ADVANCED LANDSCAPE ECOLOGY

Zoology/Forest&Wildlife Ecology/Botany 879

Course Description, Spring Semester 2022

Version: 14 January 2022

Instructor: Prof. Monica G. Turner, Department of Integrative Biology (turnermg@wisc.edu)
Credits: 3 credits
Time & place: Tuesdays and Thursdays, 9:55 – 11:50 am, 158 Birge Hall
(The room is off the main lobby, go down the hall to the left (east) as you enter from the main doors; the classroom will be straight ahead at the end of that hallway).
Instruction mode: Face-to-face

Requisites:

- Graduate student status
- General Ecology (e.g., Zoo/Bot/For 460 or equivalent) ***is required***.
- Basic familiarity with landscape ecology ***is required***.
- Familiarity with statistics is strongly recommended, and some knowledge of geographic information systems (GIS) and simulation modeling is desirable.

COURSE DESCRIPTION:
Landscape ecology is a sub-discipline of ecology that emphasizes spatial patterning–its causes, development, and importance for ecological processes. Furthermore, landscape ecology often (but not always) focuses on ecological dynamics over large regions. The field has grown tremendously and matured over the past 30+ years. Students will delve into current concepts, methods, and applications of landscape ecology through (1) class lectures; (2) reading and discussion of literature reflecting state-of-the-art research in the field; (3) completion of hands-on exercises designed to provide experience with some of the quantitative tools of landscape ecology; and (4) completion of an independent research project that allows students to apply these concepts and tools in their own studies.

The Advanced Landscape Ecology course emphasizes the current state-of-the-science of landscape ecology and covers common quantitative methods used in landscape ecology; ***it is recommended for advanced graduate students who are conducting research in this area and not for students who seek an introduction or general overview of the field. Basic knowledge of landscape ecology is assumed for Advanced Landscape Ecology. Students who have no background in landscape ecology should read the Turner & Gardner (2015) text before the semester begins.***

COURSE LEARNING OUTCOMES: Ecology graduate students will:

- Read and synthesize current scientific literature in landscape ecology
- Understand the current state-of-the-science in the major research areas of landscape ecology
- Use and interpret quantitative methods used to analyze and interpret spatial heterogeneity in ecology
- Learn how to calculate commonly used metrics and know their appropriate use
- Implement simple models of landscape change
- Apply landscape ecology concepts and methods to their thesis research
- Practice key professional research skills, including proposal development, research implementation, and communicating results in written and verbal modes
- Actively promote diversity, equity, and inclusion of all at UW-Madison

OFFICE HOURS: Office hours are by appointment. Please email me to schedule a time.

HOW ARE CREDIT HOURS MET BY THE COURSE? Learning will take place in at least 135 hours of learning activities, including time spent in class meetings (lecture, discussion, and lab); reading; writing; preparing for class; completing an independent research project related to their thesis work; and any other activities as described in the syllabus or assigned during the semester.

TEXTS (both are posted in Canvas):

Turner, M. G., and R. H Gardner. 2015. LANDSCAPE ECOLOGY IN THEORY AND PRACTICE, 2nd edition. Springer, New York. (Foundation material and used for quantitative chapters).

Gergel, S. E. and M. G. Turner, editors. 2016. LEARNING LANDSCAPE ECOLOGY, 2nd edition. Springer-Verlag, New York. (Needed for lab, available as an e-book through the library).

CLASS SIZE: Admission limited to 20 students.

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COURSE STRUCTURE:

Class meetings will generally include either a lecture followed by student-led discussion of assigned readings, or hands-on computational exercises designed to introduce students to the quantitative methods used in landscape ecology. ***<u>Important</u>: UW-Madison no longer makes computer labs available for classes without a hefty hourly fee. Students must bring a laptop to class on lab days. Ideally, Mac computers should also be configured to run Windows programs, as some programs are written only for PCs.*** Students should be able to sign out a computer from the library if needed. Lastly, we reserve classes for oral presentations of the independent projects at the end of the semester (those are always fun!)

ABSENCE POLICY:

Attendance is recorded at each class meeting. If you have an <u>anticipated</u> absence (e.g., planned conference travel or necessary field work), please let me know before the class that you will miss. If you are <u>unexpectedly</u> absent (e.g., illness), please inform me at your earliest convenience and let me know what happened.

For lecture/discussion classes that are missed, students are responsible for the material that was covered in class and for completing the readings. A summary of the assigned readings (one single-spaced page maximum for each assigned paper) should be submitted <u>no later than one week after the missed class</u>. The summary should include a brief statement of what was covered in the paper, your thoughts on the primary contribution(s) of the paper, any insights that were new for you, and questions that were raised in your mind by the paper. I want <u>your</u> thoughts about the readings, not a repetition of what the authors wrote.

For labs that are missed, students must complete the lab exercise and turn in the report. Depending on the timing of the due dates and the travel/illness, the deadline <u>may</u> be extended. Students should check with me and confirm arrangements.

READING ASSIGNMENTS:
The 2nd edition of LANDSCAPE ECOLOGY IN THEORY AND PRACTICE (Turner and Gardner 2015) will be used as reference for the class. It is posted in Canvas. You will especially need to read or review the quantitative chapters. ***Students are expected to be familiar with the text material, as it is the foundation for understanding the recent primary literature.***

This course emphasizes readings from the recent primary literature, with 4 papers assigned each week for discussion. ***Every student is expected to have read the assignments before class and be prepared to discuss the papers; responses to prompts will be posted to the Discussion Board in Canvas, or there will be occasional short reading quizzes.*** Responsibility for leading discussion will be rotated among all students. Discussion leaders should raise questions or issues to be discussed; be prepared with an evaluation of the significant contributions of the paper; and facilitate discussion among the group (see notes below). Readings from the primary literature will be on Box and accessible through Canvas or the direct link; of course, readings can also be accessed individually through the electronic collections of the library. I have numbered them by week so that it is easy to locate the grouping of papers for each class. The folder can be downloaded so you have them locally: https://uwmadison.box.com/s/w0ck1eyd1s7x7ttuyf2vrb1fhy0o1svz

Two additional useful references include an edited volume with foundational papers and background (c.f. editors' introductions to each section of the book) and a new text that is especially strong on organisms and conservation, which is Kim's primary expertise. Both are available through the library; these are not in Canvas.

Wiens, J. A., M. R. Moss, M. G. Turner and D. J. Mladenoff, editors. 2007. FOUNDATION PAPERS IN LANDSCAPE ECOLOGY. Columbia University Press, New York.
With, K. A. 2019. ESSENTIALS OF LANDSCAPE ECOLOGY. Oxford University Press.

LEADING DISCUSSION:
Each student will have the opportunity to lead the class discussion of assigned weekly readings. All students will have read the papers prior to class, so discussion leader(s) should **not** provide a detailed review of the paper. The discussion leader(s) should provide a brief summary of the main topic of the paper, just to remind everyone of which paper is being considered. Here are some tips for being effective at leading discussion.

i. Summarize for yourself some of the important points about the paper. It's often useful to have a set of questions that you answer while planning discussion. For example, consider the following: What is the main conceptual contribution of the paper? Why might it be important or influential? Is it a representative example? Does it propose a new direction or idea? How does this paper relate to other papers or general concepts with which you are familiar? Are there any new approaches represented? Are there any problems with the study? How does this reflect the current state of the science?

ii. Prepare in advance some open-ended questions that you can pose to the group to get the discussion going. Remember that questions with a "yes" or "no" answer do not facilitate a discussion! Feel free to call on people if there is silence!

iii. Keep the discussion moving by including all members of the group (this means calling on reticent members of the group and gently redirecting away from individuals who may dominate the conversation) and by curtailing discussion that goes off into tangents or dead ends.

iv. Try to summarize and synthesize as things go along. It's often helpful to use a mechanism like, "So far, we've identified the following main contributions of this paper: ….

v. Be careful not to dominate the discussion. You are a facilitator, and it is harder to do this well than you might expect. You can allow some silence. Encourage discussion by asking question of the group, not by making pronouncements.

vi. You are welcome to come up with activities, or try out some new discussion techniques on us. We make good guinea pigs. Be creative, use your imagination!

PARTICIPATING IN DISCUSSION:
Discussions are only effective for all when everyone is prepared and has perspectives to contribute. ***Everyone is expected to have read the assignment before class and given thought to the paper's content and context.*** A good strategy for being prepared is to write down a couple of questions or observations about each paper as you are reading it. Notating ideas on your hard copy or digital file is also helpful. This class benefits tremendously from the diverse interests and backgrounds of the students, and we all learn a lot by listening to one another.

Note: I ask all participants to ***minimize use of the word "like"*** unless it is appropriately used for a simile. Use of "like" has increased widely throughout society, and it has easily surpassed prior habits of speech such as "um" or "anyways". We all have the "like" habit to some degree, but now is the time in your professional development to vanquish it!

COFFEE AND SNACKS (suspended this year due to COVID):
We have a long tradition (over 20 years!) in this class of Monica providing coffee and all of us taking turns to bring snacks for the break between lecture and discussion. Alas, given the ongoing pandemic and continued need to be masked during class, no food or beverages will be permitted.

COVID SAFETY:
All campus protocols to ensure COVID safety will be followed in this class. Guidance continues to evolve with the pandemic, and current guidelines can be found at: https://covidresponse.wisc.edu/

LABORATORY EXERCISES:
A set of hands-on exercises will be assigned to provide students with experience in various aspects of landscape ecology, particularly the quantitative analyses and modeling often used in landscape ecology. Labs will take place during Friday class periods (see syllabus for dates). Concise written reports will be turned in for each exercise the following week. Lab exercises will be from the 2nd edition of LEARNING LANDSCAPE ECOLOGY.

Make sure ***always to read the lab exercise prior to coming to the class session***. You will not usually complete the lab during the time period, but you'll get going on it. Write-ups must be short—your gain comes from doing the lab and thinking about it, and I try hard to minimize the busy work (although there is still some). Unless you are told otherwise, my rule of thumb is ~2 pages of prose (typed, single space, but excluding figures, tables and references), or ~4 pages of prose when a lab is done in two parts over two weeks. Write-ups are due the following week after the lab was completed. Instructions particular for each lab will be given in class.

INDEPENDENT PROJECTS:

Project Objectives: Students will use landscape-level theory or approaches in an area of particular interest to them, thereby allowing them to apply what they are learning to their own research. The project should be an opportunity for students to augment their research (e.g., thesis or dissertation work). Students will also gain experience with the primary phases of conducting a research study: preparation of a proposal; execution of the study; preparation of a paper based on the study; and oral presentation of the results in the format suitable for a scientific meeting. All graduate students should have as many opportunities to "practice" all aspects of professional science as much as possible!

Topics: Recognizing that there is likely a wide array of interests represented in the class, the choice of topic for the project is not restricted. However, approval of a student's selection is required. Samples of projects might be: (1) analyses of spatial pattern of vegetation or land use in a study landscape; (2) synthesis of literature on how an organism responds to changes in habitat heterogeneity, with development of field-testable hypotheses, recommendations for conservation, or reserve design; (3) development of a model to address an interaction between pattern and process; (4) preparation of a management plan for a large heterogeneous landscape.

Format for Project Proposals: Proposals must be typewritten, double spaced with one-inch margins and 12-pt type with a **2-page maximum length,** excluding references. The following should be clear and succinct: Introduction/Background; Question(s); Methods; and Expected Results.

Format for Project Reports: Reports must be double-spaced with one-inch margins, and will be due during finals week. Projects should **not exceed 10 pages** of main-body text excluding the cover sheet, abstract,

acknowledgements, references, figures, and tables. The format should ***exactly*** follow that required for submission to the journal LANDSCAPE ECOLOGY, which is available on the journal's website. Pay careful attention to ALL details in the instructions to authors (which you must do any time you submit your own manuscript for publication.) And, don't forget to proof read your references for completeness, typos and format; use of bibliographic software does not eliminate the obligation to proof read and correct.

Inspire Session: Instead of full-length presentations, we will go with lightning talks for each independent project following the guidelines for Inspire Sessions (formerly called Ignite Sessions) at the annual meeting of the Ecological Society of America. Don't let the short format fool you, however; these take quite a bit of work to prepare! Details will be forthcoming, but each talk is limited to 20 slides, which advance automatically every 15 seconds. Inspire talks pose an interesting challenge in scientific communication, as they require speakers to have winnowed down to key points, work on timing, and add some entertainment value. While we always practice our talks in advance, these short ones require a surprising amount of practice and honed delivery and timing.

DUE DATES: See course syllabus for all due dates.

GRADING:
Grades will be based on the laboratory exercises (40%), class participation (10%), leading discussion (10%), and the final project (40% total: oral presentation 10%, written report 30%). Numerical grades will be assigned to letter grades as follows: 93-100 (A), 90-92 (AB), 83-89 (B), 80-82 (BC).

COURSE EVALUATIONS:
Students will be provided with an opportunity to evaluate this graduate seminar and your learning experience. Please complete the university's general course evaluation when you are notified that it is available. Your feedback is important!

DIVERSITY & INCLUSION STATEMENT:
Diversity is a source of strength, creativity, and innovation for UW-Madison. In this course and across the campus, we value the contributions of each person and respect the profound ways their identity, culture, background, experience, status, abilities, and opinion enrich the university community. We commit ourselves to the pursuit of excellence in teaching, research, outreach, and diversity as inextricably linked goals.

The University of Wisconsin-Madison fulfills its public mission by creating a welcoming and inclusive community for people from every background – people who as students, faculty, and staff serve Wisconsin and the world.

ACADEMIC INTEGRITY:
By virtue of enrollment, each student agrees to uphold the high academic standards of the University of Wisconsin-Madison; academic misconduct is behavior that negatively impacts the integrity of the institution. Cheating, fabrication, plagiarism, unauthorized collaboration, and helping others commit these previously listed acts are examples of misconduct which may result in disciplinary action. Examples of disciplinary action include, but is not limited to, failure on the assignment/course, written reprimand, disciplinary probation, suspension, or expulsion.

ACCOMODATION FOR STUDENTS WITH DISABILITIES:
The University of Wisconsin-Madison supports the right of all enrolled students to a full and equal educational opportunity. The Americans with Disabilities Act (ADA), Wisconsin State Statute (36.12), and UW-Madison policy (Faculty Document 1071) require that students with disabilities be reasonably accommodated in instruction and campus life. Reasonable accommodations for students with disabilities is a shared faculty and student responsibility. Students are expected to inform faculty [me] of their need for instructional accommodations by the end of the third week of the semester, or as soon as possible after a disability has been incurred or recognized. Faculty [I], will work either directly with the student [you] or in coordination with the McBurney Center to identify and provide reasonable instructional accommodations. Disability information, including instructional accommodations as part of a student's educational record, is confidential and protected under FERPA. (See: McBurney Disability Resource Center)

ADVANCED LANDSCAPE ECOLOGY

Texts

[1]Turner, M. G. and R. H. Gardner. 2015. LANDSCAPE ECOLOGY IN THEORY AND PRACTICE, 2nd edition. Springer-Verlag, New York.

[2]Gergel, S. E. and M. G. Turner, editors. 2016. LEARNING LANDSCAPE ECOLOGY, 2nd edition. Springer-Verlag, New York. *[Required for labs.]*

Dates	Topics, [2]Labs (blue), Due dates (red)	[1]Text chap.	Discussion readings or Lab
Tues Jan 25	Course overview and logistics	--	--
Thurs Jan 27	**(1) Contemporary landscape ecology**	1	Lawler et al. 2015 Pulsford et al. 2016 Swanborn et al. 2021
Tues Feb 1	**(2) Causes of landscape pattern**	2	Phillips 2007 Tappeiner et al. 2021 Monsted and Matlack 2021 Brudvig et al. 2021
Thurs Feb 2	Lab #1 *Introduction to Markov models*	--	LLE Chap. 8, Urban and Wallin
Tues Feb 8	**(3) Quantifying pattern I:** why, data and errors, caveats; start metrics	4	Frazier and Kedron 2017 Gustafson 2019 Cushman et al. 2008 Riva and Nielsen 2020
Thurs Feb 10	Lab #2, *Understanding landscape metrics, part 1 (hand calculations)* *Lab #1 write up due.*	--	LLE Chap. 4, Cardille & Turner
Tues Feb 15	**(4) Quantifying pattern II:** metrics and interpretation, using multiple metrics	4	Eigenbrod et al. 2011 Morand et al. 2019 Hesselbarth et al. 2019 Lepczyk et al. 2021
Thurs Feb 17	Lab #2, *Understanding landscape metrics, part 2 (Fragstats or R)* *Independent project proposals due.*	--	LLE Chap. 4, Cardille & Turner [Also: Hesselbarth et al. 2019, R]
Tues Feb 22	**(5) Spatial statistics:** what, why and how	5	Vasquez et al. 2012 Anderson et al. 2013 Schregel et al. 2018 Roy et al. 2020
Thurs Feb 24	Lab #3, *Scale detection using semivariograms and autocorrelograms* *Lab #2 write up due.*	--	LLE Chap. 5, Palmer & McGlinn
Tues Mar 1	**(6) Landscape models:** neutral landscape models, spatial models	3	Duane et al. 2021 Albrich et al. 2020 Olson et al. 2021 Thompson et al. 2020

Thurs Mar 3	Lab #4, *Neutral landscape models* *Lab #3 write up due.*	--	LLE Chap. 6, Gardner
Tues Mar 8	**(7) Disturbance and landscapes I:** reciprocal pattern-process, thresholds, interactions	6	Sommerfeld et al. 2018 Meddens et al. 2018 Uhrin and Turner 2018 Leitold et al. 2021
Thurs Mar 10	Lab #5, *Disturbance and landscape structure, part 1* *Lab #4 write up due.*	--	LLE Chap. 11, Turner & Simard
Mar 15-Mar 17	**Spring Break – No classes!**	**--**	**--**
Tues Mar 22	**(8) Disturbance and landscapes II:** compound disturbances, novel regimes, resilience	6	Cannon et al. 2019 Sommerfeld et al. 2021 Coop et al. 2020 Schoennagel et al. 2017
Thurs Mar 24	Lab #5, *Disturbance and landscape structure, part 2*	--	LLE Chap. 11, Turner & Simard
Tues Mar 29	**(9) Organisms and landscapes I:** reciprocal interactions; habitat amount vs. configuration	7	Fletcher et al. 2018 Fahrig et al. 2019 Fahrig 2019 Rios et al. 2021
Thurs Mar 31	Lab #6, *Landscape connectivity and network analysis* *Lab #5 write up due.*	--	LLE Chap. 12, Lookingbill & Minor
Tues Apr 5	**(10) Organisms and landscapes II:** species interactions, landscape connectivity	7	Diniz et al. 2020 Barnett and Belote 2021 Klinga et al. 2019 Kimberly et al. 2021
Thurs Apr 7	Lab #7, *Advances in quantifying landscape connectivity, Part 1* *Lab #6 write up due.*	--	LLE Chap. 14, Saura & de la Fuente
Tues Apr 12	**(11) Ecosystem processes in heterogeneous landscapes**	8	Asplund et al. 2021 Reinmann et al. 2020 Monk and Schmitz 2021 Gonzalez et al. 2020
Thurs Apr 14	*Lab #7, Advances in quantifying landscape connectivity, Part 2*	9	LLE Chap. 14, Saura & de la Fuente
Tues Apr 19	**(12) Ecosystem services**	10	Kremen and Merenlander 2018 Schulte et al. 2017 Palliwoda et al. 2020 Rieb and Bennett 2020
Thurs Apr 21	*Activity – Future directions* *Lab #7 write up due.*	--	--
Tues Apr 26	**(13) Landscape conservation in a changing world**	--	Belote et al. 2021 Hebblewhite et al. 2021 Arroyo-Rodriguez et al. 2020 Tscharntke et al. 2021
Thurs Apr 28	*No class meeting – work/prep day*	--	--
Tues May 3	**Ignite Session** (student presentations)		

Thurs May 5	**Ignite Session** (student presentations)		
Mon May 9	*Final written project report due to MGT by 12:00 noon CDT in hard copy.*	--	Deliver to 430/432 Birge Hall; include self-addressed campus mail envelope if you can't pick up.

ADVANCED LANDSCAPE ECOLOGY (879)
Readings, Spring 2022

(1) Thursday, January 27 – Contemporary landscape ecology

Background:

Rose, K. C., R. A. Graves, W. D. Hansen, B. J. Harvey, J. Qiu, S. A. Wood, C. Ziter, and M. G. Turner. 2017, Historical foundations and future directions in macrosystems ecology. Ecology Letters 20:147-157. [*Macrosystems is a current buzz word, but it builds directly on foundational work in landscape ecology. What is different? What is the same? This paper also offers a brief refresher on scale concepts, which underpin much of landscape ecology.]*

For discussion–theme is roots and contemporary context of LE:

Lawler, J. J., D. D. Ackerly, C. M. Albano, M. G. Anderson, S. Z. Dobrowski, J. L. Gill, N. E. Heller, R. L. Pressey, E. W. Sanderson, and S. B. Weiss. 2015. The theory behind, and the challenges of, conserving nature's stage in a time of rapid change. Conservation Biology 29:618-629. [*Synthesis of multiple factors that drive species assemblages and are changing; addresses a shifting template, which requires a landscape perspective. Contemporary landscape ecology increasingly recognizes the role of changing drivers (e.g., climate warming).*]

Pulsford, S. A., D. B. Lindenmayer and D. A. Driscoll. 2017. Reptiles and frogs conform to multiple conceptual landscape models in an agricultural landscape. Diversity and Distributions 23:1408-1422. [*This paper references diverse concepts in landscape ecology, and so it offers good reminders of foundational work.*]

Swanborn, D. J. B., V. A. I. Huvene, S. J. Pittman, and L. C. Woodall. 2021. Bridging seascape ecology to the deep seabed: A review and framework for its application. Limnology and Oceanography 9999: 1-23. [*Nice review of LE methods and ideas in the context of the deep ocean; useful re-cap and a prompt to think about the generality of LE concepts.]*

(2) Tuesday, February 1 – Causes of landscape pattern

Background (highly recommended):

Jackson, S. T. 2006. Vegetation, environment and time: the origination and termination of ecosystems. Journal of Vegetation Science 17:547-557. [*Very well written essay. Good thinking on long-term change and links to paleoecology.*]

Ellis, E. C., et al. 2021. People have shaped most of terrestrial nature for at least 12,000 years. PNAS 118(17):e2023483118. *[Not landscape ecology per se, but an excellent overview of global land-use history; it's an important paper to be aware of.]*

For discussion—theme is contingency and the role of history:

Phillips, J. D. 2007. The perfect landscape. Geomorphology 84:159-169. [*Important though under-appreciated conceptual paper that makes the point that every landscape is unique, and many contingencies lead to the development of any particular landscape pattern.*]

Tappeiner, U., G. Leitinger, A. Zarina, and M. Bürgi. 2021. How to consider history in landscape ecology: patterns, processes and pathways. Landscape Ecology 36:2317-2328. *[Focuses on understanding legacy effects; complements Phillips (2007) in emphasizing path dependence.]*

Monsted, J., and G. R. Matlack. 2021. Shaping the second-growth forest: fine-scale land use change in the Ohio Valley over 120 years. Landscape Ecology 36:3507-3521. [*Regional example from Ohio finds land-use legacies shape contemporary forest communities.]*

Brudvig, L. A., et al. 2021. Large ecosystem-scale effects of restoration fail to mitigate impacts of land-use legacies in longleaf pine savannas. Proceedings of the National Academy of Sciences 118(17): e2020935118.. [*Evaluates 45 abiotic and biotic ecological properties affects by legacies of past farming in coastal plain long-leaf pine; even restoration can't always erase the past.*]

(3) Tuesday, February 8– Quantifying pattern I

Background (highly recommended):

Li, H., and J. F. Reynolds. 1995. On definition and quantification of heterogeneity. Oikos 73:280-284. *[Nice conceptual treatment of heterogeneity; foundational paper, good food for thought on what is being quantified, and one with which you should be familiar.]*

Li, H., and J. Wu. 2004. Use and misuse of landscape indices. Landscape Ecology 19:389-399. *[Synthesis of issues associated with quantifying landscape patterns, and you should be aware of all of these!]*

Simova, P., and K. Gdulova. 2012. Landscape indices behavior: A review of scale effects. Applied Geography 34:385-394. *[The tables in this paper are especially helpful summaries of how metrics change with scale; references also provide entrée into more European literature.]*

For discussion–theme is take-home lessons and appropriate application/use:

Frazier, A. E., and P. Kedron. 2017. Landscape metrics: past progress and future directions. Current Landscape Ecology Reports doi 10.1007/s40823-017-0026-0. *[Short paper that reviews development of landscape metrics, includes a nice example that illustrates effect of grain size and the long-time goal of having scaling rules.]*

Gustafson, E. J. 2019. How has state-of-the-art for quantification of landscape pattern advanced in the twenty-first century? Landscape Ecology 34:2065-2072. *[Nice overview/perspective on evolution of landscape pattern analysis since the Gustafson 1998 review in ECOSYSTEMS.]*

Cushman, S. A., K. McGarigal, and M. C. Neel. 2008. Parsimony in landscape metrics: strength, universality and consistency. Ecological Indicators 8:691-703. *[Addresses the correlations among metrics and unique contributions of different kinds.]*

Riva, F., and S. E. Nielsen. 2020. Six key steps for functional landscape analyses of habitat change. Landscape Ecology 35:1495-1504. [*This "rules of thumb" approach focuses on habitat change, but the issues of matching analyses to the question is a general point*.]

(4) Tuesday, February 15 – Quantifying pattern II

Background:

Kupfer, J. A. 2012. Landscape ecology and biogeography: Rethinking landscape metrics in a post-FRAGSTATS landscape. Progress in Physical Geography 36:400-420. [*Nice paper for synthesis points and discussion of metrics based on network theory, which we will get to in lab when considering organism movements*.]

For discussion–theme is application and advances with foundational + recent papers:

Eigenbrod, F., S. J. Hecnar and L. Fahrig. 2011. Sub-optimal study design has major impacts on landscape-scale inference. Biological Conservation 144:298-305. [*Lays out practical issues associated with using landscape metrics as predictors. Study design is always key!*]

Morand, S., K. Blasdell, F. Bordes, P. Buchy, B. Carcy, K. Chaisiri, Y. Chaval, J. Claude, J.. Cosson, M. Desquesnes, S. Jittapalapong, T. Jihipong, A. Karnchanabanthoen, P. Pornpan, J.-M. Rolain, and A. Tran. 2019. Changing landscapes of Southeast Asia and rodent-borne diseases: decreased diversity but increased transmission risks. Ecological Applications 29(4),e01886: 1-15. *[Example of a study using landscape metrics as explanatory/predictor variables, here in a study that is another current frontier in which landscape ecology plays a role – disease transmission.]*

Hesselbarth, M. H. K., M. Sciaini, K. A. With, K. Wiegand, and J. Nowosad. 2019. landscapemetrics: an open-source R tool to calculate landscape metrics. Ecography 42:1548-1657. *[FRAGSTATS was the main analysis tool for several decades, but this powerful R package is excellent and is now being widely used.]*

Lepczyk, C. A., L. M. Wedding, G. P Asner, S. J Pittman, T. Goulden, M. A. Linderman, J. Gand, and R. Wright. 2021. Advancing landscape and seascape ecology from a 2D to a 3D science. BioScience 71:268-279. *[Introduces you to the potential for 3D data, such as lidar; with wider availability of UAVs, there are more opportunities to use these methods.]*

(5) Tuesday, February 22 – Spatial statistics

For discussion-applications & detecting scale dependence (soils, plants, genetics, corals):

Vasquez, G. M., S. Grunwald and D. B. Myers. 2012. Associations between soil carbon and ecological landscape variables at escalating spatial scales in Florida, USA. Landscape Ecology 27:355-367. [*Geostatistics are increasingly used to quantify spatial heterogeneity in soil attributes, this is a nice example of how they are used*.]

Anderson, D. P., M. G. Turner, S. M. Pearson, T. P. Albright, R. K. Peet and A. Wieben. 2013. Predicting *Microstegium vimineum* invasion in natural plant communities of the southern Blue Ridge Mountains, USA. Biological Invasions 15:1217-1230. [*Example of how spatial autocorrelation in the residuals of an analysis that includes many environmental co-variates can be informative about landscape dynamics, here an incipient invasion process.*]

Schregel, J., J. Remm, H. G. Eiken, J. E. Swenson, U. Saarma, and S. B Hagen. 2018. Multi-level patterns in population genetics: Variogram series detects a hidden isolation-by-distance-dominated structure of Scandinavian brown bears *Ursus arctos*. *[Uses semivariograms to assess the spatial clustering of genetic relatedness in Nordic brown bears, thus tying also into landscape genetics.]*

Roy, S., S. M. Robeson, A. C Ortiz, and D. A. Edmonds. 2020. Spatial and temporal patterns of land loss in the Lower Mississippi River Delta from 1983 to 2019. Remote Sensing of Environment 250: 112046. *[Assesses spatial clustering of areas that convert to water or to marsh using remotely sensed data.]*

(6) Tuesday, Feb 22 – Landscape models

Good background (highly recommended):

Strayer D. L., H. A. Ewing and S. Bigelow. 2003. What kind of spatial and temporal details are required in models of heterogeneous systems? *Oikos* 102:654-62. [*Excellent treatment of the conceptual issues associated with introducing spatial complexity into models.*]

Gustafson, E. J. 2013. When relationships estimated in the past cannot be used to predict the future: using mechanistic models to predict landscape ecological dynamics in a changing world. Landscape Ecology 28:1429-1437. *[Commentary by a forest landscape ecologist who has been developing and applying spatial models. These points remain important as scientists try to model no-analog future conditions.]*

DeAngelis, D. A. and S. Yurek. 2017. Spatially explicit modeling in ecology: A review. Ecosystems 20:284-300. [*Excellent recent review by one of the pioneers of spatially explicit individual-based models in landscape ecology, important context for how spatial models have evolved.]*

For discussion–Current examples of landscape modeling:

Duane, A., M. C. Miranda, and L. Brotons. 2021. Forest connectivity percolation thresholds for fire spread under different weather conditions. Forest Ecology and Management 498: 119558. *[Demonstrates use of percoloation thresholds (derived from neutral landscape models) in landscape studies.]*

Albrich, K., W. Rammer, and R. Seidl. 2020. Climate change causes critical transitions and irreversible alterations of mountain forests. Global Change Biology 26:4013-4027. *[Uses the process-based simulation model, iLand, to test for tipping points in forest landscapes under climate change. Excellent example of how models are important tools in our tool kits.]*

Olson, S. K., et al. 2021, Landscape-scale forest reorganization following insect invasion and harvest under future climate change scenarios. Ecosystems 24:1756-1774. *[Regionally relevant paper focused on emerald ash borer across 2-million ha of northern WI; uses LANDIS-II, aforest landscape model originally developed by emeritus FWE professor David Mladenoff.]*

Thompson, J. R., et al. 2020. Spatial simulation of codesigned land cover change scenarios in New England: Alternative futures and their consequences for conservation priorities. Earth's Future 8: e2019EF001348. *[Example of scenario-based modeling and how scenarios can bound a wide range of future conditions. Not all modeling goals include prediction.]*

(7) Tuesday, March 8 – Disturbance and landscapes I

Good background:

Turner, M. G. 2010. Disturbance and landscape dynamics in a changing world. Ecology 91:2833-2849. [*Overview of the importance of disturbance in landscapes, with examples from Yellowstone.*]

For discussion–disturbance-created spatial patterns:

Sommerfeld, A., C. Senf, B. Buma, A. W. D'Amato, T. Després, I. Díaz-Hormazábal, S. Fraver, L. E. Frelich, A. G. Gutiérrez, S. J. Hart, B. J. Harvey, H. S. He, Tom´s Hlásny, Andrés Holz, T. Kitzberger, D. Kulakowski, D. Lindenmayer, A. S. Mori, Jörg Müller, J. Paritsis, G. Perry, S. Stephens, M. Svoboda, M. G. Turner, T. T. Veblen, and R. Seidl. 2018. Patterns and drivers of recent disturbances across the temperate forest biome. Nature Communications 9:4355. *[Global scale, temperate-zone analysis of changing disturbance regimes inside and outside protected areas.]*

Meddens, A. J. H., et al. 2018. Fire refugia: what are they, and why do they matter for global change? BioScience 68:944-954. *[Disturbance-created spatial heterogeneity is important for for conservation, this paper focuses on islands of unburned forest.]*

Uhrin, A. V., and M. G. Turner. 2018. Physical drivers of seagrass spatial configuration: the role of thresholds. Landscape Ecology 33:2253-2272. *[In a coastal seascape, we see disturbance driving spatial patterns of seagrass cover, plus interesting nonlinear dynamics.]*

Leitold, V., et al. 2021. Tracking the rates and mechanisms of canopy damage and recovery following Hurricane Maria using multitemporal Lidar data. Ecosystems (early access). *[Uses continuous variables to assess measuring disturbance severity after Hurricane Maria in Puerto Rico and ties to the growing use of lidar data.]*

SPRING BREAK

(8) Tuesday, March 22 – Disturbance and landscapes II

Good background:

Fraterrigo, J. M. and J. A. Rusak. 2008. Disturbance-driven changes in the variability of ecological patterns and processes. Ecology Letters 11:756-770. [*Nice conceptual treatment focused on gaining insights from variability, along with practical guidance on how to assess it.*]

Johnstone, J. F., C. D. Allen, J. F. Franklin, L. E. Frelich, B. J. Harvey, P. E. Higuera, M. C. Mack, R. K. Meentemeyer, M. R. Metz, G. L. W. Perry, T. Schoennagel, and M. G. Turner. 2016. Changing disturbance regimes, climate warming and forest resilience. Frontiers in Ecology and the Environment 14:369-378. *[Overview of resilience ideas in the context of changing climate and disturbance regimes, here applied to forest landscapes.]*

For discussion–disturbance interactions, resilience concept):

Cannon, J. B., S. K. Henderson, M. H. Bailey, and C. J. Peterson. 2019. Interactions between wind and fire disturbance in forests: Competing amplifying and buffering effects. Forest Ecology & Management 436:117-128. *[Disturbance interactions continue to receive well-deserved attention, as landscapes don't just experience these in isolation.]*

Sommerfeld, A., W. Rammer, M. Heurich, T. Hilmers, J. Müller, and R. Seidl. 2021. Do bark beetle outbreaks amplify or dampen future bark beetle disturbances in Central Europe? Journal of Ecology 109:737-749. [*Compound disturbances are an issue, but interactions can be positive or negative.*]

Coop, J. D., et al. 2020. Wildfire-driven forest conversion in western North American landscapes. BioScience 70:659-673. *[Disturbances are interacting with other drivers to shape landscape patterns of vegetation, including conversions.]*

Schoennagel, T., J. Balch, H. Brenkert-Smith, P. Dennison, B. Harvey, M. Krawchuk, N. Miekiewicz, P. Morgan, M. Moritz, R. Rasker, M. G. Turner, and C. Whitlock. 2017. Adapt to more wildfire in western North American forests as climate changes. Proceedings of the National Academy of Sciences 114:4582-4590. *[Introduces specified, adaptive and transformative resilience in a social-ecological framework.]*

(9) Tuesday, March 29 – Organisms and landscapes I

Background – the paper that triggered the debate:

Fahrig, L. 2017. Ecological responses to habitat fragmentation per se. Annual Review of Ecology, Evolution and Systematics 48:1-23. [*Fahrig is one of the leaders in research on how organisms respond to landscape patterns; this plus her earlier paper on the Habitat Amount Hypothesis triggered the spirited debate that has played out in the literature, and which will be our focuse for discussion.*]

For discussion–theme is the contemporary debate on habitat area vs. fragmentation:

Fletcher, R. J., Jr., R. K Didham, C. Banks-Leite, J. Barlow, R. M. Ewers, J. Rosindell, R. D. Holt, A. Gonzalez, R. Pardini, E. I. Damschen, F. P. L. Melo, L. Ries, J. A. Prevedllo, T. Tscharntke, W. F. Laurance, T. Lovejoy, and N. M. Haddad. 2018. Is habitat fragmentation good for biodiversity? Biological Conservation 226:9-15. *[The habitat area hypothesis and effects of habitat fragmentation are critiqued by these authors, all of whom have worked on related topics, often in an experimental framework.]*

Fahrig, L., V. Arroyo-Rodriguez, J. R. Bennett, V. Boucher-Lalonde, E. Cazetta, D. J. Currie, F. Eigenbrod, A. T. Ford, S. P. Harrison, J. A. G. Jaeger, N. Koper, A. E. Martin, J.-L. Martin, J. P. Metzger, P. Morrison, J. R.

Rhodes, D. A. Saunders, D. Simberloff, A. C. Smith, L. Tishendorf, M. Vellen, and J. I. Watling. 2019. Is habitat fragmentation bad for biodiversity? Biological Conservation 230:179-186. *[Then Fahrig et al. respond, again with a group of authors who have also worked on these topics.]*

Fahrig, L. 2019. Habitat fragmentation: a long and tangled tale. Global Ecology and Biogeography 28:33-41. [*Fahrig's next (final?) reflections on the origins and outcomes of the controversies surrounding effects of habitat fragmentation.*]

Rios, E., M. Benchimol, P. Dodonov, K. De Vleeschouwer, and E. Cazetta. 2021. Testing the habitat amount hypothesis and fragmentation effects for medium- and large-sized mammals in a biodiversity hotspot. Landscape Ecology 36:1311-1323. *[One of a number of papers trying to test these ideas in different systems.]*

(10) Tuesday, April 5 – Organisms and landscapes II

Background--some more examples from a vast literature

Tscharntke, T., and many coauthors. 2012. Landscape moderation of biodiversity patterns and processes – eight hypotheses. Biological Reviews 87:661-685. *[Older but relevant and thought-provoking paper, timely to consider in context of more recent studies.]*

Gaynor, K. M., J. S. Brown, A. D. Middleton, M. E. Power, and J. S. Brashares. 2019. Landscapes of fear: spatial patterns of risk perception and response. Trends in Ecology & Evolution 34:355-368. *[Effects of landscape patterns on species interactions, including predator-prey dynamics, remains a hot topic. This is deals with perceived predation risk.]*

Martin, E. A., and many co-authors. 2019. The interplay of landscape composition and configuration: new pathways to manage functional biodiversity and agroecosystem services across Europe. Ecology Letters 22:1083-1094. *[Synthetic look at pollinators (also a hot topic), natural enemies and semi-natural habitats in Europe. Community-level example, not just single populations.]*

Littlefield, C. E., M. Krosby, J. L. Michalak, and J. J. Lawler. 2019. Connectivity for species on the move: supporting climate-driven range shifts. Frontiers in Ecology and the Environment doi:10.1002/fee.2043. *[Emphasizes the importance of including effects of climate change as we think about habitat connectivity and organism movements. Climate is not static!]*

For discussion–theme is landscape connectivity

Diniz, M. F., S. A. Cushman, R. B. Machado, and P. De Marco Junior. 2020. Landscape connectivity modeling from the perspective of animal dispersal. Landscape Ecology 35:41-58. *[Useful overview of how dispersal is incorporated into connectivity modeling.]*

Barnett, K., and T. Belote. 2021. Modeling an aspirational connected network of protected areas across North America. Ecological Applications 2021: e02387. *[This study explores corridors that would connect large protected areas in North America, uses a structural approach at broad scales.]*

Klinga, P., M. Mikolas, P. Smolko, M. Tejkal, J. Höglund, and L. Paule. 2019. Considering landscape connectivity and gene flow in the Anthropocene using complementary landscape genetics and habitat modelling approaches. Landscape Ecology 34:521-536. *[Integrates connectivity modeling with landscape genetics for the capercaillie; uses Conefor.]*

Kimberly, A., et al. 2021. Functional rather than structural connectivity explains grassland plant diversity patterns following landscape scale habitat loss. Landscape Ecology 36:265-280. *[Empirical study focused on changing connectivity of grasslands in Europe.]*

(11) Tuesday, April 12 – Ecosystem processes

Background:

Lovett, G. M., C. G. Jones, M. G. Turner and K. C. Weathers, editors. 2005. ECOSYSTEM FUNCTION IN HETEROGENEOUS LANDSCAPES. Springer-Verlag, New York. *[Edited book, good reference.]*

Schindler, D. E. and A. P. Smits. 2017. Subsidies of aquatic resources in terrestrial ecosystems. Ecosystems 20:78-93. *[Cross-boundary lateral movement of matter and energy is within the scope of landscape and ecosystem ecology, and lots has been done on land-water interactions. This article considers water→land.]*

Soranno, P. A., T. Wagner, S. M. Collins, J.-F. Lapierre, N. R. Lottig, and S. K. Oliver. 2019. Spatial and temporal variation of ecosystem properties at macroscales. Ecology Letters 22:1587-1598. *[Pat Soranno coined*

the term "landscape limnology" and has been leading several macrosystems projects that have examined lakes over large areas. This paper raises interesting ideas on variation in time and space.]

For discussion- from ecosystems to landscapes:

Asplund, M. E., et al. 2021. Dynamics and fate of blue carbon in a mangrove-seagrass seascape: influence of landscape configuration and land-use change. Landscape Ecology 36:1489-1509. *[Continuing with some aquatic examples, looks at C dynamics and include landscape metrics.]*

Reinmann, A. B., I. A. Smith, J. R. Thompson, and L. R. Hutyra. 2020, Urbanization and fragmentation mediate temperature forest carbon cycle response to climate. Environmental Research Letters 15:114036. *[Landscape configuration can influence regional C balance, this is a gradient from rural Harvard Forest to urban Boston.]*

Monk, J. D., and O. J. Schmitz. 2021. Landscapes shaped from the top down: predicting cascading predator effects on spatial biogeochemistry. Oikos 00:1-15 (early view). *[Linkages between species and ecosystems contribute to landscape heterogeneity in biogeochemical cycling.]*

Gonzalez, A., et al. 2020. Scaling up biodiversity-ecosystem functioning research. Ecology Letters 23:757-776. *[There is a vast BEF literature, most at fine scales; this is good intro to the BEF literature withing a context of heterogeneity and scale.]*

(12) Tuesday, April 19 —Ecosystem services

For discussion – focus on working and urban landscapes; rich and growing literature

Kremen, C. and A. M. Merenlender. 2018. Landscapes that work for biodiversity and people. Science 362: eaau6020. *[Nice overview on the challenges of balancing multiple demands from working landscapes by a thought leader in this field.]*

Schulte, L. A., J. Niemi, M. J. Helmers, M. Liebman, J. G. Arbuckle, D. E. James, R. K. Kolka, M. E. O'Neal, M. D. Tomer, J. C. Tyndall, H. Asbjornsen, P. Drobney, J. Neal, G. Van Ryswyk, and C. Witte. 2017. Prairie strips improve biodiversity and the delivery of multiple ecosystem services from corn-soybean croplands. Proceedings of the National Academy of Sciences 114:11247-11252. [*Manipulating the landscape to enhance ecosystem services in the agricultural upper Midwest.*]

Palliwoda, J., E. Banzhaaf, and J. A. Priess. 2020. How do the green components of urban green infrastructure influence the use of ecosystem services? Examples from Leipzig, Germany. Landscape Ecology 35:1127-1142. *[Nice example of a study at the intersection of urban landscape ecology and ecosystem services.]*

Rieb, J. and E. M. Bennett. 2020. Landscape structure as a mediator of ecosystem service interactions. Landscape Ecology 35:2863-2880. *[The interactions among ecosystem services is important when thinking about what landscapes can provide.]*

(13) Tuesday, April 26 —Landscape conservation

For discussion - designing landscapes

Belote, T., et al. 2021. Beyond priority pixels: Delineating and evaluating landscapes for conservation in the contiguous United States. Landscape and Urban Planning 209:104059. *[Example of incorporating landscape ecology into conservation planning.]*

Hebblewhite, M., et al. 2021. Can a large-landscape conservation vision contribute to achieving biodiversity targets? Conservation Science and Practice 4:e588. *[The Yellowstone to Yukon vision has been a conservation goal for nearly 30 years.]*

Arroyo-Rodriguez, V., et al. 2020. Designing optimal human-modified landscapes for forest biodiversity conservation. Ecology Letters 23:1404-1420. *[Argues for maintaining 40% forest cover in landscapes to conserve forest-dwelling species.]*

Tscharntke, T., I Grass, T. C. Wanger, C. Westphal, and P. Batary. 2021. Beyond organic farming–harnessing biodiversity-friendly working landscapes. Trends in Ecology and Ev olution 35:919-930. *[Conservation in agricultural landscapes is important.]*

==END OF READING LIST==