiple ways that quieter learners can participate.

Below are some *specific* examples of high-quality participation:

- **Attend each class**, **on time**.
- **Please do not use your phone** during class, since if you are "there," you are not "here" with us.
- **Your laptops are only to be used if you are taking notes or doing project work**, and are not appropriate for social media, email, and other personal uses.
- Attempt to get to know every student. One of our goals is to create a **cohesive learning community**. You may learn the most from someone with whom you do not initially connect.
- Ask a question or **make a comment that shows you are interested** in what another person says, or does, and/or encourages another person to elaborate on something they have already said or done.
- **Alert us to a resource** (a reading, website, video) not addressed in the syllabus that adds a new dimension or perspective to our learning.
- **Make a comment that underscores the linkage between two or more students' contributions** and make this link explicit in your comment. Contribute something that builds on, or emerges from, what someone else has said or done.
- If you think it is appropriate, **ask the group for a pause** to slow the pace of conversation or activity to give you, and others, time to think and process material.
- **Make a summary observation** that considers several people's contributions, and which **touches on a recurring theme** in a discussion or in the course.
- Find a way to **express appreciation for the learning** you have gained from a discussion or from our group work together. Try to be specific about what it was that helped you understand something better.
- **If you have a critical comment, make it diplomatically**, focusing on the issue at hand, and not on the people with whom you have a differing viewpoint.

To be effective, many of the above can be done one-on-one, or in small groups. You do not always have to speak in front of the entire class. I will use this rubric to assess your participation during this course.

Accommodations for students with disabilities

In compliance with the University of Michigan Rackham Graduate School policy, I am available to discuss appropriate academic accommodations that may be required for students with disabilities. Requests for academic accommodations are to be made during the first three weeks of the semester, except for unusual circumstances, so arrangements can be made. Students are encouraged to register with Office of Services for Students with Disabilities to determine eligibility for appropriate accommodations. See: http://www.rackham.umich.edu/policies/accommodations_for_graduate_students_with_disabilities/.

Academic Integrity

"The faculty believes that the conduct of a student registered or taking courses at UM should be consistent with that of a professional person. Courtesy, honesty, and respect should be shown by students toward faculty members, guest lecturers, administrative support staff, and fellow students. Similarly, students should expect faculty to treat them fairly, showing respect for their ideas and opinions and striving to help them achieve maximum benefits from their experience.

Student academic misconduct refers to behavior that may include plagiarism, cheating, fabrication, falsification of records or official documents, intentional misuse of equipment or materials (including library materials), and aiding and abetting the perpetration of such acts. The preparation of reports, papers, and examinations, assigned on an individual basis, must represent each student's own effort. Reference sources should be indicated clearly. The use of assistance from other students or aids of any kind during a written examination, except when the use of aids such as electronic devices, books or notes has been approved by an instructor, is a violation of the standard of academic conduct (Standard of Academic Conduct, University of Michigan School of Public Health)."
Source: Advisory Committee on Academic Programs (ACAP).

If you are concerned that you might be plagiarizing – using the words, data, images or ideas of others without clear attribution – you probably are. As a member of the university community, and student in the Rackham School of Graduate Studies, you are bound by their respective rules and regulations on Academic and Professional Integrity, which includes documenting the use of source materials. If you are confused, speak to the instructor. The following websites are useful:

- University of Michigan's policies on academic and professional misconduct, http://www.rackham.umich.edu/policies/academic_and_professional_integrity/
- Pamphlet on avoiding plagiarism from UC-Davis: http://sja.ucdavis.edu/files/plagiarism.pdf
- Pamphlet on unacceptable paraphrases from Indiana University Writing Tutorial Services http://www.indiana.edu/~wts/pamphlets/plagiarism.pdf
- Advice on how to use proper formats for footnotes or endnotes and bibliography, including how to cite websites: https://owl.english.purdue.edu/owl/section/2/

Diversity, Equity, and Inclusion (DEI)

This course follows the DEI statement established by the School for Environment and Sustainability (SEAS), quoted below.

"DEI is central to our mission to ensure that each member of our community has full opportunity to thrive in our environment, for we believe that diversity is key to individual and societal success, educational excellence and the advancement of knowledge.

In service to our core values of Diversity, Equity, and Inclusion, we commit to the following.

- Act with deliberateness and humility as we seek to respect and leverage diversity, ensure equity, and promote inclusion;
- Coordinate and implement practices that are aligned with our commitment to promoting diversity and to advancing equity and inclusion as core school priorities;
- Provide opportunities for all members of the community to learn and develop in ways that are in keeping with the school's commitment to diversity, equity, and inclusion;
- Develop and refine processes that seek to increase the diversity of our faculty, students, and staff;
- Establish practices and policies that make visible, discourage, and restoratively respond to acts of discrimination, harassment, or personal abuse;
- Promote generous listening and communications that assume all community members are well intentioned;
- Sensitize members of our community to the ways that seemingly innocent utterances or gestures may be experienced as insulting or demeaning by others whether or not such an effect was intentional;
- Allocate time and resources to enhancing our curriculum and pedagogical approaches to reflect and further strengthen the school's commitment to the roles of diversity, equity, and inclusion in the teaching and learning process;
- Identify systematic ways to monitor, regularly measure, and publicly document our progress in achieving our goals for diversity, equity, and inclusion;
- Examine and learn from the outcomes of our efforts and work to improve them;
- Act on our commitment to contribute to a just and sustainable society and to affirm the humanity of all persons."

Readings

No textbook is required for this course. All readings are provided under the "Files" link of the course Canvas site. **Readings in bold typeface are required.** Those in regular typeface are optional additional reading; they are not required. These readings are subject to change with two weeks' notice.

Week	Date	Topic & Readings
UNIT I: CONTEXT- AGRICULTURE AND GLOBAL CHANGE		
1	January 6	Course introduction
2	January 11	History of agricultural intensification and food system overview • **Cronon, W. 1991. Pricing the Future: Grain. Chapter 3 in *Nature's Metropolis: Chicago and the Great West*. W.W. Norton and Company, New York, *Pages 97-132*** • **White, M.M. 2019. Freedom Farmers: Agricultural Resistance and the Black Freedom Movement. The University of North Carolina Press. Chapter 1, *Pages 28-49.*** • Lee, R. and T. Ahtone. 2020. Land-grab universities. High Country News. • Philpott, T. 2021. After a century of dispossession, black farmers are fighting to get back to the land. Mother Jones, May+June.
	January 13	Agroecology and the ecosystem concept • **Odum, E.P. 1984. Properties of agroecosystems. In: Lowrance, R. et al. (Eds). *Agricultural Ecosystems: Unifying Concepts*, 5-12.** • **Paul, E.A. and G.P. Robertson. 1989. Ecology and the agricultural sciences: A false dichotomy? *Ecology* 70(6): 1594-1597.** • **Tomich, T.P., Brodt, S., Ferris, H., Galt, R., Horwath, W.R., Kebreab, E., Leveau, J.H.J., Liptzin, D., Lubell, M., Merel, P., Michelmore, R., Rosenstock, T., Scow, K., Six, J., Williams, N., Yang, L., 2011. Agroecology: A Review from a Global-Change Perspective. Annual Review of Environment and Resources 36, *Pages 193-198 (through section 1.4)*** • Wezel, A., Herren, B.G., Kerr, R.B., Barrios, E., Gonçalves, A.L.R., Sinclair, F., 2020. Agroecological principles and elements and their implications for transitioning to sustainable food systems. A review. Agronomy for Sustainable Development 40, 1-13. • Crossley, D.A., G. J. House, R. M. Snider, R.J. Snider, and B.E. Stinner. 1984. The positive interactions in agroecosystems. In: Lowrance, R. et al. (Eds). *Agricultural Ecosystems: Unifying Concepts*, 73–81. • Chapter 1: The ecosystem concept in Chapin, F. S., Matson, P.A. and H. A. Mooney. 2002. *Principles of Terrestrial Ecosystem Ecology*. New York: Springer. • Shennan, C. 2008. Biotic interactions, ecological knowledge and agriculture. *Philosophical Transactions of the Royal Society B-Biological Sciences*, 363:717-739.
3	January 18	Overview of management paradigms • **Matson, P. A., Parton, W. J., Power, A. G. and Swift, M. J. 1997. Agricultural intensification and ecosystem properties. *Science* 277: 504–509.** • Drinkwater, L.E. 2002. Cropping systems research: reconsidering agricultural experimental approaches. *HortTechnology* 12: 355-361.
	January 20	Human alteration of global C, N, and P cycles; Issue discussion: Agriculture and global change • **USGCRP- *Climate change impacts on U.S. Agriculture*. *Pages 71-78.*** • **Carpenter, S.R., N.F. Caraco, D.L. Correll, R.W. Howarth, A.N. Sharpley, and V. H. Smith. 1998. Nonpoint pollution of surface waters with phosphorus and nitrogen. Ecological Applications 8:559-568.** • IPCC, 2021: *Summary for Policymakers*. • Hristov, A. N., Johnson, J. M. F., Rice, C. W., Brown, M. E., Conant, R. T., Del Grosso, S. J.,

		Gurwick, N. P., Rotz, C. A., Sainju, U. M., Skinner, R. H., West, T. O., Runkle, B. R. K., Janzen, H., Reed, S., Cavallaro, N., Shrestha, G., Cavallaro, N., Shrestha, G., Birdsey, R., … Zhu, Z. (2018). *Chapter 5: Agriculture. Second State of the Carbon Cycle Report*. U.S. Global Change Research Program. https://doi.org/10.7930/SOCCR2.2018.Ch5 • Galloway, J. N., A. R. Townsend, J. W. Erisman, M. Bekunda, Z. Cai, J. R. Freney, L. A. Martinelli, S. P. Seitzinger, and M. A. Sutton. 2008. Transformation of the nitrogen cycle: recent trends, questions, and potential solutions. Science 320:889-897. • Gruber, N. and J.N Galloway. 2008. An Earth-system perspective of the global nitrogen cycle. Nature 451(17): 293-296. • Lobell, D. B., W. Schlenker, and J. Costa-Roberts. 2011. Climate trends and global crop production since 1980. Science 333:616-620. • Hatfield, J. L., K. J. Boote, B. Kimball, L. Ziska, R. C. Izaurralde, D. Ort, A. M. Thomson, and D. Wolfe. 2011. Climate impacts on agriculture: implications for crop production. Agronomy Journal 103:351-370. • Galloway, J. N., J. D. Aber, J. W. Erisman, S. P. Seitzinger, R. W. Howarth, E. B. Cowling, and B. J. Cosby. 2003. The nitrogen cascade. BioScience 53:341-356.
UNIT II: BASIC ECOLOGICAL PROCESSES AND PRINCIPLES		
4	January 25	Key soil science concepts/ soil organic matter • **Magdoff, F. and H. van Es. 2000. *Building Soils for Better Crops*. SARE. Chapters 2, 3, 4 and 6.** • **Robertson, G.P., and E.A. Paul. 2000. Decomposition and soil organic matter dynamics. In: E.S. Osvaldo, R.B. Jackson, H.A. Mooney, and R. Howarth, eds. Methods in Ecosystem Science. Springer Verlag, New York, New York, USA. *Pages 104-106.*** • Wander, M. 2004. Chapter 3: Soil organic matter fractions and their relevance to soil function. *Pages 67-78*. • Marriott, E. E., and M. M. Wander. 2006. Total and labile soil organic matter in organic and conventional farming systems. *Soil Science Society of America Journal* 70:950-959. • Schmidt, M.W., Torn, M.S., Abiven, S., Dittmar, T., Guggenberger, G., Janssens, I.A., Kleber, M., Kogel-Knabner, I., Lehmann, J., Manning, D.A., Nannipieri, P., Rasse, D.P., Weiner, S., Trumbore, S.E., 2011. Persistence of soil organic matter as an ecosystem property. Nature 478, 49-56. • Cotrufo, M.F., Ranalli, M.G., Haddix, M.L., Six, J., Lugato, E., 2019. Soil carbon storage informed by particulate and mineral-associated organic matter. Nature Geoscience 12, 989-994.
	January 27	Soil microbial ecology and the rhizosphere- *Kent Connell* • **Gewin, V. 2006. Discovery in the dirt. Nature 439: 384-386.** • **Handelsman, J. 2015. Why soil rocks.** • **McNear Jr., D.H. 2013. The rhizosphere—roots, soil, and everything in between. Nature Education Knowledge 4(3):1.** • Paterson, E. 2003. Importance of rhizodeposition in the coupling of plant and microbial productivity. *European Journal of Soil Science* 54:741-750. • Drinkwater, L.E. and S.S. Snapp. 2007. Understanding and managing the rhizosphere in agroecosystems. • Jones, D.L., Nguyen, C. and R.D. Finlay. 2009. Carbon flow in the rhizosphere: carbon trading at the soil-root interface. *Plant Soil* 321:5-33.
5	February 1	Functional ecology- *Etienne Herrick* • **Wood, S. A., D. S. Karp, F. DeClerck, C. Kremen, S. Naeem, and C. A. Palm. 2015.**

		Functional traits in agriculture: agrobiodiversity and ecosystem services. Trends in Ecology & Evolution 30:531-539. • Martin, A.R., Isaac, M.E., 2015. Plant functional traits in agroecosystems: a blueprint for research. J. Appl. Ecol. 52, 1425-1435. • Isbell, F., P. R. Adler, N. Eisenhauer, D. Fornara, K. Kimmel, C. Kremen, D. K. Letourneau, M. Liebman, H. W. Polley, and S. Quijas. 2017. Benefits of increasing plant diversity in sustainable agroecosystems. Journal of Ecology 105:871-879. • Blesh J. 2018. Functional traits in cover crop mixtures: biological nitrogen fixation and multifunctionality. Journal of Applied Ecology 55:38-48. • Tamburini G, Bommarco R, Wanger TC, Kremen C, van der Heijden MG, Liebman M, Hallin S. 2020. Agricultural diversification promotes multiple ecosystem services without compromising yield. Science Advances 6: eaba1715. • Damour, G., Navas, M. L., & Garnier, E. 2018. A revised trait-based framework for agroecosystems including decision rules. *Journal of Applied Ecology*, *55*(1), 12-24. • Isaac, M. E., Cerda, R., Rapidel, B., Martin, A. R., Dickinson, A. K., & Sibelet, N. 2018. Farmer perception and utilization of leaf functional traits in managing agroecosystems. *Journal of Applied Ecology*, *55*(1), 69-80.
	February 3	Soil C, N, and P cycles • **Drinkwater, L. E. et al. 2008. Ecologically-based nutrient management. *In:* Agricultural Systems: Agroecology and Rural Innovation for Development. Snapp, S. and B. Pound, Eds. *Pages 161-168*.** • Brady and Weil. Chapter 12: Nitrogen and Sulfur Economy. In: *The Nature and Properties of Soils*.
6	February 8	The N cycle and biological N fixation • **Robertson, G.P. and P.M. Groffman. 2007. Nitrogen Transformations. Pages 341-364 in E.A. Paul, ed. *Soil Microbiology, Biochemistry, and Ecology*. Springer, NY.** • Van Deynze, A. et al. 2018. Nitrogen fixation in a landrace of maize is supported by a mucilage-associated diazotrophic microbiota. *PLOS Biology* 16:e2006352.
	February 10	The P cycle and organic management • **Brady and Weil. Chapter 14: Soil Phosphorus and Potassium. In: *The Nature and Properties of Soils*. *Pages 540-557*.** • Childers, D.L., J. Corman, M. Edwards, and J.J. Elser. 2011. Sustainability challenges of phosphorus and food: solutions from closing the human phosphorus cycle. BioScience 61:117-124. • Nelson, N.O., and R.R. Janke. 2007. Phosphorus sources and management in organic production systems. HortTechnology 17:442-454.
7	February 15	Issue discussion: Dead Zones • **Mitsch et al. 2001. Reducing nitrogen loading to the Gulf of Mexico from the Mississippi River Basin: Strategies to counter a persistent ecological problem. BioScience 51(5).** • **Smith, D. R., K. W. King, and M. R. Williams. 2015. What is causing the harmful algal blooms in Lake Erie? Journal of Soil and Water Conservation 70:27A-29A.** • Sharpley, A.N., R.W. McDowell, and P.J.A. Kleinman. 2001. Phosphorus loss from land to water: integrating agricultural and environmental management. Plant and Soil 237: 287-207. • David, M.B., Drinkwater, L. E. and G.F. McIsaac. 2010. Sources of nitrate yields in the Mississippi River Basin. Journal of Environmental Quality 39:1657-1667.

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<tr><td></td><td></td><td>Diaz, R.J. and R. Rosenberg. 2008. Spreading dead zones and consequences for marine ecosystems. Science 321:926-929.</td></tr>
<tr><td colspan="3">UNIT III: AGROECOLOGICAL MANAGEMENT PRACTICES</td></tr>
<tr><td>7</td><td>February 17</td><td>Ecologically-based management systems I: Cover crops
SARE. 2012. Managing Cover Crops Profitably, Third Edition. SARE Handbook 9. <u>Read pages 9-24</u> (starting with “Benefits of cover crops”). Optional reading: pages 34-43.
Blesh, J., 2019. Feedbacks between nitrogen fixation and soil organic matter increase ecosystem functions in diversified agroecosystems. Ecological Applications 29, e01986.
Kaye, J. P., and M. Quemada. 2017. Using cover crops to mitigate and adapt to climate change. A review. Agronomy for Sustainable Development 37:4.
Bressler, A., Plumhoff, M., Hoey, L., and J. Blesh. 2021. Cover Crop Champions: Linking strategic communication approaches with farmer networks to support cover crop adoption. Society and Natural Resources. doi: 10.1080/08941920.2021.1980165</td></tr>
<tr><td>8</td><td>February 22</td><td>Ecologically-based management systems II: Intercropping – Etienne Herrick
Brooker, R.W., Bennett, A.E., Cong, W.F., Daniell, T.J., George, T.S., Hallett, P.D., Hawes, C., Iannetta, P.P., Jones, H.G., Karley, A.J., 2015. Improving intercropping: a synthesis of research in agronomy, plant physiology and ecology. New Phytol. 206, 107-117.
Snapp, S.S., D.D. Rohrbach, F. Simtowe, and H.A. Freeman. 2002. Sustainable soil management options for Malawi: can smallholder farmers grow more legumes? Agriculture, Ecosystems and Environment 91:159-174.
Snapp, S.S. et al. 2003. Pigeon Pea for Africa: A Versatile Vegetable – And More. HortScience 38:1073-1079.
Hassanali, A., H. Herren, Z. R. Khan, J. A. Pickett, and C. M. Woodcock. 2008. Integrated pest management: the push-pull approach for controlling insect pests and weeds of cereals, and its potential for other agricultural systems including animal husbandry. Philos Trans R Soc Lond B Biol Sci 363:611-621.
Li, L. et al. 1999. Interspecific complementary and competitive interactions between intercropped maize and faba bean. Plant and Soil 212:105-114.</td></tr>
<tr><td></td><td>February 24</td><td>Ecologically-based management systems III: Soil management in urban agroecosystems
Witzling, L., M. Wander, and E. Phillips. 2011. Testing and educating on urban soil lead: A case of Chicago community gardens. Journal of Agriculture, Food Systems, and Community Development 1:167-185.
Cornell Waste Management Institute. Soil Contaminants and Best Practices for Healthy Gardens. Pages 1-3
Cornell Waste Management Institute. Sources and Impacts of Contaminants in Soils. Pages 1-5.
Brown, S. 2009. A Primer: Urban Soil Contaminants and Remediation. BioCycle (second half of the Brownfields to Green Gardens PDF; 4 pages)
Gregory, M.M., T.W. Leslie, and L.E. Drinkwater. 2015. Agroecological and social characteristics of New York City community gardens: Contributions to urban food security, ecosystem services, and environmental education. Urban Ecosystems.
Cornell Waste Management Institute. Guide to Soil Testing and Interpreting Results. Pages 1-5.
McClintock, N. 2012. Assessing soil lead contamination at multiple scales in Oakland, California: Implications for urban agriculture and environmental justice. Applied</td></tr>
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		Geography 35:460-47.
9	March 1	**BREAK: NO CLASSES**
	March 3	**BREAK: NO CLASSES**
10	March 8	Ecologically-based management systems IV: *Guest lecture by Jeremy Moghtader, UM Campus Farm* • **Badgley, C., J. Moghtader, E. Quintero, E. Zakem, M. J. Chappell, K. Avilés-Vázquez, A. Samulon, and I. Perfecto. 2007. Organic agriculture and the global food supply. Renewable Agriculture and Food Systems 22:86-108.**
	March 10	Ecologically-based management systems V: livestock/grazing, manure and compost management • **Magdoff, F. and H. van Es. 2000. *Building Soils for Better Crops*. SARE. Chapter 12** • Russelle, M.P., Entz, M.H., and A.J. Franzluebbers. 2007. Reconsidering integrated crop-livestock systems in North America. Agronomy Journal 99:325-334. • Rowntree, J.E., Stanley, P.L., Maciel, I.C., Thorbecke, M., Rosenzweig, S.T., Hancock, D.W., Guzman, A., Raven, M.R., 2020. Ecosystem Impacts and Productive Capacity of a Multi-Species Pastured Livestock System. Frontiers in Sustainable Food Systems 4, 232. • Ryals, R., Hartman, M.D., Parton, W.J., DeLonge, M.S., Silver, W.L., 2015. Long-term climate change mitigation potential with organic matter management on grasslands. Ecol. Appl. 25, 531-545.
	March 12	SATURDAY SESSION: Farmer education tools—nutrient balances and the Andean nutrient management game and discussion; participatory extension • **Vanek and Drinkwater, 2013. Environmental, social, and management drivers of soil nutrient mass balances in an extensive Andean cropping system. Ecosystems 16:1517-1535.** • Van den Berg, H. and J. Jiggins. 2007. Investing in Farmers—The impacts of farmer field schools in relation to integrated pest management. World Development **35**:663-686.
11	March 15	Ecologically-based management systems VI: Comparing organic, conventional, and low-input systems; diversified farming systems and resilience • **Robertson, G., K. Gross, S. Hamilton, D. Landis, T. Schmidt, S. Snapp, and S. Swinton. 2014. Farming for ecosystem services: An ecological approach to production agriculture. BioScience: biu037.** • Pimentel, D., P. Hepperly, J. Hanson, D. Douds, and R. Seidel. 2005. Environmental, energetic, and economic comparisons of organic and conventional farming systems. BioScience 55:573-582. • Liebman, M., M. J. Helmers, L. A. Schulte, and C. A. Chase. 2013. Using biodiversity to link agricultural productivity with environmental quality: Results from three field experiments in Iowa. Renewable Agriculture and Food Systems 28:115-128. • Clark, M. S., W. R. Horwath, C. Shennan, and K. M. Scow. 1998. Changes in soil chemical properties resulting from organic and low-input farming practices. Agronomy Journal **90**:662-671. • Kremen, C., Iles, A., Bacon, C., 2012. Diversified farming systems: an agroecological, systems-based alternative to modern industrial agriculture. Ecol. Soc. 17. • Bowles, T.M., Mooshammer, M., Socolar, Y., Calderón, F., Cavigelli, M.A., Culman, S.W., Deen, W., Drury, C.F., y Garcia, A.G., Gaudin, A.C., 2020. Long-term evidence shows that crop-rotation diversification increases agricultural resilience to adverse growing conditions in North America. One Earth 2, 284-293.

	March 17	Ecologically-based management systems VII: Soil quality and soil health- *Guest lecture by Brendan O'Neill, SEAS* • **O'Neill, B., Sprunger, C.D., Robertson, G.P., 2021. Do soil health tests match farmer experience? Assessing biological, physical, and chemical indicators in the Upper Midwest United States. Soil Sci. Soc. Am. J. 85, 903-918.** • **Read through the NRCS Soil Health Awareness website: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/** • Wander, M.M., Cihacek, L., Coyne, M., Drijber, R., Grossman, J., Gutknecht, J.L., Horwath, W., Jagadamma, S., Olk, D., Snapp, S., 2019. Developments in Agricultural Soil Quality and Health: Reflections by the Research Committee on Soil Organic Matter Management. Frontiers in Environmental Science 7, 109. • Janzen, H.H., Janzen, D.W., Gregorich, E.G., 2021. The 'soil health'metaphor: Illuminating or illusory? Soil Biol. Biochem. 159, 108167. • Zimnicki, T., Boring, T., Evenson, G., Kalcic, M., Karlen, D.L., Wilson, R.S., Zhang, Y., Blesh, J., 2020. On Quantifying Water Quality Benefits of Healthy Soils. Bioscience.
UNIT IV: SYNTHESIS- POLICY, MANAGEMENT, AND SUSTAINABILITY		
12	March 22	Discussion of farmer interviews
	March 24	Role of the US Farm Bill • **Imhoff, D. 2012. Food Fight: The Citizen's Guide to the Next Food and Farm Bill. *Read Chapters 3-4; 8; and 11*.** • **Barnett, B. J. 2014. The last farm bill? Journal of Agricultural and Applied Economics 46: 311-319.**
13	March 29	US Farm Bill (continued) and other policy trends • **NSAC 2018. Farm Bill Blog Posts at http://sustainableagriculture.net/category/farm-bill/. Posts of particular interest: Commodity Programs and Crop Insurance; 2018 Farm Bill by the Numbers; Working Lands Conservation Programs; and Organic Agriculture (http://sustainableagriculture.net/blog/2018-farm-bill-drilldown-organic-ag/)** • NSAC, 2014. 2014 Farm Bill Drill Down: Conservation – Crop Insurance Linkages. http://sustainableagriculture.net/blog/2014-farmbill-hel-wetlands/ • Batie, S. S. 2009. Green payments and the US Farm Bill: information and policy challenges. *Frontiers in Ecology and the Environment* 7:380-388. • Kremen, C. and A.M. Merenlender. 2018. Landscapes that work for biodiversity and people. *Science* 362 (304).
13	March 31	Student presentations
14	April 5	Student presentations
14	April 7	Student presentations
15	April 12	Policy issue discussion: Agriculture and C sequestration- Kent Connell • **Eagle, A., L. Olander, L.R. Henry, K. Haugen-Kozyra, N. Millar, and G.P. Robertson. 2012. *Greenhouse Gas Mitigation Potential of Agricultural Land Management in the United States: A Synthesis of the Literature*. Report NI R 10-04, Third Edition. Durham, NC: Nicholas Institute for Environmental Policy Solutions, Duke University. *Read Pages 1-23 (through "Apply Biochar to Cropland" section)*** • **Gurwick, N.P. Can Organic Agricultural Practices Mitigate Climate Change? *Read Executive Summary, Pages 1-5.*** • **Lehmann, J. 2007. A handful of carbon. Nature 447:143-144.** • **VandenBygaart, A. 2016. The myth that no-till can mitigate global climate change. Agriculture, Ecosystems & Environment 216:98-99.**

		• Hristov, A. N., et al. (2018). *Chapter 5: Agriculture. Second State of the Carbon Cycle Report*. U.S. Global Change Research Program. https://doi.org/10.7930/SOCCR2.2018.Ch5 • Bradford, M. A., Carey, C. J., Atwood, L., Bossio, D., Fenichel, E. P., Gennet, S., Fargione, J., Fisher, J. R. B., Fuller, E., Kane, D. A., Lehmann, J., Oldfield, E. E., Ordway, E. M., Rudek, J., Sanderman, J., & Wood, S. A. (2019). Soil carbon science for policy and practice. Nature Sustainability, 2(12), 1070–1072. https://doi.org/10.1038/s41893-019-0431-y
	April 14	Individual/group workday- optional on-farm sampling for extra credit
16	April 19	Individual/group workday – optional on-farm sampling for extra credit