Compilation of Assigned Readings for Landscape Ecology

University of Wisconsin - Madison

(1996–2024)

Landscape Ecology (ZOO 665)

1996 and 1998

Taught by Monica G. Turner and David Mladenoff

Advanced Landscape Ecology (ZOO 879)

2000, 2002, 2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2020, 2022, 2024

Taught by Monica G. Turner

Compiled by Monica G. Turner

April 2026

Goal. This compilation is intended as a resource for students interested in a curated list of general or topical papers in landscape ecology. I first began teaching landscape ecology with Hazel Delcourt at the University of Tennessee-Knoxville in the very early 1990s, then developed my courses at the University of Wisconsin-Madison. Topical headings by week correspond to my syllabus. Readings focused on the current state-of-the-science at the time the course was offered, and many assigned papers have since become classics. Brief notes about each paper (starting consistently in 2004) were to provide students with context about why the paper was assigned, as they were reading the papers prior to lecture. As the literature has grown exponentially, I hope the compilation serves as a useful resource for students or professionals new to the field. It offers one perspective on how the field has grown and matured and how research themes have evolved over time. Happy reading!

Disclaimer. Formats of the reading lists varied among years, and there may be typos or errors, none of which are intentional.

1996

Turner, M. G. and R. H. Gardner. 1991. Quantitative methods in landscape ecology. Springer-Verlag, New York. (referred to as QMLE in the reading list).

JAN 22–Landscape ecology definition and roots; introduction to scale (**for discussion)*

*Risser, P. G., J. R. Karr, and R. T. T. Forman. 1984. Landscape ecology: directions and approaches. Special Pub. No. 2. Illinois Natural History Survey, Champaign.

*Urban, D. L., R. V. O'Neill, and H. H. Shugart. 1987. Landscape ecology. BioScience 37:119-27.

*Wiens, J. A. 1992. What is landscape ecology, really? Editorial Comment. Landscape Ecology 7:149-150.

Forman, R. T. T., and M. Godron. 1981. Patches and structural components for a landscape ecology. BioScience 31:733-40.

Levin, S. A. 1992. The problem of pattern and scale in ecology. Ecology 73:1943-1967.

Turner, M. G. 1989. Landscape ecology: the effect of pattern on process. Annual Review of Ecology and Systematics 20:171-197.

JAN 29–Causes of pattern– abiotic template; quaternary landscape ecology

Delcourt, H. R., and P. A. Delcourt. 1988. Quaternary landscape ecology: relevant scales in space and time. Landscape Ecology 2:23-44.

Emanuelsson, U. 1988. A model for describing the development of the cultural landscape. Pages 111-121 in H. H. Birks, H. J. B. Birks, P. E. Kaland and D. Moe, editors. The cultural landscape–past, present and future. Cambridge University Press, Cambridge.

Kratz, T. K., B. J. Benson, E. R. Blood, G. L. Cunningham, and R. A. Dahlgren. 1991. The influence of landscape position on temporal variability in four North American ecosystems. Am. Nat. 138:355-378.

Swanson, F. J., T. K. Kratz, N. Caine and R. G. Woodmansee. 1988. Landform effects on ecosystem patterns and processes. BioScience 38:92-98.

FEB 5–Quantifying pattern I

Gustafson, E. J. and G. R. Parker. 1992. Relationships between landcover proportion and indices of landscape spatial pattern. Landscape Ecology 7:101-110.

Spies, T. A., W. J. Ripple, and G. A. Bradshaw. Dynamics and pattern of a managed coniferous forest landscape in Oregon. Ecological Applications 4:555-568.

Turner, M. G., and R. H. Gardner. 1991. Quantitative methods in landscape ecology: an introduction. QMLE Chapter 1.

Turner, S. J., R. V. O'Neill, W. Conley, M. R. Conley, and H. C. Humphries. 1991. Pattern and scale: statistics for landscape ecology. QMLE Chapter 2.

Dunn, C. P., D. M. Sharpe, G. R. Guntennspergen, F. Stearns and Z. Yang. 1991. Methods for analyzing temporal changes in landscape pattern. QMLE Chapter 8.

FEB 12–Quantifying pattern II

Gardner, R. H., and R. V. O'Neill. 1991. Pattern, process and predictability: the use of neutral models for landscape analysis. QMLE Chapter 11.

Krummel, J. R., Gardner, R. H., Sugihara, G., O'Neill, R. V., Coleman, P. R. 1987. Landscape patterns in a disturbed environment. Oikos 48:321-24.

Meentemeyer, V., and E. O. Box. 1987. Scale effects in landscape studies. Pages 15-34 In M. G. Turner, editor. Landscape heterogeneity and disturbance. Springer-Verlag, New York.

Milne, B. T. 1991. Lessons from applying fractal models to landscape pattern. QMLE Chapter 9.

Moloney, K. A., A. Morin, and S. A. Levin. 1991. Interpreting ecological patterns generated through simple stochastic processes. Landscape Ecology 5:163-174.

FEB 19–Disturbance and succession I

Baker, W. L. 1989. Landscape ecology and nature reserve design in the Boundary Waters Canoe Area, Minnesota. Ecology 70:23-25.
Boose, E. R., D. R. Foster, and M. Fluet. 1994. Hurricane impacts to tropical and temperate forest landscapes. Ecological Monographs 64:369-400.
Franklin, J. F., and R. T. T. Forman. 1987. Creating landscape patterns by forest cutting: ecological consequences and principles. Landscape Ecology 1:5-18.
Freelich, L. E., and C. G. Lorimer. 1991. Natural disturbance regimes in hemlock-hardwood forests of the Upper Great Lakes region. Ecological Monographs 61:145-164.
Knight, D. H. and L. L. Wallace. 1989. The Yellowstone fires: issues in landscape ecology. BioScience 39:700-706.

FEB 26–Disturbance and succession II

Bonan, G. B. 1989. Environmental factors and ecological processes controlling vegetation patterns in boreal forests. Landscape Ecology 3:111-130.
Davis, M. B. and D. B. Botkin. 1985. Sensitivity of cool-temperate forests and their fossil pollen record to rapid temperature change. Quaternary Research 23:327-340.
Heinselman, M. L. 1973. Fire in the virgin forests of the Boundary Waters Canoe Area. Quaternary Research 3:329-382.

MAR 4–Responses of organisms to spatial pattern I

Den Boer, P. J. 1981. On the survival of populations in a heterogeneous and variable environment. Oecologia 50:39-53.
Dunning, J. B., B. J. Danielson, and H. R. Pulliam 1992. Ecological processes that affect populations in complex landscapes. Oikos 65:169-175.
Herkert, J. R. 1994. The effects of habitat fragmentation on midwestern grassland bird communities. Ecological Applications 4:461-471.
Merriam, G., K. Henein and K. Stuart-Smith. 1991. Landscape dynamic models. QMLE, Chapter 16.
Wiens, J. A., and B. T. Milne. 1989. Scaling of 'landscapes' in landscape ecology, or landscape ecology from a beetle's perspective. Landscape Ecology 3:87-96.

MAR 18–Responses of organisms to spatial pattern II

Franklin, J. F. 1993. Preserving biodiversity: species, ecosystems, or landscapes? Ecological Applications 3:202-205.
Kotliar, N. B., and J. A. Wiens. 1990. Multiple scales of patchiness and patch structure: a hierarchical framework for the study of heterogeneity. Oikos 59:253-260.
Pearson, S. M. 1993. The spatial extent and relative influence of landscape-level factors on wintering bird populations. Landscape Ecology 8:3-18.
Senft, R. L., Coughenour, M. B., Bailey, D. W., Rittenhouse, L. R., Sala, O. E., et al. 1987. Large herbivore foraging and ecological hierarchies. BioScience 37:789-99.
Wiens, J. A., N. C. Stenseth, B. Van Horne, and R. A. Ims. 1993. Ecological mechanisms and landscape ecology. Oikos 66:369-380.

MAR 25–Land-water interactions

Osborne, L. L., and D. A. Kovacic. 1993. Riparian vegetated buffer strips in water-quality restoration and stream management. Freshwater Biology 29:243-258.
Peterjohn, W. T., and D. L. Correll. 1984. Nutrient dynamics in an agricultural watershed: observations on the role of a riparian forest. Ecology 65:1466-75.

Stanford, J. A. and J. V. Ward. 1992. Management of aquatic resources in large catchments: recognizing interactions between ecosystem connectivity and environmental disturbance. Pages 91-124 in: R. J. Naiman, editor. Watershed Management. Springer-Verlag, New York.

APR 1–Spatial modeling

Bart, J. 1995. Acceptance criteria for using individual-based models to make management decisions. Ecological Applications 5:411-420.

Wu, J. and S. A. Levin. 1994. A spatial patch dynamic modeling approach to pattern and process in an annual grassland. Ecological Monographs 64:447-464.

Sklar, F. H., and R. Costanza. 1990. The development of spatial simulation modeling for landscape ecology. QMLE Chapter 10.

Special Feature on Spatially Explicit Population Models, 1995, Ecological Applications 5:2-27.

APR 8–Ecosystem processes at regional scales

Burke, I. C., D. S. Schimel, C. M. Yonker, W. J. Parton, and L. A. Joyce. 1990. Regional modeling of grassland biogeochemistry using GIS. Landscape Ecology

Kesner, B. T., and V. B. Meentemeyer. 1989. A regional analysis of total nitrogen in an agricultural landscape. Landscape Ecology 2:151-164.

Running, S. W., R. R. Nemani, D. L. Peterson, L. E. Band,D. F. Potts, L. L. Pierce, and M. A. Spanne. 1989. Mapping regional forest evapotranspiration and photosynthesis by coupling satellite data with ecosystem simulation. Ecology 70:1090-1101.

Seagle, S. W., and S. J. McNaughton. 1992. Spatial variation in forage nutrient concentrations and the distribution of Serengeti grazing ungulates. Landscape Ecology 7:229-241.

APR 15–Ecosystem management; forestry practices

Grumbine, R. E. 1994. What is ecosystem management? Conservation Biology 8:27-38.

Slocombe, D. S. 1993. Implementing ecosystem-based management. BioScience 43:612-622.

Wallin, D. O., F. J. Swanson, and B. Marks. 1994. Landscape pattern response to changes in pattern generation rules: land-use legacies in forestry. Ecological Applications 4:569-580.

APR 22–Land-use patterns, socioeconomic considerations

Dale, V. H., R. V. O'Neill, M. Pedlowski, and F. Southworth. 1993. Causes and effects of land-use change in central Rondonia, Brazil. Photogrammetric Engineering and Remote Sensing 59:997-1005.

Dale, V. H., S. M. Pearson, H. L. Offerman and R. V. O'Neill. 1994. Relating patterns of land-use change to faunal biodiversity in the central Amazon. Conservation Biology 8:1027-1036.

Foster, D. R. 1992. Land-use history (1730-1900) and vegetation dynamics in central New England, USA. Journal of Ecology 80:753-772.

Litvaitis, J. A. 1993. Response of early successional vertebrates to historic changes in land use. Conservation Biology 7:866-873.

APR 29–Conservation biology

Hansen, A. J., S. L. Garman, B. Marks and D. L. Urban. 1993. An approach for managing vertebrate diversity across multiple-use landscapes. Ecological Applications 3:481-496.

Hansson, L., and P. Angelstam. 1991. Landscape ecology as a theoretical basis for nature conservation. Landscape Ecology 5:191-201.

MAY 6–Regional risk assessment

Graham, R. L., C. T. Hunsaker, R. V. O'Neill and B. L. Jackson. 1991. Ecological risk at the regional scale. Ecological Applications 1:196-206.

Hunsaker, C. T., R. L. Graham, L. W. Barnthouse, R. H. Gardner, R. V. O'Neill and G. W. Suter III. 1990. Assessing ecological risk on a regional scale. Environmental Management 14:325-332.

1998

Turner, M. G. and R. H. Gardner. 1991. Quantitative methods in landscape ecology. Springer-Verlag, New York. (Paperback, available at University Bookstore on State Street).

*indicates readings that will be the focus for the discussion in class; the other readings are assigned and may be referred to during discussion or lecture. For each week, we provide a very brief background/context for the set of readings and why we chose these to illustrate aspects of the topics covered that week. We suggest that you read the papers in the order presented.

Week 1 (Jan 23)–Landscape ecology definition and roots; introduction to scale
Turner (1989) was the first review of landscape ecology in the days when you really could read all the literature in the field. Urban et al. (1987) was one of the early papers that also defined landscape ecology and particularly related it to hierarchy theory. Pickett and Cadenasso (1995) is the most recent concise statement of what comprises landscape ecology. It was written as an invited paper for Science in an issue that was designed to highlight ecology. King (1997) presents an introduction to hierarchy theory written especially for an audience interested in landscape ecology.

Turner, M. G. 1989. Landscape ecology: the effect of pattern on process. Annual Review of Ecology and Systematics 20:171-197.
Urban, D. L., R. V. O'Neill, and H. H. Shugart. 1987. Landscape ecology. BioScience 37:119-27.
*Pickett, S. T. A. and M. L. Cadenasso. 1995. Landscape ecology: spatial heterogeneity in ecological systems. Science 269:331-334.
*King, A. W. 1997. Hierarchy theory: a guide to system structure for wildlife biologists. Pages 185-212 in J. A. Bissonette, editor. Wildlife and landscape ecology. Effects of pattern and scale. Springer-Verlag, New York.

Week 2 (Jan 30)–Causes of pattern–abiotic template; quaternary landscape ecology
Swanson (1988) provides a general overview of geomorphological processes and those broad-scale constraints imposed by landform and is important background reading. Bonan (1989) uses a forest modeling approach to examine the relative importance of large-and small abiotic and biotic factors in determining landscape pattern. Davis et al. (1994) use a spatially precise paleoecological record to develop an understanding of how pattern develops in the upper midwest at a much finer spatial scale than is often found. Delcourt and Delcourt (1988) offer a perspective that includes the influences of humans over the past 10,000 years; human activities are very important generators of pattern, yet the past influences often seem invisible to us. This paper also was a winner of the best paper award from US-IALE.

Swanson, F. J., T. K. Kratz, N. Caine and R. G. Woodmansee. 1988. Landform effects on ecosystem patterns and processes. BioScience 38:92-98.
*Bonan, G. B. 1989. Environmental factors and ecological processes controlling vegetation patterns in boreal forests. Landscape Ecology 3:111-130.
*Davis, M. B., et al. 1994. Historical development of alternate communities in a hemlock hardwood forest in northern Michigan, USA. In: Large-scale ecology and conservation biology. P. Edwards. R. May, and N. Webb, eds. Blackwell Scientific Publishers, Inc.
*Delcourt, H. R., and P. A. Delcourt. 1988. Quaternary landscape ecology: relevant scales in space and time. Landscape Ecology 2:23-44.

Week 3 (Feb 6)–Quantifying pattern I

Turner and Gardner (1991) provide context for why the quantification of spatial pattern is important; Quattrochi and Pelletier (1991) provide a very elementary introduction to remote sensing; and Dunn et al. (1991) include a nice general overview of the sources of data used in landscape analyses and the detection of changes through time. Haines-Young and Chopping (1996) is one of two recent reviews of landscape metrics, and it does an excellent job of synthesizing the recent literature. The Spies et al. (1994) paper provides an illustration of how landscape metrics can be used to explore difference between landscapes, in this case examing changes through time as a function of land ownership. Moody and Woodcock (1995) demonstrate effects of changing the scale of the data on the results of landscape pattern analysis.

Turner, M. G., and R. H. Gardner. 1991. Quantitative methods in landscape ecology: an introduction. QMLE Chapter 1.

Quattrochi, D. A. and R. E. Pelletier. 1991. Remote sensing for analysis of landscapes: an introduction. QMLE Chapter 3.

Dunn, C. P., D. M. Sharpe, G. R. Guntennspergen, F. Stearns and Z. Yang. 1991. Methods for analyzing temporal changes in landscape pattern. QMLE Chapter 8.

*Haines-Young, R. and M. Chopping. 1996. Quantifying landscape structure: a review of landscape indices and their application to forested landscapes. Progress in Physical Geography 20:418-445.

*Spies, T. A., W. J. Ripple, and G. A. Bradshaw. 1994. Dynamics and pattern of a managed coniferous forest landscape in Oregon. Ecological Applications 4:555-568.

*Moody, A., and C. E. Woodcock. 1995. The influence of scale and the spatial characteristics of landscape on land-cover mapping using remote sensing. Landscape Ecology 10:363-379.

Week 4 (Feb 13)–Quantifying pattern II

With and King (1997) do a fabulous job of describing what neutral landscape models are and why and how they are used, providing an excellent summary of the primary literature in this area. Andren (1994) reviewed the literature on habitat fragmentation for empirical support for the concept of critical thresholds as applied to birds and mammals. Gardner and O'Neill (1991) review the development of neutral landscape models, and Milne (1991) does a good job of introducing fractal models. Leduc et al. (1994) describe some sources of variability that influence fractal measures and get us thinking about our next topic, spatial stats.

Gardner, R. H., and R. V. O'Neill. 1991. Pattern, process and predictability: the use of neutral models for landscape analysis. QMLE Chapter 11.

*With, K. A., and A. W. King. 1997. The use and misuse of neutral landscape models in ecology. Oikos 79:219-229.

*Andren, H. 1994. Effects of habitat fragmentation on birds and mammals in landscape with different proportions of suitable habitat: a review. Oikos 71:335-366.

Milne, B. T. 1991. Lessons from applying fractal models to landscape pattern. QMLE Chapter 9.

*Leduc, A., Y. T. Prairie and Y. Bergeron. 1994. Fractal dimension estimates of a fragmented landscape: sources of variability. Landscape Ecology 9:279-286.

Week 5 (Feb 20) – Spatial statistics and scale detection

Turner et al. (1991) is a nice overview of the various techniques used in scale detection. Bell et al. (1993) do a nice job of comparing the results of different measures of spatial autocorrelation using a variety of environmental variables; very interesting implications. The Cohen et al. (1990) paper provides another example of the use of semivariance analysis.

Turner, S. J., R. V. O'Neill, W. Conley, M. R. Conley, and H. C. Humphries. 1991. Pattern and scale: statistics for landscape ecology. QMLE Chapter 2.

*Bell, G., M. J. Lechowicz, A. Appenzeller, M. Chandler, E. DeBlois, L. Jackson, B. Mackenzie, R. Preziosi, M. Schallenberg, N. Tinker. 1993. The spatial structure of the physical environment. Oecologia 96:114-121.

*Cohen, W. B., T. A. Spies and G. A. Bradshaw. 1990. Semivariograms of digital imagery for analysis of conifer canopy structure. Remote Sensing of Environment 34:167-178.

Week 6 (Feb 27)–Disturbance and succession

Franklin and Forman (1987) was one of the first papers to deal with disturbance spread in a spatial landscape context and it also illustrates the power of rather simple conceptual models. Knight and Wallace (1989) describe a number of landscape-level considerations about disturbance in the context of the 1988 Yellowstone fires. The Turner et al. (1997) comparison among disturbances is included to provide an overview of some of the differences and similarities among quite different disturbances; this also provides a general framework for considering generalities among disturbances in forests (e.g., the Boose et al. 1994 paper) and in a marine system, the Great Barrier Reef (Connell et al. 1997). Baker (1989) explores the issue of equilibrium and scale in a landscape in which fire is the dominant disturbance.

Franklin, J. F., and R. T. T. Forman. 1987. Creating landscape patterns by forest cutting: ecological consequences and principles. Landscape Ecology 1:5-18.

Knight, D. H. and L. L. Wallace. 1989. The Yellowstone fires: issues in landscape ecology. BioScience 39:700-706.

Turner, M. G., V. H. Dale, and E. E. Everham, III. 1997. Fires, hurricanes, and volcanoes: comparing large disturbances. BioScience 47:758-768.

*Boose, E. R., D. R. Foster, and M. Fluet. 1994. Hurricane impacts to tropical and temperate forest landscapes. Ecological Monographs 64:369-400.

*Connell, J. H., T. P. Hughes, and C. C. Wallace. 1997. A 30-year study of coral abundance, recruitment, and disturbance at several scales in space and time. Ecological Monographs 67:461-488.

*Baker, W. L. 1989. Landscape ecology and nature reserve design in the Boundary Waters Canoe Area, Minnesota. Ecology 70:23-25.

Week 9 (Mar 20)–No class because of US-IALE meetings.

Week 10 (Mar 27)–Responses of organisms to spatial pattern I

Den Boer (1981) is one of the classic papers which emphasized populations and space. Merriam et al. (1991) review a number of landscape characteristics and their applicability to demography and behavior. The Dunning et al. (1992) article is a nice overview and conceptual framework for populations and spatial heterogeneity. Lidicker and Koenig (1996) review literature on vertabrate responses to pattern. Wiens and Milne (1991) illustrate the use of model systems in which experiments can actually be conducted to evaluate organism responses to spatial pattern. Note that the literature in this subject area is now enormous!

Den Boer, P. J. 1981. On the survival of populations in a heterogeneous and variable environment. Oecologia 50:39-53.

Merriam, G., K. Henein and K. Stuart-Smith. 1991. Landscape dynamic models. QMLE, Chapter 16.

*Dunning, J. B., B. J. Danielson, and H. R. Pulliam 1992. Ecological processes that affect populations in complex landscapes. Oikos 65:169-175.

*Lidicker, W. Z., and W. D. Koenig. 1997. Responses of terrestrial vertebrates to habitat edges and corridors. Pages 85-109 in D. R. McCullough, editor. Metapopulations and wildlife conservation. Island Press, Washington, DC.

*Wiens, J. A., and B. T. Milne. 1989. Scaling of 'landscapes' in landscape ecology, or landscape ecology from a beetle's perspective. Landscape Ecology 3:87-96.

Week 11 (Apr 3)–Responses of organisms to spatial pattern II.
Franklin (1993) is a short commentary addressing the scales at which we should be considering conservation of biodiversity. Pearson (1993) pioneered an empirical technique of evaluating statistical relationships between populations and the landscape at multiple scales (i.e., landscape context) which has subsequently been widely applied in other studies. Wiens (1996) presents a good overview of metapopulations and landscape mosaics. Wiens et al. (1993) is a more theoretical treatment of how organisms respond to space. The Special Feature in Ecological Applications examines spatially explicit population models from a variety of perspectives and is a good overview of individual based models in landscape ecology.

Franklin, J. F. 1993. Preserving biodiversity: species, ecosystems, or landscapes? Ecological Applications 3:202-205.
Pearson, S. M. 1993. The spatial extent and relative influence of landscape-level factors on wintering bird populations. Landscape Ecology 8:3-18.
*Wiens, J. A. 1996. Wildlife in patchy environments: metapopulations, mosaics, and management. Pages 53-84 in D. R. McCullough, editor. Metapopulations and wildlife conservation. Island Press, Washington, DC.
*Wiens, J. A., N. C. Stenseth, B. Van Horne, and R. A. Ims. 1993. Ecological mechanisms and landscape ecology. Oikos 66:369-380.
*Special Feature on Spatially Explicit Population Models, 1995, Ecological Applications 5:2-27.

Week 12 (Apr 8)–Spatial landscape modeling (note Wednesday discussion)
Sklar and Costanza (1990) and Baker (1989) provide reviews of spatial modeling; although a bit dated, the general categorizations still apply. There is not presently a more recent review. Acevedo et al. (1995) and Baker (1995) exemplify divergent approaches to forest landscape modeling, and how approaches using different grain and detail can be used for insight into varied questions

Sklar, F. H., and R. Costanza. 1990. The development of spatial simulation modeling for landscape ecology. QMLE Chapter 10.
Baker, W. L. 1989. A review of models of landscape change. Landscape Ecology 2: 111-133.
*Acevedo, M. F., D. L. Urban, and M. Ablan. 1995. Transition and gap models of forest dynamics. Ecological Applications 5: 1040-1055.
*Baker, W. L. 1995. Longterm response of disturbance landscapes to human intervention and global change. Landscape Ecology 10: 143-159.

Week 13 (April 17)–Ecosystem processes at landscape scales
Stanford and Ward (1992) address land-water interactions. Burke et al. (1990) present an approach to regional modeling of ecosystem processes; the group at CSU has been a leader in the development of these broad-scale approaches. Bartell and Brenkert (1991) present one of the early spatial models of N dynamics within a small watershed that has been extensively studied on the Oak Ridge Reservation. Sorrano et al. (1996) developed a simple model that predicts P loading in Lake Mendota under different land use scenarios. Johnson (1994), a paper which won the best publication award from US-IALE, present an extremely careful and thorough analysis that integrates ecosystem dynamics, population establishment, land use patterns, and geomorphology to examine the Platte River and associated vegetation dynamics; this is a great example of a detailed empirical study that uses different types of data.

Stanford, J. A. and J. V. Ward. 1992. Management of aquatic resources in large catchments: recognizing interactions between ecosystem connectivity and environmental disturbance. Pages 91-124 in: R. J. Naiman, editor. Watershed Management. Springer-Verlag, New York.

Burke, I. C., D. S. Schimel, C. M. Yonker, W. J. Parton, and L. A. Joyce. 1990. Regional modeling of grassland biogeochemistry using GIS. Landscape Ecology 4: 45-54.
Bartell, S. M. and A. L. Brenkert. 1991. A spatial-temporal model of nitrogen dynamics in a deciduous forest watershed. QMLE, Chapter 15.
*Soranno, P. A., S. L. Hubler, S. R. Carpenter, and R. C. Lathrop. 1996. Phosphorus loads to surface waters: a simple model to account for spatial pattern of land use. Ecological Applications 6:865-878.
*Johnson, W. C. 1994. Woodland expansion in the Platte River, Nebraska: patterns and causes. Ecological Monographs 64:45-84.

Week 14 (Apr 24)–Applications I and II. Ecosystem management; biodiversity

Wallin et al. (1994) illustrate that even under modified harvesting procedures, forest landscape patterns caused by recent forest management have long-term consequences in the Pacific Northwest. Hansson and Anglestam (1991) describe how landscape ecology concepts, including fragmentation, patch, and connectivity, provide a framework for describing and managing lands for biodiversity goals. Ludwig et al. (1993), and Holling and Meffe (1996) illustrate some of the problems that occur where social forces, and incomplete scientific knowledge meet practical management of resources. Finally, Hansen et al. (1995) simulate different forest management scenarios in the Pacific Northwest, and assess tradeoffs between economic outputs and biodiversity maintenance.

Wallin, D. O., F. J. Swanson, and B. Marks. 1994. Landscape pattern response to changes in pattern generation rules: land-use legacies in forestry. Ecological Applications 4:569-580.
Hansson, L., and P. Angelstam. 1991. Landscape ecology as a theoretical basis for nature conservation. Landscape Ecology 5:191-201.
*Ludwig, D. R. Hilborn, and C. Walters. 1993. Uncertainty, resource exploitation, and conservation: lessons from history. Science 260:17-36.
*Holling, C. S., and G. K. Meffe. 1996. Command and control and the pathology of natural resource management. Conservation Biology 10: 328-337.
*Hansen, A. J. et al. 1995. Alternative silvicultural regimes in the Pacific northwest: simlation of ecological and economic effects. Ecological Applications 5: 535-554.

Week 15 (Apr 29)–Applications III. Land-use (Note: Wednesday discussion)

Foster (1992) and collaborators work in Petersham Township, New England, provides a benchmark for how the effects of past land use on present-day vegetation patterns are being recognized. Litvaitis (1993) documents changes in vertebrates and land use in New England. These two papers do a nice job of documenting some important effects of land-use change. White et al. (1997) do an outstanding job of exploring the potential impacts of future development on species using extensive empirical data. O'Neill et al. (1997) propose a series of ecological indicators that would be sensitive to a variety of influences, including land use. Parks (1991) provides an overview of some initial attempts to link economic considerations to ecological models of land use change.

Foster, D. R. 1992. Land-use history (1730-1900) and vegetation dynamics in central New England, USA. Journal of Ecology 80:753-772.
Litvaitis, J. A. 1993. Response of early successional vertebrates to historic changes in land use. Conservation Biology 7:866-873.
*White, D., P. G. Minotti, M. J. Barczak, J. C. Sifneos, K. E. Freemark, M. V. Santelmann, C. F. Steinitz, A. R. Kiester, and E. M. Preston. 1997. Assessing risks to biodiversity from future landscape change. Conservation Biology 11:349-360.
* Parks, P. J. 1991. Models of forested and agricultural landscapes: integrating economics. QMLE, Chapter 12.

2000

[Alphabetical listing for discussion readings; assignments by week were in the syllabus.]

Background:

Turner, M. G., R. H. Gardner, and R. V. O'Neill. 2000. Pattern and process: landscape ecology in theory and practice. Springer-Verlag, New York. Forthcoming.

Lab Exercises:

Gergel, S. E. and M. G. Turner, editors. 2000. Learning landscape ecology: a practical guide to concepts and techniques. Springer-Verlag, New York. Forthcoming.

Discussion Readings:

Bell, G., M. J. Lechowicz, A. Appenzeller, M. Chandler, E. DeBlois, L. Jackson, B. Mackenzie, R. Preziosi, M. Schallenberg, N. Tinker. 1993. The spatial structure of the physical environment. Oecologia 96:114-121.

Cain, D. H., K. Riitters, and K. Orvis. 1997. A multi-scale analysis of landscape statistics. Landscape Ecology 12:199-212.

Di Castri, F. 1997. Editorial: Landscape ecology in a changing globalized environment. Landscape Ecology 12:3-5.

Fan, W., J. C. Randolph and J. L. Ehman. 1998. Regional estimation of nitrogen mineralization in forest ecosystems using Geographic Information Systems. Ecological Applications 8:734-747.

Foster, D. R., M. Fluet, and E. R. Boose. 1999. Human or natural disturbance: landscape-scale dynamics of the tropical forests of Puerto Rico. Ecological Applications 9(2):555-572.

Frelich, L. E. and P. B. Reich. 1999. Neighborhood effects, disturbance severity, and community stability. Ecosystems 2:151-166.

Gardner, R. H. 1998. Pattern, process and the analysis of spatial scales. Pp. 17-34 *in* D. L. Petersen and V. T. Parker , eds. Ecological Scale: Theory and Applications. Columbia University Press, New York.

Hargis, C. D., J. A. Bissonette and J. L. David. 1998. The behavior of landscape metrics commonly used in the study of habitat fragmentation. Landscape Ecology 13:167-186.

Hobbs, R. J. 1996. Future landscapes and the future of landscape ecology. Landscape and Urban Planning 37:1-9.

Hobbs, R. J. 1999. Clark Kent or Superman: where is the phone booth for landscape ecology? Pages 11-23 in J. M. Klopatek and R. H. Gardner, editors. Landscape ecological analysis: issues and applications. Springer-Verlag, New York.

Hunter, M. L., Jr. 1993. Natural fire regimes as spatial models for managing boreal forests. Biological Conservation 65:115-120.

Landres, P. B., P. Morgan, and F. J. Swanson. 1999. Overview of the use of natural variability concepts in managing ecological systems. Ecological Applications 9:1179-1188.

Li, H., and J. F. Reynolds. 1995. On definition and quantification of heterogeneity. Oikos 73:280-284.

Likens, G. E. 1998. Limitations to intellectual progress in ecosystem science. Pages 247-271 in M. L. Pace and P. M. Groffman, editors. 1998. Successes, limitations and frontiers in ecosystem science. Springer-Verlag, New York.

Liu, J. and P. S. Ashton. 1999. Simulating effects of landscape context and timber harvest on tree species diversity. Ecological Applications 9:186-201.

Motzkin, G., W. A. Patterson III and D. R. Foster. 1999. A historical perspective on pitch pine-scrub oak communities in the Connecticut Valley of Massachusetts. Ecosystems 2:255-273.

Naiman, R. J. 1996. Water, society and landscape ecology. Landscape Ecology 11:193-196.

O'Neill, R. V., C. T. Hunsaker, K. B. Jones, K. H. Riiters, J. D. Wickham, P. M. Schwartz, I. A. Goodman, B. L. Jackson, and W. S. Baillargeon. 1997. Monitoring environmental quality at the landscape scale. BioScience 47:513-519.

Riitters, K. H., R. V. O'Neill, K. B. Jones. 1997. Assessing habitat suitability at multiple scales: a landscape-level approach. Biological Conservation 81:191-202.

Risser, P. A. 1995. The Allerton Park workshop revisted—a commentary. Landscape Ecology 10:129-132.

Risser, P. G. 1999. Landscape ecology: does the science only need to change at the margin? Pages 3-10 in: J. M. Klopatek and R. H. Gardner, editors.

Saab, V. 1999. Importance of spatial scale to habitat use by breeding birds in riparian forests: a hierarchical analysis. Ecological Applications 9(1):135-151.

Soranno, P. A., K. E. Webster, J. L. Riera, T. K. Kratz, J. S. Baron, P. A. Bukaveckas, G. W. Kling, D. S. White, N. Caine, R. C. Lathrop, and P. R. Leavitt. 1999. Spatial variation among lakes within landscapes: Ecological organization along lake chains. Ecosystems 2:395-410.

Tinker, D. B., C. A. C. Resor, G. P. Beauvais, k. F. Kipfmueller, C. I. Fernandes, and W. L. Baker. 1998. Watershed analysis of forest fragmentation by clearcuts and roads in a Wyoming forest. Landscape Ecology 13:149-165.

Trzcinski, M. K., L. Fahrig, and G. Merriam 1999. Independent effects of forest cover and fragmentation on the distribution of forest breeding birds. Ecological Applications 9(2):586-593.

Wear, D. N. and P. Bolstad. 1998. Land-use changes in southern Appalachian landscapes: spatial analysis and forecast evaluation. Ecosystems 1:575-594.

Weller, D. E., T. E. Jordan, and D. L. Correll. 1998. Heuristic models for material discharge from landscapes with riparian buffers. Ecological Applications 8:1156-1169.

Wiens, J. A. 1999. The science and practice of landscape ecology. Pages 372-383 in J. M. Klopatek and R. H. Gardner, editors. Landscape ecological analysis: issues and applications. Springer-Verlag, New York.

With, K. A., and A. W. King. 1997. The use and misuse of neutral landscape models in ecology. Oikos 79:219-229.

With, K. A., S. J. Cadaret, and C. Davis. 1999. Movement responses to patch structure in experimental fractal landscapes. Ecology 80(4):1340-1353.

Zollner, P. A. and S. L. Lima. 1999. Search strategies for landscape-level interpatch movements. Ecology 80(3):1019-1030.

2002

Texts

Turner, M. G., R. H. Gardner, and R. V. O'Neill. 2001. Landscape ecology in theory and practice. Springer-Verlag, New York.

Gergel, S. E. and M. G. Turner, editors. 2002. Learning landscape ecology. Springer-Verlag, New York.

Weekly Discussion Readings

January 23/25

Wiens, J. A. 1999. The science and practice of landscape ecology. Pages 372-383 in J. M. Klopatek and R. H. Gardner, editors. Landscape ecological analysis: issues and applications. Springer-Verlag, New York.

Ludwig, J. A., J. A. Wiens and D. J. Tongway. 2000. A scaling rule for landscape patches and how it applies to conserving soil resources in savannas. Ecosystems 3:84-97.

January 30/February 1

Foster, D. R., D. H. Knight, and J. F. Franklin. 1998. Landscape patterns and legacies resulting from large infrequent forest disturbances. Ecosystems 1:497-510.

Helmer, E. H. 2000. The landscape ecology of tropical secondary forest in montane Costa Rica. Ecosystems 3:98-114.

February 6/8

Li, H., and J. F. Reynolds. 1995. On definition and quantification of heterogeneity. Oikos 73:280-284.

Gustafson, E. J. 1998. Quantifying landscape spatial pattern: What is the state of the art? Ecosystems 1:143-156.

February 13/15

Tischendorf, L. 2001. Can landscape indices predict ecological processes consistently? Landscape Ecology 16:235-254.

Jones, K. B., A. C. Neale, M. S. Nash, R. D. Van Remortel, J. D. Wickham, K. H. Riitters and R. V. O'Neill. 2001. Predicting nutrient and sediment loadings to streams from landscape metrics: A multiple watershed study from the United States Mid-Atlantic Region. Landscape Ecology 16:301-312.

February 20/22

Bell, G., M. J. Lechowicz, A. Appenzeller, M. Chandler, E. DeBlois, L. Jackson, B. Mackenzie, R. Preziosi, M. Schallenberg, N. Tinker. 1993. The spatial structure of the physical environment. Oecologia 96:114-121.

Pastor, J., B. Dewey, R. Moen, D. J. Mladenoff, M. White and Y. Cohen. 1998. Spatial patterns in the moose-forest-soil ecosystem on Isle Royale, Michigan, USA. Ecological Applications 8:411-424.

February 27/March 1

With, K. A., and A. W. King. 1997. The use and misuse of neutral landscape models in ecology. Oikos 79:219-229.

With, K. A., S. J. Cadaret, and C. Davis. 1999. Movement responses to patch structure in experimental fractal landscapes. Ecology 80(4):1340-1353.

March 6/8

Urban, D. L., M. F. Acevedo, and S. L. Garman. 1999. Scaling fine-scale processes to large-scale patterns using models derived from models: meta-models. Pages 70-98 in D. J. Mladenoff and W. L. Baker, editors. Spatial modeling of forest landscape change. Cambridge University Press, Cambridge.

Dale, V. H. and S. M. Pearson 1999. Modeling the driving factors and ecological consequences of deforestation in the Brazilian Amazon. Pages 256-276 in D. J. Mladenoff and W. L. Baker, editors. Spatial modeling of forest landscape change. Cambridge University Press, Cambridge.

March 13/15 –LONG-TERM LANDSCAPE DEVELOPMENT-Readings TBA

March 20/22

Kramer, M. G., A. J. Hansen, M. L. Taper, and E. J. Kissinger. 2001. Abiotic controls on long-term windthrow disturbance and temperate rain forest dynamics in southeast Alaska. Ecology 82(10):2749-2768.

Landres, P. B., P. Morgan, and F. J. Swanson. 1999. Overview of the use of natural variability concepts in managing ecological systems. Ecological Applications 9:1179-1188.

April 3/5

Frelich, L. E. and P. B. Reich. 1999. Neighborhood effects, disturbance severity, and community stability. Ecosystems 2:151-166.

Wu, J., and O. L. Loucks. 1995. From balance of nature to hierarchical patch dynamics: a paradigm shift in ecology. Quarterly Review of Biology 70:439-466.

April 10/12

Trzcinski, M. K., L. Fahrig, and G. Merriam 1999. Independent effects of forest cover and fragmentation on the distribution of forest breeding birds. Ecological Applications 9(2):586-593.

Metzger, J. P. 2000. Tree functional group richness and landscape structure in a Brazilian tropical fragmented landscape. Ecological Applications 10:1147-1161.

Mitchell, M. S., R. A. Lancia and J. A. Gerwin. 2001. Using landscape-level data to predict the distribution of birds on a managed forest: effects of scale. Ecological Applications 11:1692-1708.

April 17/19

Augustine, D. J. and D. A. Frank. 2001. Effects of migratory grazers on spatial heterogeneity of soil nitrogen properties in a grassland ecosystem. Ecology 82:3149-3162.

Hansen, A. J., J. J. Rotella, M. P. V. Kraska and D. Brown. 2000. Spatial patterns of primary productivity in the Greater Yellowstone Ecosystem. Landscape Ecology 15:505-522.

Weller, D. E., T. E. Jordan, and D. L. Correll. 1998. Heuristic models for material discharge from landscapes with riparian buffers. Ecological Applications 8:1156-1169.

April 24/26 – NO CLASS, US-IALE Annual Meeting

May 1/3

White, D., P. G. Minotti, M. J. Barczak, J. C. Sifneos, K. E. Freemark, M. V. Santelmann, C. F. Steinitz, A. R. Kiester, and E. M. Preston. 1997. Assessing risks to biodiversity from future landscape change. Conservation Biology 11:349-360.

Wear, D. N. and P. Bolstad. 1998. Land-use changes in southern Appalachian landscapes: spatial analysis and forecast evaluation. Ecosystems 1:575-594.

Poiani, K. A., B. D. Richter, M. G. Andeson, and H. E. Richter. 2000. Biodiversity conservation at multiple scales: functional sites, landscapes, and networks. BioScience 50:133-146.

May 8

Palik, B. J., P. C. Goebel, L. K. Kirkman and L. West. 2000. Using landscape hierarchies to guide restoration of disturbed ecosystems. Ecological Applications 10:189-202.

O'Neill, R. V., C. T. Hunsaker, K. B. Jones, K. H. Riiters, J. D. Wickham, P. M. Schwartz, I. A. Goodman, B. L. Jackson, and W. S. Baillargeon. 1997. Monitoring environmental quality at the landscape scale. BioScience 47:513-519.

Urban, D. L. 2000. Using model analysis to design monitoring programs for landscape management and impact assessment. Ecological Applications 10:1820-1832.

May 10

Liu, J. and R. J. Hobbs. 2001. Key issues and research topics in landscape ecology. Submitted to Landscape Ecology (and distributed in class with permission of the authors; please do not cite this paper without consulting with the authors.)

2004

TEXTS

Turner, M. G., R. H. Gardner, and R. V. O'Neill. 2001. Landscape ecology in theory and practice. Springer-Verlag, New York. *This will be used as background material and also for the quantitative analyses component of the course.*

Gergel, S. E. and M. G. Turner, editors. 2002. Learning landscape ecology. Springer-Verlag, New York. *This book will be used for our lab exercises.*

WEEKLY DISCUSSION READINGS

FRIDAY, JANUARY 23 – SCOPE OF LANDSCAPE ECOLOGY

Wu, J. and R. J. Hobbs. 2002. Key issues and research priorities in landscape ecology: an idiosyncratic synthesis. Landscape Ecology 17:355-365. *[US synthesis of state of landscape ecology, emerged from a US-IALE symposium.]*

Opdam, P., R. Foppen and C. Vos. 2001. Bridging the gap between ecology and spatial planning in landscape ecology. Landscape Ecology 16:767-779. *[European view on landscape ecology, especially as it relates to planning, which is a strong link in Europe.]*

Reiners WA, Driese KL. 2001. The propagation of ecological influences through heterogeneous environmental space. Bioscience 51:939-950. *[Attempts to develop a broader conceptual framework that is not only focused on the land, but is even more general.]*

Wiens, J. A. 2002. Riverine landscapes: taking landscape ecology into the water. Freshwater Biology 47(4):501-515. *[Perspective from Wiens, leading landscape ecologist, on what characterizes landscape ecology, and what insights might be gained by its application to riverine systems.]*

WEDNESDAY, JANUARY 28 – CAUSES AND CHANGES IN LANDSCAPE PATTERN

Kramer, M. G., A. J. Hansen, M. L. Taper, and E. J. Kissinger. 2001. Abiotic controls on long-term windthrow disturbance and temperate rain forest dynamics in southeast Alaska. Ecology 82(10):2749-2768. *[This relates to disturbance dynamics also, but does also focuses attention on the importance of the abiotic template.]*

Foster, D. R., D. H. Knight, and J. F. Franklin. 1998. Landscape patterns and legacies resulting from large infrequent forest disturbances. Ecosystems 1:497-510. *[Comparative synthesis of disturbances as causes of change on landscapes, with emphasis on large infrequent disturbances.]*

Black, A. E., P. Morgan, and P. F. Hessburg. 2003. Social and biophysical correlates of change in forest landscapes of the interior Columbia Basin, USA. Ecological Applications 13(1):51-67. *[Reflects the current trend toward examining a wide range of factors associated with or predictive of landscape change, particularly with human land uses.]*

Helmer, E. H. 2000. The landscape ecology of tropical secondary forest in montane Costa Rica. Ecosystems 3:98-114. *[Another example of considering multiple and different types of factors that explain landscape pattern, here old-growth vs. secondary forest in a tropical setting.]*

WEDNESDAY, FEBRUARY 4 – LONG-TERM LANDSCAPE DEVELOPMENT

Baker R.G., E. A. Bettis, D. P. Schwert, D. G. Horton, C. A. Chumbley, L. A. Gonzalez, and M. K. Reagan. 1996. Holocene paleoenvironments of northeast Iowa. Ecological Monographs 66 (2): 203-234. *[Landscapes change a lot over long time periods; understanding of these changes comes from paleoecological studies, this being an example from the Midwest.]*

Dupouey, J. L., E. Dambrine, J. D. Laffite and C. Moares. 2002. Irreversible impact of past land use on forest soils and biodiversity. Ecology 83(11):2978-2984. *[European example that looks over a very long time period; focuses on the effects of agriculture. Example of recent focus on the effects of land-use legacies on state of contemporary ecosystems.]*

Cousins, S. A. O. and O. Eriksson. 2002. The influence of management history and habitat on plant species richness in a rural hemiboreal landscape, Sweden. Landscape Ecology 17:517-529. *[Analysis looks back to the 17th century using historical records.]*

Parshall, T., D. R. Foster, E. Faison, D. MacDonald and B.C.S. Hansen. 2003. Long-term history of vegetation and fire in pitch pine-oak forests on Cape Cod, Massachusetts. Ecology 84(3):736-748. *[Recent paper from the leading group working on understanding the role of land-use history in shaping today's ecosystems and landscapes. David Foster presented some of this work at the MEG symposium a couple years ago.]*

WEDNESDAY FEBRUARY 11 /13 –QUANTIFYING PATTERN I

Li, H., and J. F. Reynolds. 1995. On definition and quantification of heterogeneity. Oikos 73:280-284. *[Nice conceptual treatment of heterogeneity; older paper, but good food for thought on what is being quantified.]*

Gustafson, E. J. 1998. Quantifying landscape spatial pattern: What is the state of the art? Ecosystems 1:143-156. [*Relatively recent article addressing spatial analyses recognizing both categorical and continuous measures.]*

Dorner et al., 2002. Landscape pattern in topographically complex landscapes: issues and techniques for analysis. Landscape Ecology 17:729-743. *[Recent paper address some of the challenges associated with applying landscape metrics.]*

Moilanen, A. and M. Nieminen. 2002. Simple connectivity measures in spatial ecology. Ecology 83(4):1131-1145. *[Evaluation of different connectivity measurements using an empirical data set; addresses issues of simplicity vs. complexity in the metric and how to evaluate its usefulness.]*

WEDNESDAY FEBRUARY 18 –QUANTIFYING PATTERN II

Wu et al., 2002. Empirical patterns of the effects of changing scale on landscape metrics. Landscape Ecology 17:761-782. *[Recent paper dealing with effects of scale change.]*

Jones, K. B., A. C. Neale, M. S. Nash, R. D. Van Remortel, J. D. Wickham, K. H. Riitters and R. V. O'Neill. 2001. Predicting nutrient and sediment loadings to streams from landscape metrics: A multiple watershed study from the United States Mid-Atlantic Region. Landscape Ecology 16:301-312. *[Sample study of metrics in use!]*

Riitters et al. 2002. Fragmentation of continental United States forests. Ecosystems 5:815-822. *[More on metrics in use! Country-level analysis based on landscape metrics, uses the NLCDB.]*

Tischendorf, L. 2001. Can landscape indices predict ecological processes consistently? Landscape Ecology 16:235-254. *[Modeling analysis, comes from the Fahrig lab, looking at whether the metrics match up to the qualities that are of interest. What do they really tell us? How ought that be evaluated? Where are the pitfalls?]*

WEDNESDAY FEBRUARY 25–SPATIAL STATISTICS

Dungan, J. L., J. N. Perry, M. R. T. Dale, P. Legendre, S. Citron-Pousty, M.-J. Fortin, A. Jakomulska, M. Miriti, and M.S. Rosenberg. 2002. A balanced view of scale in spatial statistical analysis. Ecography 25(5):626-640. *[This is one from a set of papers that developed from an NCEAS working group, and many of the other papers are also really nice. This is a good review of scale concepts.]*

Wang et al., 2002. Spatial dependence and the relationship of soil organic carbon and soil moisture in Luquillo Experimental forest. Landscape Ecology 17:671-684. *[Fits different types of models for soil variables.]*

Bolstad, PV, Swank W, Vose J. 1998. Predicting Southern Appalachian overstory vegetation with digital terrain data. Landscape Ecology 13:271-283. *[Uses both spatial stats and other predictive models to extrapolate forest community composition to the landscape of Coweeta.]*

Burrows, S. N., S. T. Gower, M. K. Clayton, D. S. Mackay, D. E. Ahl, J. M. Norman and G. Diak. 2002. Application of geostatistics to characterize leaf area index (LAI) from flux tower to landscape scales using a cyclic sampling design. Ecosystems 5:667-679. *[Applies spatial stats in empirical sampling, nice application and description of cyclic sampling.]*

WEDNESDAY MARCH 3 – LANDSCAPE MODELS, NEUTRAL LANDSCAPE MODELS

With, K. A., and A. W. King. 1997. The use and misuse of neutral landscape models in ecology. Oikos 79:219-229. *[Earlier than most of our readings, but still the most succinct and complete discussion of neutral landscape models and their use.]*

With, K. A., D. M. Pavuk, J. L. Worchuck, R. K. Oates, and J. L. Fisher. 2002. Threshold effects of landscape structure on biological control in agroecosystems. Ecological Applications 12(1):52-65. *[Kim has been a leader in NLM and EMS research, integrating theory with empirical study.]*

Mladenoff, D. J. and W. L. Baker. 1999. Development of forest and landscape modeling approaches. Pages 1-13 in D. J. Mladenoff and W. L. Baker, editors. Spatial modeling of forest landscape change. Cambridge University Press, Cambridge. *[Intro chapter to a book edited by the same authors, lays out development of forest landscape modeling.]*

Baker, W. L. and D. J. Mladenoff. 1999. Progress and future directions in spatial modeling of forest landscapes. Pages 333-350 in in D. J. Mladenoff and W. L. Baker, editors. Spatial modeling of forest landscape change. Cambridge University Press, Cambridge. *[Concluding chapter to a book edited by the same authors,looks forward.]*

Rastetter, E.B., J. D. Aber, D. P. C. Peters, D. S. Ojima, I. C. Burke. 2003. Using mechanistic models to scale ecological processes across space and time. BioScience 53(1): 68-76. *[General paper from the set that showcased LTER research by several leaders in modeling and its application to landscape studies.]*

WEDNESDAY MARCH 10–DISTURBANCE AND LANDSCAPES

Paine, R. T., M. J. Tegner, and E. A. Johnson. 1998. Compounded perturbations yield ecological surprises. Ecosystems 1:535-545. *[Dealing with multiple disturbances is important, and this deals with unexpected effects.]*

Bebi, P., D. Kulakowski and T. T. Veblen. 2003. Interactions between fire and spruce beetles in a subalpine Rocky Mountain forest landscape. Ecology 84:362-371. *[Interaction between multiple disturbances.]*

Perry, G. L. W. 2002. Landscapes, space and equilibrium: shifting viewpoints. Progress in Physical Geography 26(3):339-359. *[Recent synthesis of an issue of long-term interest and importance in ecology.]*

Jules, E. S., M. J. Kauffman, W. D. Ritts and A. L. Carroll. 2002. Spread of an invasive pathogen over a variable landscape: a nonnative root rot on Port Orford Cedar. Ecology 83(11):3167-3181. [Interaction of roads and creeks; invasive species and l.s. patterns; plant pathogen.]

WEDNESDAY MARCH 24 – ORGANISMS

Fagan, W. F. 2002. Connectivity, fragmentation, and extinction risk in dendritic metapopulations. Ecology 83(12):3243-3249. *[Compliments other metapopulation work by examining the dendritic connections in river-creek systems; relevant for how general various ideas are. nice example of alternative geometries.]*

Kie, J. G., R. T. Bowyer, M. C. Nicholson, B. B. Boroski, and E. R. Loft. 2002. Landscape heterogeneity at differing scales: effects on spatial distribution of mule deer. Ecology 83(2):530-544. *[Integration of landscape concepts and methods with telemetry data; uses current methods of resource selection function for organisms.]*

Tallmon, D. A., E. S. Jules, N. J. Radke, and L. S. Mills. 2003. Of mice and men and Trillium: cascading effects of forest fragmenetation. Ecological Applications 13(5):1193-1203. *[Illustrates how indirect effects can emerge from how populations respond to spatial heterogeneity; moves beyond the single species (or functional group)-space study.]*

Lundberg, J. and F. Moberg. 2003. Mobile link organisms and ecosystem functioning: implications for ecosystem resilience and management. Ecosystems 6:87-98. *[Conceptual discussion of mobile organisms as a vector that moves around; extends beyond the habitat-use mode of thinking about organisms moving around in landscapes; not "l.e', but certainly relevant, bridges to other theory.]*

Steffan-Dewenter, I., U. Munzenberg, C. Burger, C. Thies and T. Tscharntke. 2002. Scale-dependent effects of landscape context on three pollinator guilds. Ecology 83:1421-1432. *[Example uses plant-pollinator interaction, and also demonstrates study conducted at multiple scales, this is still fundamental to many studies; German research].*

MARCH 31-APRIL2— NO CLASS , US-IALE MEETING

WEDNESDAY APRIL 7 – ECOSYSTEM PROCESSES

Currie and Nadelhoffer, 2002. The imprint of land-use history: patterns of carbon and nitrogen in downed woody debris at the Harvard Forest. Ecosystems 5:446-460. *[Role of land-use or disturbance legacies on contemporary ecosystem process measurements is area of current interest.]*

Seagle, S.W. 2003. Can deer foraging in multiple-use landscapes alter forest nitrogen budgets? Oikos 103:230-234. *[Organisms respond to spatial pattern and their movements/activities produce important nutrient transfers across the landscape; landscape pattern may influence these.]*

Strayer, D. L., R. E. Beighley, L. C. Thompson, S. Brooks, C. Nilsson, G. Pinay, and R. J. Naiman. 2003. Effects of land cover on stream ecosystems: roles of empirical models and scaling issues. Ecosystems 6(5):407-423. *[Recent synthesis of big literature relating landscape pattern to streams.]*

TBA—final chapter or two from the book that emerged from the May 2003 Tenth Cary Conference, Ecosystem processes in heterogeneous landscapes. Chapters are currently being revised by authors.

APRIL 14 – APPLIED LANDSCAPE ECOLOGY I –FRAGMENTATION, RESOURCE MANAGEMENT

Haila, Y. 2002. A conceptual genealogy of fragmentation research: from island biogeography to landscape ecology. Ecological Applications 12(2):321-334. *[History of this issue.]*

McGarigal, K. and S. A. Cushman. 2002. Comparative evaluation of experimental approaches to the study of habitat fragmentation effects. Ecological Applications 12(2):335-345. *[Part of a special feature on habitat fragmentation, this article reviews 134 experimental fragmentation studies published in three major ecological journals.]*

Boutin, S. and D. Herbert. 2002. Landscape ecology and forest management: developing an effective partnership. Ecological Applications 12(2):390-397. *[Closing article in a nice special feature on fragmentation studies.]*

Wiens, J. A., B. Van Horne and B. R. Noon. 2002. Integrating landscape structure and scale into natural resource management. Pages 23-67 in J. Liu and W. W. Taylor, editors. Integrating landscape ecology into natural resource management. Cambridge University Press, Cambridge, UK.

Schneider, R. L., E. L. Mills and D. C. Josephson. 2002. Aquatic-terrestrial linkages and implications for landscape management. Pages 241-262 in J. Liu and W. W. Taylor, editors. Integrating landscape ecology into natural resource management. Cambridge University Press, Cambridge, UK.

WEDNESDAY APRIL 21—APPLIED LANDSCAPE ECOLOGY II – LAND USE, RESTORATION

Wear, D. N. and P. Bolstad. 1998. Land-use changes in southern Appalachian landscapes: spatial analysis and forecast evaluation. Ecosystems 1:575-594. *[Modeling study that won the US-IALE publication award, illustrates current approaches to land-use change models and predictions.]*

Costanza, R., A. Voinov, R. Boumans, T. Maxwell, F. Villa, L. Wainger and H. Voinov. 2002. Integrated ecological economic modeling of the Patuxent River watershed, Maryland. Ecological Monographs 72(2):203-232. *[Example of how modeling is becoming important in considering land use effects.]*

Palik, B. J., P. C. Goebel, L. K. Kirkman and L. West. 2000. Using landscape hierarchies to guide restoration of disturbed ecosystems. Ecological Applications 10:189-202. *[How does landscape ecology fit in with restoration ecology?]*

Lugo, A. E. 2002. Can we manage tropical landscapes? – an answer from the Caribbean perspective. Landscape Ecology 17:601-615. *[Nice essay describing changes in the PR landscape, historical perspective; integrates with succession and management.]*

FRIDAY APRIL 23 – FUTURE DIRECTIONS IN LANDSCAPE ECOLOGY

Manel, S., M. K. Schwartz, G. Luikart and P. Taberlet. 2003. Landscape genetics: combining landscape ecology and population genetics. Trends in Ecology and Evolution 18(4):189-197. *[There is tremendous opportunity for linking some of the new molecular/genetic techniques with understanding the dynamics of species over large spatial areas. Not much has been done, nor has landscape ecology integrated much with evolutionary theory.]*

Nicolson, C., J. E. Pizzuto, G. E. Moglen, M. A. Palmer, E. H. Stanley, N. E. Bockstael, and L. C. Thompson. 2002. Ten heuristics for interdisciplinary modeling projects. Ecosystems 5:376-384. *[Many landscape studies are collaborative, and often interdisciplinary; this paper applies to modeling projects directly but also more generally to interdisciplinary group projects.]*

Teixido, N., J. Garrabou, and W. E. Arntz. 2002. Spatial pattern quantification of Antarctic benthos communities using landscape indices. Marine Ecology Progress Series 242:1-14. *[How widely applicable are the methods, concepts, approaches of landscape ecology to aquatic or marine systems? What is similar, what is different?]*

Bastian, O. 2001. Landscape ecology: towards a unified discipline? Landscape Ecology 16(8):757-766. *[Representative of the European perspective; illustrates one view of where landscape ecology should go.]*

2006

TEXTS

Turner, M. G., R. H. Gardner, and R. V. O'Neill. 2001. Landscape ecology in theory and practice. Springer-Verlag, New York. *This will be used as background material and also for the quantitative analyses component of the course.*

Gergel, S. E. and M. G. Turner, editors. 2002. Learning landscape ecology. Springer-Verlag, New York. *This book will be used for our lab exercises.*

WEEKLY DISCUSSION READINGS

FRIDAY, JAN 20 – SCOPE OF LANDSCAPE ECOLOGY

Background

Turner, M. G. 2005. Landscape ecology: what is the state of the science? Annual Review of Ecology, Evolution and Systematics.

Discussion

•Wu, J. and R. J. Hobbs. 2002. Key issues and research priorities in landscape ecology: an idiosyncratic synthesis. Landscape Ecology 17:355-365. *[US synthesis of state of landscape ecology, emerged from a US-IALE symposium.]*

•Wiens, J. A. 2002. Riverine landscapes: taking landscape ecology into the water. Freshwater Biology 47:501-515. *[Perspective from Wiens, leading landscape ecologist, on what characterizes landscape ecology, and what insights might be gained by its application to riverine systems. Landscape ecology is not just terrestrial!]*

WEDNESDAY, JANUARY 25 – LANDSCAPE ECOLOGY COMES OF AGE

SPECIAL FEATURE—LANDSCAPE ECOLOGY. 2005. Ecology 86(8):1965-2017.

[*This special feature was designed to present the current state of landscape ecology, focusing on a selected set of issues.*]

•Fortin, M-J and A. A. Agrawal. 2005. Landscape ecology comes of age. Ecology 86:1965–1966.

•Turner, M. G. 2005. Landscape ecology in North America: past, present and future. Ecology 86:1967–1974.

•Wagner, H. H. and M-J Fortin. 2005. Spatial analysis of landscapes: concepts and statistics. Ecology 86:1975–1987.

•Bélisle, M. 2005. Measuring landscape connectivity: the challenge of behavioral landscape ecology. Ecology 86:1988–1995.

•Urban, D. L. 2005. Modeling ecological processes across scales. Ecology 86:1996–2006.

•Burgman, M. A., D. B. Lindenmayer, and J. Elith. 2005. Managing landscape for conservation under uncertainty. Ecology 86:2007–2017.

FRIDAY, JANUARY 27 – CAUSES AND CHANGES IN LANDSCAPE PATTERN

•Burgi, M., A. M. Hersperger and N. Schneeberger. 2004. Driving forces of landscape change–current and new directions. Landscape Ecology 19:857-868. [*Discussion of the issues associated with studying landscape change; perspective from both Europe and from environmental history.*]

•Kramer MG, Hansen AJ, Taper ML, Kissinger EJ. 2001. Abiotic controls on long-term windthrow disturbance and temperate rain forest dynamics in southeast Alaska. *Ecology* 82:2749-68. [*Importance of the abiotic template in influencing landscape changes, here natural disturbance patterns.*]

•Parsons M, McLoughlin CA, Kotschy KA, Rogers KH, Rountree MW. 2005. The effects of extreme floods on the biophysical heterogeneity of river landscapes. Frontiers in Ecology and the

Environment 3(9): 487-494. [*Disturbances are a key driver of landscape patterns; again, aquatic systems are suitable subjects for landscape ecology studies!*]

•Black, A. E., P. Morgan, and P. F. Hessburg. 2003. Social and biophysical correlates of change in forest landscapes of the interior Columbia Basin, USA. Ecological Applications 13(1):51-67. *[Reflects the current trend toward examining a wide range of factors associated with or predictive of landscape change, particularly with human land uses.]*

FRIDAY, FEB 3 – LONG-TERM LANDSCAPE DEVELOPMENT

•Baker R.G., E. A. Bettis, D. P. Schwert, D. G. Horton, C. A. Chumbley, L. A. Gonzalez, and M. K. Reagan. 1996. Holocene paleoenvironments of northeast Iowa. Ecological Monographs 66 (2): 203-234. *[Landscapes change a lot over long time periods; understanding of these changes comes from paleoecological studies, this being an example from the Midwest.]*

•Dupouey, J. L., E. Dambrine, J. D. Laffite and C. Moares. 2002. Irreversible impact of past land use on forest soils and biodiversity. Ecology 83(11):2978-2984. *[European example that looks over a very long time period; focuses on the effects of agriculture. Example of recent focus on the effects of land-use legacies on state of contemporary ecosystems.]*

•Lindborg, R. and O. Eriksson. 2004. Historical landscape connectivity affects present plant species diversity. Ecology 85:1840-1845. [*Example, again from Europe, of the long-term influence of landscape configuration (vs. simply what was done at a given site) for grassland communities.]*

•Bellemare, J., G. Motzkin and D. R. Foster. 2002. Legacies of the agricultural past in the forested present: an assessment of historical land-use effects on rich mesic forests. Journal of Biogeography 29:1401-1420. *[The researchers at Harvard Forest, in particular David Foster, have made enormous contributions in understanding the importance of historical land use on vegetation of New England. This is but one example of a large body of work.]*

FRIDAY, FEB 10—QUANTIFYING PATTERN I

Good background

Li, H., and J. F. Reynolds. 1995. On definition and quantification of heterogeneity. Oikos 73:280-284. *[Nice conceptual treatment of heterogeneity; older paper, but good food for thought on what is being quantified.]*

For discussion

•Gustafson, E. J. 1998. Quantifying landscape spatial pattern: What is the state of the art? Ecosystems 1:143-156. [*Relatively recent article addressing spatial analyses recognizing both categorical and continuous measures.]*

•Teixido, N., J. Garrabou, and W. E. Arntz. 2002. Spatial pattern quantification of Antarctic benthos communities using landscape indices. Marine Ecology Progress Series 242:1-14. *[Application of landscape metrics to non-traditional landscapes--How widely applicable are the methods, concepts, approaches of landscape ecology to aquatic or marine systems? What is similar, what is different?]*

•Dorner, B., K. Lertzman and J. Fall. 2002. Landscape pattern in topographically complex landscapes: issues and techniques for analysis. Landscape Ecology 17:729-743. *[Recent paper addresses some of the challenges associated with applying landscape metrics.]*

•Li, H. and J. Wu. 2004. Use and misuse of landscape indices. Landscape Ecology 19:389-399. *[Recent synthesis of issues associated with quantifying landscape patterns.]*

FRIDAY, FEB 17 – QUANTIFYING PATTERN II

•Riitters KH, Wickham JD, O'Neill RV, Jones KB, Smith ER, et al. 2002. Fragmentation of continental United States forests. Ecosystems 5:815-22. [*Example of using landscape metrics to quantify broad-scale patterns of interest.*]

•Wu, J. 2004. Effects of changing scale on landscape pattern analysis: scaling relations. Landscape Ecology 19:125-138. *[Recent paper dealing with effects of scale change.]*

•Fortin, M-J, B. Boots, F. Csillag and T. K. Remmel. 2003. On the role of spatial stochastic models in understanding landscape indices. Oikos 102:203-212.

•Remmel TK, F. Csillag. 2003. When are two landscape pattern indices significantly different? J. Geograph. Syst. 5:331-351.

FRIDAY, FEB 24 – SPATIAL STATISTICS

•Bolstad, PV, Swank W, Vose J. 1998. Predicting Southern Appalachian overstory vegetation with digital terrain data. Landscape Ecology 13:271-283. *[Uses both spatial stats and other predictive models to extrapolate forest community composition to the landscape of Coweeta.]*

•Wang, H., C. A. S. Hall, J. D. Cornell and M. H. P. Hall. 2002. Spatial dependence and the relationship of soil organic carbon and soil moisture in Luquillo Experimental forest. Landscape Ecology 17:671-684. *[Fits different types of models for soil variables.]*

•Fraterrigo, J. M., M. G. Turner, S. M. Pearson, and P. Dixon. 2005. Effects of past land use on spatial heterogeneity of soil nutrients in Southern Appalachian forests. Ecological Monographs 75:215-230. [*Uses spatial heterogeneity and scale of pattern as a response variable when testing for the effects of land-use legacies in soils.*]

•Schwarz, P. A., T. J. Fahey and C. E. McCullouch. 2003. Factors controlling spatial variation of tree species abundance in a forested landscape. Ecology 84:1862-1878. [*Uses semivariograms to understand mechanisms driving tree species patterns.*]

FRIDAY, MAR 3 – LANDSCAPE MODELS

•With, K. A., and A. W. King. 1997. The use and misuse of neutral landscape models in ecology. Oikos 79:219-229. [*Earlier than most of our readings, but still the most succinct and complete discussion of neutral landscape models and their use.*]

•Strayer DL, Ewing HA, Bigelow S. 2003a. What kind of spatial and temporal details are required in models of heterogeneous systems? *Oikos* 102:654-62. [*Nice treatment of the issues associated with introducing spatial complexity into models.*]

•Costanza, R., A. Voinov, R. Boumans, T. Maxwell, F. Villa, L. Wainger and H. Voinov. 2002. Integrated ecological economic modeling of the Patuxent River watershed, Maryland. Ecological Monographs 72(2):203-232. *[Example of how modeling is becoming important in considering land use effects.]*

•Nassauer, J. I. and R. C. Corry. 2004. Using normative scenarios in landscape ecology. Landscape Ecology 19:343-356. [*Example of a different type of model, and coming from outside the traditional realm of ecological modeling.*]

FRIDAY, MAR 10 – DISTURBANCE AND LANDSCAPES

•Perry, G. L. W. 2002. Landscapes, space and equilibrium: shifting viewpoints. Progress in Physical Geography 26(3):339-359. *[Recent synthesis of an issue of long-term interest and importance in ecology.]*

•Mermoz, M., T. Kitzberger and T. T. Veblen. 2005. Landscape influences on occurrence and spread of wildfires in Patagonian forests and shrublands. Ecology 86(10):2705-2715. [*Study addresses 4 questions related to the biotic and abiotic influences on fire occurrence, examining the effect of l.s. heterogeneity on disturbance.*]

•Bebi, P., D. Kulakowski and T. T. Veblen. 2003. Interactions between fire and spruce beetles in a subalpine Rocky Mountain forest landscape. Ecology 84:362-371. *[Interaction between multiple disturbances, which is just starting to get some reasonable attention.]*

•DeGayner, E. J., M. G. Kramer, J. G. Doerr and M. J. Robertsen. 2005. Windstorm disturbance effects on forest structure and black bear dens in southeast Alaska. Ecological Applications 15(4):1306-1316. [*This study relates the disturbance regime to a focal population through a spatially explicit*

model that predicts habitat changes and field data; thus, it moves toward another ecological link in terms of disturbance-created heterogeneity.]

FRIDAY, MAR 24 – ORGANISMS AND LANDSCAPES

•Murphy, H.T. and J. Lovett-Doust. 2004. Context and connectivity in plant metapopulations and landscape mosaics: does the matrix matter? Oikos *1*05:3-14. [*It isn't just the patches that are important! Also a nice comparison of metapopulation and landscape approaches.*]

•Steffan-Dewenter, I., U. Munzenberg, C. Burger, C. Thies and T. Tscharntke. 2002. Scale-dependent effects of landscape context on three pollinator guilds. Ecology 83:1421-1432. *[Example uses plant-pollinator interaction, and also demonstrates study conducted at multiple scales, this is still fundamental to many studies; German research].*

•Stoffels, R. J., K. R. Clarke and G. P. Closs. 2005. Spatial scale and benthic community organization in the littoral zones of large oligotrophic lakes: potential for cross-scale interactions. Freshwater Biology 20:1131-1145. [*Illustrates an approach to dealing with interactions across scales, and is in a system (benthic invertebrate community)) not usually attended to by landscape ecologists—indeed, I don't think they use the term at all!*]

•Hebblewhite, M., E. H. Merrill and T. L. McDonald. 2005. Spatial decomposition of predation risk using resource selection functions: an example in a wolf-elk predator-prey system. Oikos 111:101-111. [*Paper decomposing spatial risk of predation on the landscape, focusing on how spatial heterogeneity influences different components of the pred-prey interaction.*]

FRIDAY, MAR 31 – SPATIAL HETEROGENEITY AND ECOSYSTEM PROCESSES

•Strayer, D. L., R. E. Beighley, L. C. Thompson, S. Brooks, C. Nilsson, G. Pinay, and R. J. Naiman. 2003. Effects of land cover on stream ecosystems: roles of empirical models and scaling issues. Ecosystems 6:407-423. *[Recent synthesis of a big empirical literature relating landscape pattern to streams.]*

•Gergel, S. E. 2005. Spatial and non-spatial factors: When do they affect landscape indicators of watershed loading? Landscape Ecology 20:177-189. [*Recent modeling study addressing when spatial pattern might be important for nutrient inputs to surface water; example of using a neutral landscape model as basis for process study.*]

•Seagle, S.W. 2003. Can deer foraging in multiple-use landscapes alter forest nitrogen budgets? Oikos 103:230-234. *[Organisms respond to spatial pattern and their movements/activities produce important nutrient transfers across the landscape; landscape pattern may influence these, and linking organisms to ecosystem processes is facilitated by a landscape approach.]*

•Jenerette, D. G. and Wu. 2004. Oikos. [*Understanding the spatial heterogeneity of biogeochemical processes—causes, consequences, scales of variability, etc.—is still in its infancy. This paper attempts to link spatial patterns to N cycing.*]

FRIDAY, APRIL 7 – APPLIED LANDSCAPE ECOLOGY I (FRAGMENTATION, CONSERVATION)

•Haila Y. 2002. A conceptual genealogy of fragmentation research: from island biogeography to landscape ecology. *Ecol. Appl.* 12:321-334. [*Evolution of L.E. ideas from perspective of the population folks*.]

•Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution and Systematics 34:487-515. [*Overview of current understanding of fragmentation effects from a leading landscape ecologist who has focused primarily on how populations respond to heterogeneous landscapes—and the MEG speaker this month.*]

•Bruinderink GG, Van Der Sluis T, Lammertsma D, Opdam P, Pouwels R. 2003. Designing a coherent ecological network for large mammals in northwestern Europe. *Conserv. Biol.* 17:549-57. [*Developing conservation networks has been a major focus of European researchers*.]

•Polasky, S., E. Nelson, E. Lonsdorf, P. Fackler and A. Starfield. 2005. Conserving species in a working landscape: land use with biological and economic objectives. Ecological Applications

15(4):1387-1401. [*Integrating social/economic/ecological variables in the same analysis remains an important goal.*]

FRIDAY, APRIL 14 – APPLIED LANDSCAPE ECOLOGY II (LAND-USE CHANGE)

Brown, D. G., K. M. Johnson, T. R. Loveland and D. M. Theobald. 2005. Rural land-use trends in the conterminous United States, 1950-2000. Ecological Applications 15:1851-1863. [*One paper from a special feature on land-use change in rural America, nicely describing current trends.*]

Hansen, A. J., R. L. Knight, J. M. Marzluff, S. Powell, K. Brown, P. H. Gude and K. Jones. 2005. Effects of exurban development on biodiversity: patterns, mechanisms, and research needs. Ecological Applications 15:1893-1905. [*Also from the special feature, provides an overview of some of the ecological implications of these changing patterns of land use.*]

Gustafson, E. J., R. B. Hammer, V. C. Radeloff and R. S. Potts. 2005. The relationship between environmental amenities and changing human settlement patterns between 1980 and 2000 in the Midwestern USA. Landscape Ecology 20:773-789. [*Local example from our neck of the woods dealing with the wildland-urban interface* .]

Levy, P. E., A. D. Friend, A. White and M. G. R. Cannell. 2004. The influence of land use change on global-scale fluxes of carbon from terrestrial ecosystems. Climatic Change 67:185-209. [*Along with regional land-use changes, there is tremendous interest in understanding the effects of land-use change on a variety of global-scale processes, including carbon fluxes.*]

WEDNESDAY, APRIL 19 – FUTURE DIRECTIONS IN LANDSCAPE ECOLOGY

<u>Invasive species</u>

•With, K. A. 2002. The landscape ecology of invasive spread. Conserv. Biol. 16:1192-1203. [*Conceptual paper using neutral landscape models to reason through the implications of landscape structure for the spread of an invasive species.*]

•Knight, K. S. and P. B. Reich. 2005. Opposite relationships between invasibility and native species richness at patch vs. landscape scales. Oikos 109:81-88. [*Empirical. Relationship between buckthorn abundance and native species richness changes direction at different scales. Invasive species at landscape scales getting more attention recently.*]

<u>Landscape genetics:</u>

•Manel, S., M. K. Schwartz, G. Luikart and P. Taberlet. 2003. Landscape genetics: combining landscape ecology and population genetics. Trends in Ecology and Evolution 18:189-197. [*The recent developments in genetics offer an enormous opportunity to evaluate factors like relatedness and dispersal patterns in landscapes. This has really taken off among ecologists in Europe.*]

<u>Disease spread as affected by landscape pattern</u>

•Allan, BF, Keesing F, Ostfeld RS. 2003. Effect of forest fragmentation on Lyme disease risk. *Conserv. Biol.* 17:267-272. [*Looking at the interaction of landscape pattern and disease is an interesting contemporary topic. Ostfeld's group has done the bulk of the work on Lyme disease.*]

<u>Cross-scale interactions and spatial thresholds</u>

•Peters, D. P. C., R. A. Pielke, Sr., B. T. Bestelmeyer, C. D. Allen, S. Munson-McGee and K. M. Havstad. 2004. Cross-scale interactions, nonlinearities, and forecasting catastrophic events. Proceedings of the National Academy of Sciences 101:15130-15135. [*Illustrates a conceptual approach for linking cross-scale phenomena and understanding critical threshold dynamics.*]

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TEXTS

Turner, M. G., R. H. Gardner, and R. V. O'Neill. 2001. Landscape ecology in theory and practice. Springer-Verlag, New York. *This will be used as background material and also for the quantitative analyses component of the course.*

Gergel, S. E. and M. G. Turner, editors. 2002. Learning landscape ecology. Springer-Verlag, New York. *This book will be used for our lab exercises.*

WEEKLY DISCUSSION READINGS

Friday, January 25 – Scope of landscape ecology, conceptual issues, scale, foundations

Background for lecture:

Turner, M. G. 2005. Landscape ecology: what is the state of the science? Annual Review of Ecology, Evolution and Systematics. [*My perspective on the more recent progress in landscape ecology.*]

For discussion—some recent perspectives on L.E. from different angles:

Kent, M. 2007. Biogeography and landscape ecology. Progress in Physical Geography 31:345-355. [*Perspectives from a British geographer*.]

Fu, B-j and Y-h Lu. 2006. The progress and perspectives of landscape ecology in China. Progress in Physical Geography 30:232-244. [*Much of the literature from China is not in English, thus this paper provides a valuable insight into the rapid development of landscape ecology in China.*]

Wednesday, January 30 – Causes of landscape pattern

Black, A. E., P. Morgan, and P. F. Hessburg. 2003. Social and biophysical correlates of change in forest landscapes of the interior Columbia Basin, USA. Ecological Applications 13(1):51-67. *[Reflects the current trend toward examining a wide range of factors associated with or predictive of landscape change, particularly with human land uses.]*

Ernoult, A., S Freire-Diaz, E. Langlois and D. Alard. 2006. Are similar landscapes the results of similar histories? Landscape Ecology 21:631-639. [*Makes the point that similar sites could have developed from different histories, and similarly, similar initial patterns could produce different trajectories.*]

Schulte, L. A., D. J. Mladenoff, T. R. Crow, Laura C. Merrick, and D. T. Cleland. 2007. Homogenization of northern U.S. Great Lakes forests due to land use. Landscape Ecology 22:1089-1103. [*What about when some drivers cause a reduction, rather than an increase, in spatial heterogeneity?*]

Friday, February 1 – Landscape ecology comes of age (extended discussion)

SPECIAL FEATURE—LANDSCAPE ECOLOGY. 2005. Ecology 86(8):1965-2017. [*This special feature was designed to present the current state of landscape ecology, focusing on a selected set of issues.*]

Fortin, M-J and A. A. Agrawal. 2005. Landscape ecology comes of age. Ecology 86:1965–1966.

Turner, M. G. 2005. Landscape ecology in North America: past, present and future. Ecology 86:1967–1974.

Wagner, H. H. and M-J Fortin. 2005. Spatial analysis of landscapes: concepts and statistics. Ecology 86:1975–1987.

Bélisle, M. 2005. Measuring landscape connectivity: the challenge of behavioral landscape ecology. Ecology 86:1988–1995.

Urban, D. L. 2005. Modeling ecological processes across scales. Ecology 86:1996–2006.

Burgman, M. A., D. B. Lindenmayer, and J. Elith. 2005. Managing landscape for conservation under uncertainty. Ecology 86:2007–2017.

Wednesday, February 6 – Long-term landscape development

Jackson, S. T. 2006. Vegetation, environment and time: the origination and termination of ecosystems. Journal of Vegetation Science 17:547-557.

Baker R.G., E. A. Bettis, D. P. Schwert, D. G. Horton, C. A. Chumbley, L. A. Gonzalez, and M. K. Reagan. 1996. Holocene paleoenvironments of northeast Iowa. Ecological Monographs 66 (2): 203-234. *[Landscapes change a lot over long time periods; understanding of these changes comes from paleoecological studies, this being an excellent example from the Midwest.]*

Dupouey, J. L., E. Dambrine, J. D. Laffite and C. Moares. 2002. Irreversible impact of past land use on forest soils and biodiversity. Ecology 83:2978-2984. *[European example that looks over a very long time period; focuses on the effects of agriculture. Example of recent focus on the effects of land-use legacies on state of contemporary ecosystems.]*

Faison, E. K., D. R. Foster, W. W. Oswald, B. C. S. Hansen and E Doughty. 2006. Early Holocene openlands in southern New England. Ecology 87:2537-2547. [*Recent paper from the Harvard Forest research team addressing a particular element of the landscape and providing the long-term context for understanding its occurrence.*]

Wednesday, February 13 – Quantifying pattern

Good background:

Li, H., and J. F. Reynolds. 1995. On definition and quantification of heterogeneity. Oikos 73:280-284. *[Nice conceptual treatment of heterogeneity; older paper, but good food for thought on what is being quantified.]*

Gustafson, E. J. 1998. Quantifying landscape spatial pattern: What is the state of the art? Ecosystems 1:143-156. [*Relatively recent article addressing spatial analyses recognizing both categorical and continuous measures.]*

For discussion:

Li, H. and J. Wu. 2004. Use and misuse of landscape indices. Landscape Ecology 19:389-399. *[Recent synthesis of issues associated with quantifying landscape patterns.]*

Teixido, N., J. Garrabou, J. Gutt and W. E. Arntz. 2007. Iceberg disturbance and successional spatial patterns: the case of the shelf Antarctic benthic communities. Ecosystems 10:142-157. [*Nice example of an more unusual landscape in which landscape metrics are applied, and also an example of taking a multivariate analysis approach to multiple metrics.*]

Dorner, B., K. Lertzman and J. Fall. 2002. Landscape pattern in topographically complex landscapes: issues and techniques for analysis. Landscape Ecology 17:729-743. *[Recent paper addresses some of the challenges associated with applying landscape metrics.]*

Fall, A., M.-J. Fortin, M. Manseau, and D. O'Brien. 2007. Spatial graphs: principles and applications for habitat connectivity. Ecosystems 10:448-461. [*Thinking outside the patch: spatial application of graph theory, offering a different perspective on spatial pattern analysis with a sample application.*]

Wednesday, February 20 – Quantifying pattern, cont'd

Wu, J. 2004. Effects of changing scale on landscape pattern analysis: scaling relations. Landscape Ecology 19:125-138. *[Recent paper dealing with effects of scale change on landscape metrics; there is a larger body of literature, and this is an important practical consideration for all studies using landscape metrics.]*

Fortin, M-J, B. Boots, F. Csillag and T. K. Remmel. 2003. On the role of spatial stochastic models in understanding landscape indices. Oikos 102:203-212. [*Lays out an approach for interpreting landscape metrics numerically.*]

Remmel TK, F. Csillag. 2003. When are two landscape pattern indices significantly different? J. Geograph. Syst. 5:331-351. [*Addresses the key issue of statistical significance when comparing metrics, which has been problematic in many studies.*]

Cardille, J. A., M. G. Turner, M. Clayton, S. Price, and S. E. Gergel. 2005. METALAND: Characterizing spatial patterns and statistical context of landscape metrics. BioScience 55:983-988. [*Presents a framework for examining the spatial pattern of metric values, along with multivariate approaches.*]

Wednesday, February 27 – Spatial statistics

Bolstad, PV, Swank W, Vose J. 1998. Predicting Southern Appalachian overstory vegetation with digital terrain data. Landscape Ecology 13:271-283. *[Uses both spatial stats and other predictive models to extrapolate forest community composition to the landscape of Coweeta; nice comparison of some different methods.]*

Schwarz, P. A., T. J. Fahey and C. E. McCullouch. 2003. Factors controlling spatial variation of tree species abundance in a forested landscape. Ecology 84:1862-1878. [*Uses semivariograms to understand mechanisms driving tree species patterns.*]

Murwira A, and Skidmore A. K. 2005. The response of elephants to the spatial heterogeneity of vegetation in a Southern African agricultural landscape. Landscape Ecology 20:217-234. [*Somewhat lengthy, but illustrates use of semivariograms to examine relationship between animals and habitat.*]

Mayor, S. J., J. A. Schaefer, D. C. Schneider and S. P. Mahoney. 2007. Spectrum of selection: new approaches to detecting the scale-dependent response to habitat. Ecology 88:1634-1640. [*Habitat selection has been a major theme in organism-landscape studies for several years; this is an example of a sophisticated scale-dependent approach using spatial statistics.*]

Wednesday, March 5 – Landscape models

Perry, G. L. W. and N. J. Enright. 2006. Spatial modeling of vegetation change in dynamic landscapes: a review of methods and applications. Progress in Physical Geography 30:47-72. [*Nice recent review of landscape models.*]

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

Gardner, R. H. and D. L. Urban. 2007. Neutral models for testing landscape hypotheses. Landscape Ecology 22:15-29. [*Gardner was lead author of the original neutral landscape model paper; this is a nice summary of the current state of those models.*]

Minor, E. S. and D. L. Urban. 2007. Graph theory as a proxy for spatially explicit population models in conservation planning. Ecology 17:1771-1782. [*Urban has been a key contributor to new quantitative approaches in landscape ecology, and this is a type of model quite different from many that you will read about.]*

Wednesday, March 12 – Disturbance and landscapes

Perry, G. L. W. 2002. Landscapes, space and equilibrium: shifting viewpoints. Progress in Physical Geography 26(3):339-359. *[Synthesis of an issue of long-term interest and importance in ecology.]*

Leroux, S. J., F. K. A. Schmiegelow, R. B. Lessard and S. G. Cumming. 2007. Minimum dynamic reserves: a framework for determining reserve size in ecosystems structured by large disturbances. Biological Conservation 138:464-473. [*Recent paper continuing the discussion of reserve design in the face of disturbance, and approaches that integrate across a wide variety of disturbance types.*]

Kulakowski, D. and T. T. Veblen. 2007. Effect of prior disturbances on the extent and severity of wildfire in Colorado subalpine forests. Ecology 88:759-769. *[Interaction between multiple disturbances, which is just starting to get some reasonable attention.]*

Allen, C. D. 2007. Interactions across spatial scales among forest dieback, fire, and erosion in northern New Mexico landscapes. Ecosystems 10:797-808. [*Consideration of interactions among disturbances, considered in the context of cross-scale interactions.*]

Friday, March 14 – Landscape ecology, climate change, disease (extended discussion)

[*This is an emerging area focused on how spatial heterogeneity can affect disease incidence in plants, animals and people. Literature is developing in both the ecological arena and also the epidemiology arena.*]

Ostfeld, R. S., G. E. Glass and F. Keesing. 2006. Spatial epidemiology: an emerging (or re-emerging) discipline. TREE 20(6):328-336.

Holdenrieder, O., M. Pautasso, P. J. Weisberg and D. Lonsdale. 2004. Tree diseases and landscape processes: the challenge of landscape pathology. TREE 19(8):446-452.

Plantegenest, M., C. Le May, and F. Fabre. 2007. Landscape epidemiology of plant diseases. J. R. Soc. Interface 4:963-972.

Despommier D, Ellis BR, Wilcox BA. 2006. The role of ecotones in emerging infectious diseases. Ecohealth 3(4): 281-289.

Brownstein, J. S., D. K. Skelly, T. R. Holford, and D. Fish. 2005. Forest fragmentation predicts local scale heterogeneity of Lyme disease risk. Oecologia 146:469-475.

Jackson LE, Hilborn ED, Thomas JC. 2006. Towards landscape design guidelines for reducing Lyme disease risk. International Journal of Epidemiology 35 (2): 315-322.

Wednesday, March 26 – Organisms and landscapes

Murphy, H.T. and J. Lovett-Doust. 2004. Context and connectivity in plant metapopulations and landscape mosaics: does the matrix matter? Oikos *1*05:3-14. [*It isn't just the patches that are important! Also a nice comparison of metapopulation and landscape approaches.*]

Henry, M., J-M. Pons and J-F. Cosson. 2007. Foraging behavior of a frugivorous bat helps bridge landscape connectivity and ecological processes in a fragmented rainforest. Journal of Animal Ecology 76:801-813. [*Recent paper with an organism-specific functional approach to landscape connectivity; tropical; integrates measures of landscape with movement data.*]

Hebblewhite, M., E. H. Merrill and T. L. McDonald. 2005. Spatial decomposition of predation risk using resource selection functions: an example in a wolf-elk predator-prey system. Oikos 111:101-111. [*Paper decomposing spatial risk of predation on the landscape, focusing on how spatial heterogeneity influences different components of the pred-prey interaction.*]

Dormann, C. F., O. Schweiger, I. Augenstein and many others. 2007. Effects of landscape structure and land-use intensity on similarity of plant and animal communities. Global Ecology and Biogeography 16:774-787. [*Example of recent studies moving beyond single-species analysis to consider communities.*]

Wednesday, April 2 – Spatial heterogeneity and ecosystem processes

Jenerette, D. G. and J. Wu. 2004. Interactions of ecosystem processes with spatial heterogeneity in the puzzle of nitrogen limitation. Oikos 107:273-282. [*Understanding the spatial heterogeneity of biogeochemical processes—causes, consequences, scales of variability, etc.—is still in its infancy. This paper attempts to link spatial patterns to N cycing.*]

Groffman PM, Pouyat RV, Cadenasso ML, et al. 2006. Land use context and natural soil controls on plant community composition and soil nitrogen and carbon dynamics in urban and rural forests. Forest Ecology and Management 236:177-192. [*Comparing the relative effects of different factors on soil processes in forests.*]

Bennett EM, Carpenter SR, Clayton MK. 2005. Soil phosphorus variability: scale-dependence in an urbanizing agricultural landscape. Landscape Ecology 20: 389-400. [*Local example for the Lake Mendota watershed, where P is the element of importance in land-lake interactions.*]

Burcher, C. L., H. M. Valett and E. F. Benfield. 2007. The land-cover cascade: relationships coupling land and water. Ecology 88:228-242. [*Connecting the dots from land-cover change, as it interacts with other abiotic factors, to adjacent stream systems; also lays out some new approaches for analysis.*]

Wednesday, April 16 – Applied landscape ecology (invasives, land-use change)

With, K. A. 2002. The landscape ecology of invasive spread. Conservation Biology 16:1192-1203. [*Conceptual paper using neutral landscape models to reason through the implications of landscape structure for the spread of an invasive species.*]

Kumar, S., T. J. Stohlgren and G. W. Chong. 2006. Spatial heterogeneity influences native and nonnative plant species richness. Ecology 87:3186-3199. [*Nice paper showing that incorporation of landscape variables always improved the models.*]

Pejchar L, Morgan PM, Caldwell MR, et al. 2007. Evaluating the potential for conservation development: Biophysical, economic, and institutional perspectives. Conservation Biology 21: 69-78. [*Draws in part on lessons from landscape ecology to examine alternative development patterns and effects on biodiversity.*]

Lindenmayer, D., R. J. Hobbs, R. Montague-Drake, and many others. 2008. A checklist for ecological management of landscapes for conservation. Ecology Letters 11:78-91. [*Includes some of the leading landscape ecologists in Australia, nice synthesis of landscape concepts and their application to conservation.*]

Friday, April 18 – Emerging directions (landscape ecology and ecosystem services)

Cumming GS. 2007. Global biodiversity scenarios and landscape ecology. Landscape Ecology 22: 671-685.

Kreme, C., N. M. Williams, M. A. Aizen and 17 other authors. 2007. Pollination and other ecosystem services produced by mobile organisms: a conceptual framework for the effects of land-use change. Ecology Letters 10:299-314.

Swift, M. G., A.-M. N. Izac, and M. van Noordwijk. 2004. Biodiversity and ecosystem services in agricultural landscapes–are we asking the right questions? Agriculture, Ecosystems and Environment 104:113-134.

Tscharntke, T., A. M. Klein, A. Kruess, I. Steffan-Dewenter and C. Thies. 2005. Landscape perspectives on agricultural intensification and biodiversity—ecosystem service management. Ecology Letters 8:857-874.

Wednesday, April 23 – Emerging directions (landscape genetics)

Manel, S., M. K. Schwartz, G. Luikart and P. Taberlet. 2003. Landscape genetics: combining landscape ecology and population genetics. Trends in Ecology and Evolution 18:189-197. [*The recent developments in genetics offer an enormous opportunity to evaluate factors like relatedness and dispersal patterns in landscapes. This has really taken off among ecologists in Europe.*]

Holderegger, R. and H. H. Wagner. 2006. A brief guide to landscape genetics. Landscape Ecology 21:793-796. [*Introduction to a special feature.*]

Hoderegger, R., U. Kamm and F. Gugerli. 2006. Adaptive vs. neutral genetic diversity: implications for landscape genetics. Landscape Ecology 21:797-807. [*Explanations of the genetics that work well for landscape ecologists.*]

Storfer, A., M. A. Murphy, J. S. Evans, C. S. Goldberg, S. Robinson, S. F. Spear, R. Dezzani, E. Delmelle, L. Vierling and L. P. Watts. 2007. Putting the 'landscape' in landscape genetics. Heredity 98:128-142. [*Highlighting the spatial developments that are relevant for genetics, and what might develop from the merger.*]

2010

TEXTS

Turner, M. G., R. H. Gardner, and R. V. O'Neill. 2001. Landscape ecology in theory and practice. Springer-Verlag, New York. *This will be used as background material and also for the quantitative analyses component of the course.*

Gergel, S. E. and M. G. Turner, editors. 2002. Learning landscape ecology. Springer-Verlag, New York. *This book will be used for our lab exercises.*

WEEKLY DISCUSSION READINGS

Friday, January 22 – Scope of landscape ecology, conceptual issues, scale, foundations

Background:

Turner, M. G. 1989. Landscape ecology: the effect of pattern on process. Annual Review of Ecology and Systematics 20:171-197. [*My early review of landscape ecology as the field was developing in North America.*]

Turner, M. G. 2005. Landscape ecology: what is the state of the science? Annual Review of Ecology, Evolution and Systematics. [*My perspective on the more recent progress in landscape ecology, essentially a reprise on the ideas in the 1989 review.*]

For discussion—some recent perspectives on L.E.

Laurance, W. F. 2008. Theory meets reality: how habitat fragmentation research has transcended island biogeographic theory. Biological Conservation 141:1731-1744. [*Nice perspective on how thinking has evolved from roots in island biogeography.*]

Kent, M. 2007. Biogeography and landscape ecology. Progress in Physical Geography 31:345-355. [*Perspectives from a British geographer*.]

Metzger, J. P. 2008. Landscape ecology: perspectives based on the 2007 IALE world congress. Landscape Ecology 23:501-504. [*Perspectives on the discipline from the most recent congress, held every four years, from a South American landscape ecologist.*]

Wiens, J. A. 2008. Allerton Park 1983: the beginnings of a paradigm for landscape ecology? Landscape Ecology 23:125-128. [*Wiens has been an influential thinker since the 1970s; these are some reflections on where L.E. has come since the initial NSF-funded workshop.*]

Wednesday, January 27 – Causes of landscape pattern

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

Plue, J., M. Hermy, K. Verheyen, P. Thuiller, R. Saguez and G. Decocq. 2008. Persistent changes in forest vegetation and seed bank 1,600 years after human occupation. Landscape Ecology 23:673-688. *[Example of recent focus on the effects of land-use legacies on contemporary ecosystems from one of the leading European groups addressing the topic.]*

Arce-Nazario, J. A. 2007. Human landscapes have complex trajectories: reconstructing Peruvian Amazon landscape history from 1948-2005. Landscape Ecology 22:89-101. [*More narrative example of landscape change over time.*]

Crk, T., M. Uriarte, F. Corsi and D. Flynn. 2009. Forest recovery in a tropical landscape: what is the relative importance of biophysical, socioeconomic, and landscape variables? [*Landscape patterns result from multiple, interacting drivers; many studies employ similar statistical methods to identify variables associated with land-cover change.*]

Wednesday, February 3, Quantifying pattern I

Good 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; older paper, but good food for thought on what is being quantified.]*

Gustafson, E. J. 1998. Quantifying landscape spatial pattern: What is the state of the art? Ecosystems 1:143-156. [*Relatively recent article addressing spatial analyses recognizing both categorical and continuous measures.]*

For discussion:

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.]*

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

Teixido, N., J. Garrabou, J. Gutt and W. E. Arntz. 2007. Iceberg disturbance and successional spatial patterns: the case of the shelf Antarctic benthic communities. Ecosystems 10:142-157. [*Nice example of a more unusual landscape in which landscape metrics are applied, and also an example of taking a multivariate analysis approach to multiple metrics.*]

Cardille, J. A. and M. Lambois. 2009. From the redwood forest to the Gulf Stream waters: human signature nearly ubiquitous in representative US landscapes. Frontiers in Ecology and the Environment. Available online. doi:10.1890/080132. [*Using landscape analyses to identify human influence on landscapes.*]

Wednesday, February 10 – Quantifying pattern II

Fortin, M-J, B. Boots, F. Csillag and T. K. Remmel. 2003. On the role of spatial stochastic models in understanding landscape indices. Oikos 102:203-212. [*Lays out an approach for interpreting landscape metrics numerically.*]

Remmel TK, F. Csillag. 2003. When are two landscape pattern indices significantly different? J. Geograph. Syst. 5:331-351. [*Addresses the key issue of statistical significance when comparing metrics, which has been problematic in many studies.*]

McGarigal, K., S. Tagil, and S. A. Cushman. 2009, Surface metrics: an alternative to patch metrics for the quantification of landscape structure. Landscape Ecology 24:433-450. [*A new class of metrics that can be useful in landscape studies.*]

Grant, E. H. C., W. H. Lowe and W. F. Fagan. 2007. Living in the branches: population dynamics and ecological processes in dendritic networks. Ecology Letters 10:165-175. [*Not all systems are analyzed appropriately by "traditional" landscape statistics, and there are other representations of spatial structure.*]

Wednesday, February 17 – Spatial statistics

Gundale, M. J., K. L. Metlen, C. E. Fiedler and T. H. DeLuca. 2006. Nitrogen spatial heterogeneity influences diversity following restoration in a ponderosa pine forest, Montana. Ecological Applications 16:479-489. [*Uses spatial statistics to relate resource heterogeneity to plant community patterns.*]

Smithwick, E. A. H., M. C. Mack, M. G. Turner, F. S. Chapin III, J. Zhu and T. C. Balser. 2005. Spatial heterogeneity and soil nitrogen dynamics in a burned black spruce forest stand: distinct controls at different scales. Biogeochemistry 76:517-537. [*Trying to understand relationships between heterogeneity at different spatial scales.*]

DeJager, N. R. and J. Pastor. 2009. Declines in moose population density at Isle Royale National Park, MI, USA and accompanied changes in landscape patterns. Landscape Ecology 24:1389-1403. [*Understanding changes in continuous response variables in landscape.*]

Mayor, S. J., J. A. Schaefer, D. C. Schneider and S. P. Mahoney. 2007. Spectrum of selection: new approaches to detecting the scale-dependent response to habitat. Ecology 88:1634-1640. [*Habitat selection has been a major theme in organism-landscape studies for several years; this is an example of a sophisticated scale-dependent approach using spatial statistics.*]

Wednesday, February 24– Landscape models

Gardner, R. H. and D. L. Urban. 2007. Neutral models for testing landscape hypotheses. Landscape Ecology 22:15-29. [*Gardner was lead author of the original neutral landscape model paper; this is a nice summary of the current state of those models.*]

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

Perry, G. L. W. and N. J. Enright. 2006. Spatial modeling of vegetation change in dynamic landscapes: a review of methods and applications. Progress in Physical Geography 30:47-72. [*Nice recent review of landscape models.*]

Robinson, D. T., D. G. Brown and W. S. Currie. 2009. Modelling carbon storage in highly fragmented and human-dominated landscapes: linking land-cover patterns and ecosystem models. Ecological Modelling 220:1325-1338. [*Sample modeling study integrating carbon dynamics with landscape pattern.*]

Wednesday, March 3 – Disturbance and landscapes I

Recommended background reading:

Perry, G. L. W. 2002. Landscapes, space and equilibrium: shifting viewpoints. Progress in Physical Geography 26(3):339-359. *[Synthesis of an issue of long-term interest and importance in ecology.]*

For discussion:

Kupfer, J. A., A. T. Myers, S. E. McLane, and G. N. Melton. 2008. Patterns of forest damage in a southern Mississippi landscape caused by Hurricane Katrina. Ecosystems 11:45-60. [*Example of differential susceptibility to disturbance from a relatively recent, high-profile event.*]

Kulakowski, D. and T. T. Veblen. 2007. Effect of prior disturbances on the extent and severity of wildfire in Colorado subalpine forests. Ecology 88:759-769. *[Interaction between multiple disturbances, which is just starting to get some reasonable attention.]*

Allen, C. D. 2007. Interactions across spatial scales among forest dieback, fire, and erosion in northern New Mexico landscapes. Ecosystems 10:797-808. [*Consideration of interactions among disturbances, considered in the context of cross-scale interactions.*]

Ostfeld, R. S., G. E. Glass and F. Keesing. 2006. Spatial epidemiology: an emerging (or re-emerging) discipline. TREE 20(6):328-336. [*Understanding disease patterns for plants, animals or humans in heterogeneous landscapes is an emerging research area.*]

Wednesday, March 10-Disturbance and landscapes II

Long, J. N. 2009. Emulating natural disturbance regimes as a basis for forest management: a North American view. Forest Ecology and Management 257:1868-1973. [*Emulating disturbance is one of the ways in which managers attempt to mitigate undesirable consequences of harvest.*]

Keane, R. E., P. F. Hessburg, P. B. Landres and F. J. Swanson. 2009. The use of historical range and variability (HRV) in landscape management. Forest Ecology and Management 258:1025-1037. [*HRV is one of the key management-relevant concepts to emerge from studies of landscape*

disturbance.]

Millar, C. I., N. L. Stephenson, and S. L. Stephens. 2007. Climate change and forests of the future: managing in the face of uncertainty. Ecological Applications 17:2145-2151. [*Discusses strategies for both adaptation and mitigation.*]

Kurz, W. A., G. Stinson, G. J. Rampley, C. C. Dymond, and E. T. Neilson. 2008. Risk of natural disturbances makes future contribution of Canada's forests to the global carbon cycle highly uncertain. PNAS 105: 1551-1555. [*Consequences and uncertainty.*]

Wednesday, March 17 – Organisms and landscapes I

Background reading:

Fahrig L. 2003. Effects of habitat fragmentation on biodiversity. Annu. Rev. Ecol. Evol. Syst. 34:487-15. [*Key reference on relative importance of habitat area vs. configuration.*]

For discussion:

Newton, T. J., D. A. Woolnough and D. L. Strayer. 2008. Using landscape ecology to understand and manage freshwater mussel populations. Journal of the North American Benthological Socieity 27:424-439. [*Landscape ecology concepts also apply in aquatic systems; this is a nice review of concepts with an aquatic flavor.*]

Chetkiewicz, C.-L. B., St. Clair C. C. and M. S. Boyce. 2006. Corridors for conservation: integrating pattern and process. Ann. Rev. Ecol. Evol. Syst. 37:317-342. [*Corridors are receiving a bit more attention again, and this is a recent review.]*

Damschen, E. I., L. A. Brudvig, N. M. Haddad, D. J. Levey, J. L. Orrock and J. J. Tewksbury. 2008. The movement ecology and dynamics of plant communities in fragmented landscapes. PNAS 105:19078-19083. [*Focuses on roles of dispersal vectors and habitat features.*]

Prugh, L. R., K. E. Hodges, A. R. E. Sinclair, and J. S. Brasheres. 2008. Effect of habitat area and isolation on fragmented animal populations. PNAS 105:20770-20775. [*Very large comparative study, identifies importance of patch area and isolation aas well as matrix quality.*]

Wednesday, March 24 – Organisms and landscapes II

Background reading on invasives:

With, K. A. 2002. The landscape ecology of invasive spread. Conservation Biology 16:1192-1203. [*Conceptual paper using neutral landscape models to reason through the implications of landscape structure for the spread of an invasive species.*]

For discussion:

Melbourne, B. A., H. V. Cornell, K. F. Davies, C. J. Dugaw, S. Elmendorf, A. L. Freestone, R. J. Hall, S. Harrison, A. Hastings, M. Holland, M. Holyoak, J. Lambrinos, K. Moors and H. Yokomizo. 2007. Invasion in a heterogeneous world: resistance, coexistence or hostile takeover? Ecology Letters 10:77-94. [*Neat summary of the effects of heterogeneity on invasibility of a community.*]

Brown, C.D. & Boutin, C. 2009. Linking past land use, recent disturbance, and dispersal mechanism to forest composition. Biological Conservation 142: 1647-1656. [*Study relating land-use legacies to invasion.*]

Hebblewhite, M., E. H. Merrill and T. L. McDonald. 2005. Spatial decomposition of predation risk using resource selection functions: an example in a wolf-elk predator-prey system. Oikos 111:101-111. [*With regard to species interactions…paper decomposing spatial risk of predation on the landscape, focusing on how spatial heterogeneity influences different components of the pred-prey interaction.*]

Dormann, C. F., O. Schweiger, I. Augenstein and many others. 2007. Effects of landscape structure and land-use intensity on similarity of plant and animal communities. Global Ecology and

Biogeography 16:774-787. [*Example of recent studies moving beyond single-species analysis to consider communities.*]

Friday, March 26 – Landscape genetics

Background reading:

Manel, S., M. K. Schwartz, G. Luikart and P. Taberlet. 2003. Landscape genetics: combining landscape ecology and population genetics. Trends in Ecology and Evolution 18:189-197. [*Landscape genetics offer an enormous opportunity to evaluate factors like relatedness and dispersal patterns in landscapes. This is the main foundation paper.*]

For discussion:

Hoderegger, R., U. Kamm and F. Gugerli. 2006. Adaptive vs. neutral genetic diversity: implications for landscape genetics. Landscape Ecology 21:797-807. [*Explanations of the genetics that work well for landscape ecologists.*]

Storfer, A., M. A. Murphy, J. S. Evans, C. S. Goldberg, S. Robinson, S. F. Spear, R. Dezzani, E. Delmelle, L. Vierling and L. P. Watts. 2007. Putting the 'landscape' in landscape genetics. Heredity 98:128-142. [*Highlighting the spatial developments that are relevant for genetics, and what might develop from the merger.*]

Holderegger, R. and H. H. Wagner. 2008. Landscape genetics. BioScience 58:199-208. [*Nice recent summary that lays out research directions.*]

Kozak, K. H., Graham, C. H., and Wiens, J. J. 2008. Integrating GIS-based environmental data into evolutionary biology. Trends in Ecology and Evolution 23: 141-148. [*Understanding spatial environmental correlates of adaptation.*]

Wednesday, April 14 – Spatial heterogeneity and ecosystem processes

Bennett EM, Carpenter SR, Clayton MK. 2005. Soil phosphorus variability: scale-dependence in an urbanizing agricultural landscape. Landscape Ecology 20: 389-400. [*Local example for the Lake Mendota watershed, where P is the element of importance in land-lake interactions.*]

Billings, S. A. and E. A. Gaydess. 2008. Soil nitrogen and carbon dynamics in a fragmented landscape experiencing forest succession. Landscape Ecology 23:581-593. [*Addresses some causes of spatial heterogeneity in process rates related to successional patterns and patch size.*]

Bump, J. K., R. O. Peterson and J. A. Vucetich. 2009. Wolves modulate soil nutrient heterogeneity and foliar nitrogen by configuring the distribution of ungulate carcasses. Ecology 90:3159-3167. [*Species interactions play out on landscapes and have important implications for heterogeneity in ecosystem process rates.*]

Holtgrieve, G. W., D. E. Schindler and P. K. Jewett. 2009. Large predators and biogeochemical hotspots: brown bear (*Ursos arctos*) predation on salmon alters nitrogen cycling in riparian soils. Ecological Research 24:1125-1135. [*The translocation of marine-derived nutrients to particular terrestrial habitats has been a fascinating story involving spatial heterogeneity.*]

Wednesday, April 21 – Ecosystem services and sustainability

Background reading:

Carpenter SR, Mooney HA, Agard J, Capistrano D, DeFries R, Diaz S, Dietz T, Duriappah A, Oteng-Yeboah A, Pereira HM, Perrings C, Reid WV, Sarukhan J, Scholes RJ, Whyte A. 2009. Science for managing ecosystem services: Beyond the Millennium Ecosystem Assessment. Proc Natl Acad Sci USA 106: 1305-1312.

For discussion:

Turner, B. L., II, and P. Robbins. 2008. Land-change science and political ecology: similarities, differences and implications for sustainability science. Annual Review of Environmental Resources 33:295-316. [*Great review that compares what we typically think of in landscape ecology with a social-science perspective.*]

Lovell, S. T. and D. M. Johnston. 2009. Creating multifunctional landscapes: how can the field of ecology inform the design of the landscape? Frontiers in Ecology and the Environment 7:212-220. [*This remains a big challenge!*]

Priess, J. A., M. Mimler, A.-M. Klein, S. Schwarze, T. Tscharntke and I. Steffan-Dewenter. 2007. Linking deforestation scenarios to pollination services and economic returns in coffee agroforestry systems. Ecological Applications 17: 407-417. [*Demonstrates importance of landscape context on a key ecosystem service in coffee plantations.*]

Chapin, F. S., III, A. L. Lovecraft, E. S. Zavaleta, J. Nelson, M. D. Robards, G. P. Kofinas, S. F. Trainor, G. D. Peterson, H. P. Huntington, and R. L. Naylor. 2006. Policy strategies to address sustainability of Alaskan boreal forests in response to a directionally changing climate. PNAS 103:16637-16643. [*Thinking about how to manage integrated social-economic systems faced with major change.*]

Friday, April 23 – Future directions

Lindenmayer, D., R. J. Hobbs, R. Montague-Drake, and many others. 2008. A checklist for ecological management of landscapes for conservation. Ecology Letters 11:78-91. [*Application of landscape concepts to conservation remains an important direction; this is nice synthesis.*]

Turner, M. G. 2010. Disturbance and landscape dynamics in a changing world. 2009 MacArthur Address, submitted to Ecology. [*Consequences of changing disturbance regimes for landscape dynamics and social-ecological systems present an important future challenge*.]

Rietkerk, M., S. C. Dekker, P. C. de Ruiter, and J. van de Koppe. 2004. Self-organized patchiness and catastrophic shifts in ecosystems. Science 305:1926-1929. [*Review of emerging theory on catastrophic shifts in ecosystems with a focus on spatially extensive systems.*]

NSF call for the Macrobiology initiative.

2012

TEXTS

Turner, M. G., R. H. Gardner, and R. V. O'Neill. 2001. Landscape ecology in theory and practice. Springer-Verlag, New York. *This will be used as background material and also for the quantitative analyses component of the course.*

Gergel, S. E. and M. G. Turner, editors. 2002. Learning landscape ecology. Springer-Verlag, New York. *This book will be used for our lab exercises.*

WEEKLY DISCUSSION READINGS

Wed, January 25 – Scope of landscape ecology, conceptual issues, scale, foundations

Background:

Turner, M. G. 1989. Landscape ecology: the effect of pattern on process. Annual Review of Ecology and Systematics 20:171-197. [*My early review of landscape ecology as the field was developing in North America.*]

Turner, M. G. 2005. Landscape ecology: what is the state of the science? Annual Review of Ecology, Evolution and Systematics. [*My perspective on the more recent progress in landscape ecology, essentially a reprise on the ideas in the 1989 review.*]

Turner, M. G. Forthcoming. Twenty-five years of US landscape ecology: looking back and forging ahead. In: G. W. Barrett, T. Barrett and J. Wu, editors. History of landscape ecology in the United States. Springer, New York. (Submitted). [*The US chapter of the International Association for Landscape Ecology marked the 25th annual landscape ecology that was held again in Athens, GA. This chapteris a 1st-person account of the context for that first meeting and the establishment of US-IALE.*]

Read for Friday's discussion:

Boström C., S. J. Pittman, C. Simenstad and R. T. Kneib. 2011. Seascape ecology of coastal biogenic habitats: advances, gaps, and challenges. Marine Ecology Progress Series 427:191-217. *[Landscape ecology is not all "land;" the concepts developed in landscape ecology are also applied in aquatic and marine systems. This paper talks generally about landscape ecology concepts and applications, but in a different system.]*

Friday, January 27 – Causes of landscape pattern

*Bostrom et al. (2011) will be discussed today.

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

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

Plue, J., M. Hermy, K. Verheyen, P. Thuiller, R. Saguez and G. Decocq. 2008. Persistent changes in forest vegetation and seed bank 1,600 years after human occupation. Landscape Ecology 23:673-688. *[Example of recent focus on the effects of land-use legacies on contemporary ecosystems from one of the leading European groups addressing the topic.]*

Wednesday, February 1 Quantifying pattern I

Good 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; older paper, but good food for thought on what is being quantified.]*

Gustafson, E. J. 1998. Quantifying landscape spatial pattern: What is the state of the art? Ecosystems 1:143-156. [*Relatively recent article addressing spatial analyses recognizing both categorical and continuous measures.]*

For discussion:

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.]*

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

Cardille, J. A. and M. Lambois. 2010. From the redwood forest to the Gulf Stream waters: human signature nearly ubiquitous in representative US landscapes. Frontiers in Ecology and the Environment 8:130-134. [*Using landscape analyses to identify human influence on landscapes.*]

Fahrig, L., J. Baudry, L. Brotons, F. G. Burel, T. O Crist, R. J. Fuller, C. Sirami, G. M. Siriwardena and J.-L. Martin. 2011. Functional landscape heterogeneity and animal biodiversity in agricultural landscapes. Ecology Letters 14:101-112. [*Considers quantifying landscape pattern for a given purpose, and does a nice job describing structural vs. functional connectivity.*]

Wednesday, February 15 – Quantifying pattern II

McGarigal, K., S. Tagil, and S. A. Cushman. 2009. Surface metrics: an alternative to patch metrics for the quantification of landscape structure. Landscape Ecology 24:433-450. [*A new class of metrics that can be useful in landscape studies.*]

Fortin, M-J, B. Boots, F. Csillag and T. K. Remmel. 2003. On the role of spatial stochastic models in understanding landscape indices. Oikos 102:203-212. [*Lays out an approach for interpreting landscape metrics numerically.*]

Remmel TK, F. Csillag. 2003. When are two landscape pattern indices significantly different? J. Geograph. Syst. 5:331-351. [*Addresses the key issue of statistical significance when comparing metrics, which has been problematic in many studies.*]

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

Wednesday, February 22 – Spatial statistics

**These readings illustrate use of spatial statistics in different types of studies and including examples addressing population- and ecosystem-level questions.*

Gundale, M. J., K. L. Metlen, C. E. Fiedler and T. H. DeLuca. 2006. Nitrogen spatial heterogeneity influences diversity following restoration in a ponderosa pine forest, Montana. Ecological Applications 16:479-489. [*Uses spatial statistics to relate resource heterogeneity to plant community patterns.*]

Lee, H., E. A. Schuur, J. G. Vogel, M. Lvoie, D. Bhadra and C. L. Staudhammer. 2011. A spatially explicit analysis to extrapolate carbon fluxes in upland tundra where permafrost is thawing. Global Change Biology 17:1379-1393. [*Assesses the spatial structure of predictor variables, presents results in context of the bigger question.*]

DeJager, N. R. and J. Pastor. 2009. Declines in moose population density at Isle Royale National Park, MI, USA and accompanied changes in landscape patterns. Landscape Ecology 24:1389-1403. [*Understanding changes in continuous response variables in landscape.*]

Mayor, S. J., J. A. Schaefer, D. C. Schneider and S. P. Mahoney. 2007. Spectrum of selection: new approaches to detecting the scale-dependent response to habitat. Ecology 88:1634-1640. [*Habitat selection has been a major theme in organism-landscape studies for several years; this is an example of a sophisticated scale-dependent approach using spatial statistics.*]

Wednesday, February 29– Landscape models

Good background (highly recommended):

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

For discussion:

Gardner, R. H. and D. L. Urban. 2007. Neutral models for testing landscape hypotheses. Landscape Ecology 22:15-29. [*Gardner was lead author of the original neutral landscape model paper; this is a nice summary of the current state of those models.*]

Perry, G. L. W. and N. J. Enright. 2006. Spatial modeling of vegetation change in dynamic landscapes: a review of methods and applications. Progress in Physical Geography 30:47-72. [*Nice recent review of landscape models.*]

Prasad et al.

Berland, A., B. Shumna, and S. M. Manson. 2011. Simulated importance of dispersal, disturbance, and landscape history in long-term ecosystem change in the Big Woods of Minnesota. Ecosystems 14:398-414. *[Example model study using LANDIS, a widely used forest landscape simulator developed by UW colleague David Mladenoff and students.]*

Wednesday, March 7 – Disturbance and landscapes I

Recommended background reading:

Perry, G. L. W. 2002. Landscapes, space and equilibrium: shifting viewpoints. Progress in Physical Geography 26(3):339-359. *[Synthesis of an issue of long-term interest and importance in ecology.]*

For discussion:

Perry, D. A., P. F. Hessburg, C. N. Skinner, T. A. Spies, S. L. Stephens, A. H. Taylor, J. F. Franklin, B. McComb, and G Riegel. 2011. The ecology of mixed severity fire regimes in Washington, Oregon, and Northern California. Forest Ecology and Management 262:703-717. [*Review article considering a range of variation in fire severity*.]

Barrett, K., A. D. McGuire, E. E. Hoy, and E. S. Kasischke. 2011. Potential shifts in dominant forest cover in interior Alaska driven by variations in fire severity. Ecological Applications 21:2380-2396. [*Disturbances are recognized as a key catalyst for changing forest extent and composition, and this is a hot topic.*]

Allen, C. D. 2007. Interactions across spatial scales among forest dieback, fire, and erosion in northern New Mexico landscapes. Ecosystems 10:797-808. [*Consideration of interactions among disturbances in the context of cross-scale interactions.*]

Ostfeld, R. S., G. E. Glass and F. Keesing. 2006. Spatial epidemiology: an emerging (or re-emerging) discipline. TREE 20(6):328-336. [*Understanding disease patterns for plants, animals or humans in heterogeneous landscapes is an emerging research area.*]

Wednesday, March 14-Disturbance and landscapes II

Keane, R. E., P. F. Hessburg, P. B. Landres and F. J. Swanson. 2009. The use of historical range and variability (HRV) in landscape management. Forest Ecology and Management 258:1025-1037. [*HRV is one of the key management-relevant concepts to emerge from studies of landscape disturbance.*]

Thompson, J. R., S. L. Duncan and K. N. Johnson. 2009. Is there potential for the historical range of variability to guide conservation given the social range of variability? Ecology and Society 14(1):18. [online] URL: http://www.ecologyandsociety.org/vol14/iss1/art18/ *[Study from a well studied region considers the social part of the equation.]*

Kurz, W. A., G. Stinson, G. J. Rampley, C. C. Dymond, and E. T. Neilson. 2008. Risk of natural disturbances makes future contribution of Canada's forests to the global carbon cycle highly uncertain. PNAS 105: 1551-1555. [*Emphasizes consequences and uncertainty.*]

Wednesday, March 21 – Organisms and landscapes I

Background reading:

Fahrig L. 2003. Effects of habitat fragmentation on biodiversity. Annu. Rev. Ecol. Evol. Syst. 34:487-15. [*Key reference on relative importance of habitat area vs. configuration; also, there are many excellent publications from Fahrig and her students that include modeling and empirical study and a large variety of taxa.]*

For discussion:

Prugh, L. R., K. E. Hodges, A. R. E. Sinclair, and J. S. Brasheres. 2008. Effect of habitat area and isolation on fragmented animal populations. PNAS 105:20770-20775. [*Very large comparative study, identifies importance of patch area and isolation as well as matrix quality.*]

Oliver, T., D. B. Roy, J. K. Hill, T. Brereton and C. D. Thomas. 2010. Heterogeneous landscapes promote population stability. Ecology Letters 13:473-484. *[This takes a prominent theoretical idea focused on population stability and explores it empirically.]*

Thornton, D. H., L. C. Branch and M. E. Sunquist. 2011. The influence of landscape, patch, and within-patch factors on species presence and abundance: a review of focal patch studies. Landscape Ecology 26:7-18. *[Review of published studies, highlights importance of study design.]*

Gagné, S. A. and L. Fahrig. 2011. Do birds and beetle show similar responses to urbanization? Ecological Applications 21:2297-2312. [*Sample empirical study that compares responses of different taxa and looks at urban land use.*]

Wednesday, March 28 – Organisms and landscapes II

Background reading:

With, K. A. 2002. The landscape ecology of invasive spread. Conservation Biology 16:1192-1203. [*Conceptual paper using neutral landscape models to reason through the implications of landscape structure for the spread of an invasive species.*]

Yeager, L. A., C. A. Layman, J. E. Allgeier. 2011. Effects of habitat heterogeneity at multiple spatial scales on fish community assembly. Oecologia 167:157-168. [*Landscape approach to fish communities that complements the Dormann et al. terrestrial paper.]*

For discussion:

Melbourne, B. A., H. V. Cornell, K. F. Davies, C. J. Dugaw, S. Elmendorf, A. L. Freestone, R. J. Hall, S. Harrison, A. Hastings, M. Holland, M. Holyoak, J. Lambrinos, K. Moors and H. Yokomizo. 2007. Invasion in a heterogeneous world: resistance, coexistence or hostile takeover? Ecology Letters 10:77-94. [*Neat summary of the effects of heterogeneity on invasibility of a community.*]

Dormann, C. F., O. Schweiger, I. Augenstein and many others. 2007. Effects of landscape structure and land-use intensity on similarity of plant and animal communities. Global Ecology and Biogeography 16:774-787. [*Example of recent studies moving beyond single-species analysis to consider communities.*]

Schüepp, C., J. D. Herrmann, F. Herzog, and M. H. Schmidt-Engling. 2011. Differential effects of habitat isolation and landscape composition on wasps, bees, and their enemies. Oecologia 165:713-721. [*An example of landscape influences on species interactions, this time parasitism.*]

Thaker, M., A. T. Vanak, C. R. Owen, M. B. Ogden, S. M. Niemann and R. Slotow. 2011. Minimizing predation risk on a landscape of multiple predators: effects on the spatial distribution of African ungulates. Ecology 92:398-407. [*Paper on how spatial heterogeneity influences pred-prey interaction in an African landscape with multiple predators and multiple prey.*]

Wednesday, April 11 – Ecosystem processes

Background reading:

Strayer, D. L., R. E. Beighley, L. C. Thompson, A. Brooks, C. Nilsson C, et al. 2003. Effects of land cover on stream ecosystems: roles of empirical models and scaling issues. Ecosystems 6:407-23. [*Nice review of the relationship between land cover and surface water condition.*]

For discussion:

Massol, F., D. Gravel, N. Mouquet, M. W. Cadotte, T. Fukami and M. A. Liebold. 2011. Linking community and ecosystem dynamics through spatial ecology. Ecology Letters 14:313-323. [*Conceptual paper attempting to bridge distinct avenues of inquiry.*]

Bump, J. K., R. O. Peterson and J. A. Vucetich. 2009. Wolves modulate soil nutrient heterogeneity and foliar nitrogen by configuring the distribution of ungulate carcasses. Ecology 90:3159-3167. [*Species interactions, including food webs, play out on landscapes and affect heterogeneity of ecosystem process rates.*]

Buffam, I., M. G. Turner, A. Desai, P. J. Hanson, J. Rusak, N. Lottig and S. R. Carpenter. 2011. Integrating aquatic and terrestrial components to construct a complete carbon budget for a north temperate lake district. Global Change Biology 17:1193-1211. [*Example of building a regional carbon budget that includes all major ecosystem types; focus is on spatial heterogeneity of vertical fluxes.*]

Shen, W., Y. Lin, G. D. Jenerett and J. Wu. 2011. Blowing litter across a landscape: effects on ecosystem nutrient flux and implications for landscape management. Landscape Ecology 26:629-644. [*Example of lateral fluxes of matter across a heterogeneous landscape.*]

Wednesday, April 18—Landscape management and conservation

Brudvig, L. A. 2011. The restoration of biodiversity: where has research been and where does it need to go? American Journal of Botany 98:549-558. [*Thoughtful consideration of the role of landscape and historical factors in restoration ecology.*]

Shanahan, D. F., C. Miller, H. P. Possingham and R. A. Fuller. 2011. The influence of patch area and connectivity on avian communities in urban revegetation. Biological Conservation 144:722-729. [*Example of considering landscape characteristics in urban restoration.*]

Gude, P. H., A. J. Hansen and D. A. Jones. 2007.Biodiversity consequences of alternative future land use scenarios in Greater Yellowstone. Ecological Applications 17:1004-1018. [*Explores the consequences of exurban development for a range of different species in a wildland-urban interface.*]

Meehan, T. D., A. H. Hurlbert and C. Gratton. 2010. Bird communities in future bioenergy landscapes of the Upper Midwest. PNAS 43:18533-18538. [*Current issue in our region and elsewhere—what are the conservation consequences of increased bioenergy production?*]

Wednesday, April 21 – Ecosystem services and sustainability

Background reading:

Carpenter SR, Mooney HA, Agard J, Capistrano D, DeFries R, Diaz S, Dietz T, Duriappah A, Oteng-Yeboah A, Pereira HM, Perrings C, Reid WV, Sarukhan J, Scholes RJ, Whyte A. 2009. Science for managing ecosystem services: Beyond the Millennium Ecosystem Assessment. Proc Natl Acad Sci USA 106: 1305-1312.

For discussion:

Turner, B. L., II, and P. Robbins. 2008. Land-change science and political ecology: similarities, differences and implications for sustainability science. Annual Review of Environmental Resources 33:295-316. [*Great review that compares what we typically think of in landscape ecology with a social-science perspective.*]

Cumming, G. S. 2011. Spatial resilience: integrating landscape ecology, resilience and sustainability. Landscape Ecology 26:899-909. [*Nice discussion of resilience concepts and their spatial extension.*]

Raudsepp-Hearne C, G. D. Peterson and E. M. Bennett. 2010. Ecosystem service bundles for analyzing tradeoffs in diverse landscapes. Proc Nat Acad Sci USA 107:5242-5247. [*Begins to consider spatial tradeoffs among multiple ecosystem services using landscapes outside Montreal, Canada.*]

Eigenbrod, F., P. R. Armsworth, B. J. Anderson, A. Heinemeyer, S. Gillings, D. B. Roy, C. D. Thomas and K. J. Gaston. 2010. The impact of proxy-based methods on mapping the distribution of ecosystem services. Journal of Applied Ecology 47:377-385. [*Discusses pitfalls associated with making assumptions about how land cover patterns relate to ecosystem services.*]

Friday, April 27 – Future directions in landscape ecology

Holderegger, R., D. Buehler, F. Gugerli and S. Manel. 2010. Landscape genetics of plants. Trends in Plant Science 15:675-683. [*Landscape genetics has been continuing to develop over about the past decade*.]

Knowlton, J. L. and C. H. Graham 2010. Using behavioral landscape ecology to predict species' responses to land-use and climate change. Biological Conservation 143:1342-1354. [*There are many opportunities to continue to link behavior to landscape patterns and employ different types of study methods.*]

Pijanowski, B. D., L. R. Iverson, D. A. Drew, H. N. N. Bulley, J. M. Rhemtulla, et al. 2010. Addressing the interplay of poverty and the ecology of landscapes: a Grand Challenge for landscape ecologists? Landscape Ecology 25:5-16. [*Example of new interdisciplinary questions that could be considered in landscape ecology*.]

Pardini, R., A. de Arruda Bueno, T. A. Gardner, P. I. Prado and J. P. Metzger. 2010. Beyond the fragmentation threshold hypothesis: regime shifts in biodiversity across fragmented landscapes. PLoS ONE 5(10): e13666. doi:10.1371/journal.pone.0013666. [*The concept of regime shifts in spatial landscapes is receiving increased attention; more generally, understanding when qualitative landscape changes are expected is a research frontier.*]

2014

TEXT

Turner, M. G. and R. H. Gardner. Forthcoming. Landscape ecology in theory and practice, 2nd edition. Springer-Verlag, New York. (*Pre-print manuscript*)

WEEKLY DISCUSSION READINGS

Fri, January 24 – Scope of landscape ecology, conceptual issues, scale, foundations

Laurance, W. F. 2008. Theory meets reality: how habitat fragmentation research has transcended island biogeographic theory. Biological Conservation 141:1731-1744. [*Nice perspective on how thinking has evolved from roots in island biogeography.*]

Boström C., S. J. Pittman, C. Simenstad and R. T. Kneib. 2011. Seascape ecology of coastal biogenic habitats: advances, gaps, and challenges. Marine Ecology Progress Series 427:191-217. *[Landscape ecology is not all "land;" the concepts developed in landscape ecology are also applied in aquatic and marine systems. This paper talks generally about landscape ecology concepts and applications, but in a different system.]*

Wu, J. 2013. Key concepts and research topics in landscape ecology revisited: 30 years after the Allerton Park workshop. Landscape Ecology 28:1-11. [*Jingle Wu is the current editor-in-chief of Landscape Ecology, and these are reflections 30 yrs after the seminar workshop organized by Paul Risser, Jim Karr, and Richard Forman.*]

Jenerette, G. D. and W. Shen. 2012. Experimental landscape ecology. Landscape Ecology, published online, DOI 10.1007/s10980-012-9797-1. [*Nice overview of the role of experimentation in landscape ecology.*]

Wednesday, January 28 – Causes of landscape pattern

Background:

Hermy, M. and K. Verheyen. 2007. Legacies of the past in the present-day forest biodiversity: a review of past land-use effects on forest plant species composition and diversity. Ecological Research 22:361-271. *[There is a very large body of European work focused on the very long-term legacies of historical land use on contemporary ecosystems, and this review provides an excellent entrée into that literature.]*

For discussion:

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

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

Power, M. J., C. Whitlock, and P. J. Bartlein. 2011. Postglacial fire, vegetation, and climate history across an elevational gradient in the Northern Rocky Mountains, USA and Canada. Quaternary Science Reviews 30:2520-2533. *[Example of how paleoecological studies produce a deep understanding of how landscapes have developed and changed; it is important to have this long-term context for most landscape studies.]*

De Frenne, P., L. Baeten, B. J. Graae, J. Brunet, M. Wulf, et al. 2011. Interregional variation in the floristic recovery of post-agricultural forests. Journal of Ecology 99:600-609. *[Recent meta-*

analysis of multiple studies in Europe, again providing excellent overview of work on land-use legacies.]

Wednesday, February 5– 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 issues associated with introducing spatial complexity into models.*]

For discussion:

Perry, G. L. W. and N. J. Enright. 2006. Spatial modeling of vegetation change in dynamic landscapes: a review of methods and applications. Progress in Physical Geography 30:47-72. [*Nice recent review of landscape models.*]

Gardner, R. H. and D. L. Urban. 2007. Neutral models for testing landscape hypotheses. Landscape Ecology 22:15-29. [*Gardner was lead author of the original neutral landscape model paper; this is a nice summary of the current state of those models, which will be used in this week's lab.*]

Prasad, A. M., L. R. Iverson, M. P. Peters, et al. 2010. Modeling the invasive emerald ash borer risk of spread using a spatially explicit cellular model. Landscape Ecology 25:353-369. [*Example of an organism-based spatial landscape model, for an emerging issue in our Upper Midwest region.*]

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.]*

Wednesday, February 12 Quantifying pattern I

Good 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; older paper, but good food for thought on what is being quantified.]*

Gustafson, E. J. 1998. Quantifying landscape spatial pattern: What is the state of the art? Ecosystems 1:143-156. [*Relatively recent article addressing spatial analyses recognizing both categorical and continuous measures.]*

For discussion:

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.]*

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

Wedding, L. M., C. A. Lepczyk, S. J. Pittman, A. M. Friedlander and S. Jorgensen. 2011. Quantifying seascape structure: extending terrestrial spatial pattern metrics to the marine realm. Marine Ecology Progress Series 427:219-232. [*Applications are not only terrestrial!*]

Símovsá, P. and K. Gdulová. 2012. Landscape indices behavior: A review of scale effects. Applied Geography 34:385-394. [*There are a fair number of empirical papers documenting the consequences of changing grain and extent on landscape metrics, and this paper provides an overview.*]

Wednesday, February 19 – Quantifying pattern II

Good background:

Fortin, M-J, B. Boots, F. Csillag and T. K. Remmel. 2003. On the role of spatial stochastic models in understanding landscape indices. Oikos 102:203-212. [*Lays out an approach for interpreting landscape metrics numerically and uses stochastic models, like NLMs, to do so; also provides background for the Remmel and Csillag 2003 paper.*]

McGarigal, K., S. Tagil, and S. A. Cushman. 2009. Surface metrics: an alternative to patch metrics for the quantification of landscape structure. Landscape Ecology 24:433-450. [*Presents a new class of metrics that use continuous rather than categorical data and can be useful in landscape studies. These are not yet widely used.*]

For discussion:

Remmel, T. K. and F. Csillag. 2003. When are two landscape pattern indices significantly different? J. Geograph. Syst. 5:331-351. [*Addresses the key issue of statistical significance when comparing metrics, which has been problematic in many studies.*]

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

Burnicki, A. C. 2012. Impact of error on landscape pattern analyses performed on land-cover change maps. Landscape Ecology 27:713-729. [*Accuracy of the data used in any landscape analysis will influence the results, and this is especially important when you want to quantify how landscapes change over time.*]

Kupfer, J. A. 2012. Landscape ecology and biogeography: Rethinking landscape metrics in a post-FRAGSTATS landscape. Progress in Physical Geography 36:400-420. [*Current paper offering synthesis points and discussing metrics based on network theory.*]

Wednesday, February 26 – Spatial statistics

Gundale, M. J., K. L. Metlen, C. E. Fiedler and T. H. DeLuca. 2006. Nitrogen spatial heterogeneity influences diversity following restoration in a ponderosa pine forest, Montana. Ecological Applications 16:479-489. [*Uses spatial statistics to relate resource heterogeneity to plant community patterns.*]

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

DeJager, N. R. and J. Pastor. 2009. Declines in moose population density at Isle Royale National Park, MI, USA and accompanied changes in landscape patterns. Landscape Ecology 24:1389-1403. [*Understanding changes in continuous response variables in landscape.*]

Barrell, J. and J. Grant. 2013. Detecting hot and cold spots in a seagrass landscape using local indicators of spatial association. Landscape Ecology 28:2005-2018. [*Use of spatial statistics to detect pattern at multiple spatial scales in a seascape.*]

Wednesday, March 5 – Disturbance and landscapes I

Recommended background:

Perry, G. L. W. 2002. Landscapes, space and equilibrium: shifting viewpoints. Progress in Physical Geography 26:339-359. *[Synthesis of an issue of long-term interest and importance in ecology.]*

For discussion:

Paritsis, J., A. Holz, T. T. Veblen, and T. Kitzberger. 2013. Habitat distribution modeling reveals vegetation flammability and land use as drivers of wildfire in SW Patagonia. Ecosphere DOI: 10.1890/ES12-00378.1. [*Considers a variety of independent variables that may aid spatial prediction of probability of fire occurrence.*]

Chapman, T. B., T. T. Veblen, and T. Schoennagel. 2012. Spatiotemporal patterns of mountain pine beetle activity in the southern Rocky Mountains. Ecology 93:2175-2185. [*Recent, extensive bark beetle outbreaks have affected landscape patterns throughout western North America.*]

Hicke, J. A., M. C. Johnson, J. L. Hayes, H. K. Preisler. 2012. Effects of bark beetle-caused tree mortality on wildfire. Forest Ecology and Management 271:81-90. [*Understanding how disturbances interact on landscapes is a topic of intense current interest, and this paper summarizes current understanding of bark beetle-fire interactions.]*

Meentemeyer, R. K., S. E. Haas and T. Vaclavik. 2012. Landscape epidemiology of emerging infectious diseases in natural and human-altered ecosystems. Annual Review of Phytopathology 50:379-402. [*Landscape or spatial epidemiology has emerged as an interesting area of research that overlaps with landscape ecology and disturbance.*]

Wednesday, March 12-Disturbance and landscapes II

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.*]

For discussion:

Keane, R. E., P. F. Hessburg, P. B. Landres and F. J. Swanson. 2009. The use of historical range and variability (HRV) in landscape management. Forest Ecology and Management 258:1025-1037. [*HRV is one of the key management-relevant concepts to emerge from studies of landscape disturbance.*]

Duncan, S. L., B. C. McComb and K. N. Johnson. 2010. Integration ecological and social ranges of variability in conservation of biodiversity: past, present, and future. Ecology and Society Vol15/iss1/art5/. [*Adds the social part of the equation to the HRV concept.*]

Pickell, P. D., D. W. Andison, and N. C. Coops. 2013. Characterizations of anthropogenic disturbance patterns in the mixedwood boreal forest of Alberta, Canada. Forest Ecology and Management 304:245-253. [*Evaluates forest landscapes relative to attempts to mimic natural disturbances and remain within the HRV.*]

Baker, S. G., T. A. Spies, T. J. Wardlaw, J. Balmer, J. F. Franklin, and G. J. Jordan. 2013. The harvested side of edges: Effect of retained forests on the re-establishment of biodiversity in adjacent harvested areas. Forest Ecology & Management 302:107-121. [*Edge varies substantially with spatial pattern, and this discusses the influence of edge in harvested forest landscapes on biodiversity.]*

Wednesday, March 26 – Organisms and landscapes I

Background reading:

Fahrig L. 2003. Effects of habitat fragmentation on biodiversity. Annu. Rev. Ecol. Evol. Syst. 34:487-15. [*Key reference on relative importance of habitat area vs. configuration (i.e., loss vs. fragmentation); also, there are many excellent publications from Fahrig and her students that include modeling and empirical study and a large variety of taxa.]*

For discussion:

Thornton, D. H., L. C. Branch and M. E. Sunquist. 2011. The influence of landscape, patch, and within-patch factors on species presence and abundance: a review of focal patch studies. Landscape Ecology 26:7-18. *[Review of published studies, highlights importance of study design.]*

Fahrig, L., J. Baudry, L. Brotons, F. G. Burel, T. O Crist, R. J. Fuller, C. Sirami, G. M. Siriwardena and J.-L. Martin. 2011. Functional landscape heterogeneity and animal biodiversity in agricultural

landscapes. Ecology Letters 14:101-112. [*Considers quantifying landscape pattern for a given purpose, and does a nice job describing structural vs. functional connectivity.*]

Moorcroft, P. R. 2012. Mechanistic approaches to understanding and predicting mammalian space use: recent advances, future directions. Journal of Mammalogy 93:903-916. [*Space use is a key area of overlap between population and wildlife ecology and landscape ecology. Nice review.*]

Tscharntke, T., J. M. Tylianakis, T. A. Rand, R. K. Didham, L. Fahrig, et al. 2012. Landscape moderation of biodiversity patterns and processes – eight hypotheses. Biological Reviews 87:661-685. [*Synthesizing landscape effects on biodiversity, good ideas within!*]

Wednesday, April 2 – Organisms and landscapes II

Background reading:

Dormann, C. F., O. Schweiger, I. Augenstein and many others. 2007. Effects of landscape structure and land-use intensity on similarity of plant and animal communities. Global Ecology and Biogeography 16:774-787. [*Example of recent studies moving beyond single-species analysis to consider communities.*]

For discussion:

Yeager, L. A., C. A. Layman, J. E. Allgeier. 2011. Effects of habitat heterogeneity at multiple spatial scales on fish community assembly. Oecologia 167:157-168. [*Recent studies are looking at communities; this is an example of a landscape approach to fish communities.]*

Chaplin-Kramer, R., M. E. O'Rourke, E. J. Blitzer, and C. Kremen. 2011. A meta-analysis of crop pest and natural enemy response to landscape complexity. Ecological Letters 14:922-932. [*Review of extensive literature on pred-prey relationships in agricultural landscapes.*]

Martin, E. A., B. Reineking, B. Seo, and I. Steffan-Dewenter. 2013. Natural enemy interactions constrain pest control in complex agricultural landscapes. PNAS 110:5534-5539. [*Very interesting study demonstrating effects of landscape complexity on the interactions between different natural enemies; also demonstrates an experimental approach.*]

Thaker, M., A. T. Vanak, C. R. Owen, M. B. Ogden, S. M. Niemann and R. Slotow. 2011. Minimizing predation risk on a landscape of multiple predators: effects on the spatial distribution of African ungulates. Ecology 92:398-407. [*Paper on how spatial heterogeneity influences pred-prey interaction in an African landscape with multiple predators and multiple prey.*]

Wednesday, April 9 – Ecosystem processes

Background reading:

Strayer, D. L., R. E. Beighley, L. C. Thompson, A. Brooks, C. Nilsson C, et al. 2003. Effects of land cover on stream ecosystems: roles of empirical models and scaling issues. Ecosystems 6:407-23. [*Nice review of the relationship between land cover and surface water condition.*]

For discussion:

Massol, F., D. Gravel, N. Mouquet, M. W. Cadotte, T. Fukami and M. A. Liebold. 2011. Linking community and ecosystem dynamics through spatial ecology. Ecology Letters 14:313-323. [*Conceptual paper attempting to bridge distinct avenues of inquiry.*]

Cheruvelil, K. S., P. A. Soranno, K. E. Webster, and M. T. Bremigan. 2013. Multi-scaled drivers of ecosystem state: quantifying the important of the regional spatial scale. Ecological Applications 23:1603-1618. [*A lot of work has been conducted on understanding landscape effects on surface waters and the scales and predictors of variation among lakes.*]

Buffam, I., M. G. Turner, A. Desai, P. J. Hanson, J. Rusak, N. Lottig and S. R. Carpenter. 2011. Integrating aquatic and terrestrial components to construct a complete carbon budget for a north temperate lake district. Global Change Biology 17:1193-1211. [*Example of building a regional*

budget that includes all major ecosystem types; focus here is on spatial heterogeneity of vertical fluxes.]

Bump, J. K., R. O. Peterson and J. A. Vucetich. 2009. Wolves modulate soil nutrient heterogeneity and foliar nitrogen by configuring the distribution of ungulate carcasses. Ecology 90:3159-3167. [*Species interactions, including food webs, play out on landscapes and affect heterogeneity of ecosystem process rates.*]

Wednesday, April 16 – Ecosystem services and sustainability

Background reading:

Turner, B. L., II, and P. Robbins. 2008. Land-change science and political ecology: similarities, differences and implications for sustainability science. Annual Review of Environmental Resources 33:295-316. [*Great review that compares what we typically think of in landscape ecology with a social-science perspective.*]

For discussion:

Mitchell, M. G. T., E. M. Bennett and A. Gonzalez. 2013. Linking landscape connectivity and ecosystem service provision: current knowledge and research gaps. Ecosystems: 16:894-908. [*Ecosystem services are a hot research topic with quite a lot of opportunity for developing the spatial and landscape aspects.*]

Eigenbrod, F., P. R. Armsworth, B. J. Anderson, A. Heinemeyer, S. Gillings, D. B. Roy, C. D. Thomas and K. J. Gaston. 2010. The impact of proxy-based methods on mapping the distribution of ecosystem services. Journal of Applied Ecology 47:377-385. [*Discusses pitfalls associated with making assumptions about how land-cover patterns relate to ecosystem services.*]

Eigenbrod, F., V. A. Bell, H. N. Davies, A. Heinemeyer, P. R. Armsworth, and K. J. Gaston. 2011. The impact of projected increases in urbanization on ecosystem services. Proceedings of the Royal Society B-Biological Sciences 278:3201-3208. [*Example of a study that projects urbanization and future ecosystem services.*]

Maes, J., M. L. Paracchini, G. Zulian, M. B. Dunbar, and R. Alkemade. 2012. Synergies and trade-offs between ecosystem service supply, biodiversity and habitat conservation status in Europe. Biological Conservation 155:1-12. [*Linking biodiversity with ecosystem services remains relatively under studied.*]

Friday, April 18—Landscape management and sustainability

Wiens, J. A. 2013. Is landscape sustainability a useful concept in a changing world? Landscape Ecology 28:1047-1052. [*John Wiens has been a leading thinker for >40 yrs, and these are some of his current thoughts.*]

Lindenmayer, D. B. and S. A. Cunningham. 2013. Six principles for managing forests as ecologically sustainable ecosystems. Landscape Ecology 28:1099-1110. [*Lindenmayer has done a lot of excellent and creative work; this conceptual paper nicely highlights lessons from landscape ecology for forest landscape management.*]

Brudvig, L. A. 2011. The restoration of biodiversity: where has research been and where does it need to go? American Journal of Botany 98:549-558. [*Thoughtful consideration of the role of landscape and historical factors in restoration ecology.*]

Travis, J. M. J., M. Delgado, G. Bocedi, M. Baguette, K. Barton, et al. 2013. Dispersal and species responses to climate change. Oikos 122:1532-1540. [*Because landscape patterns will influence dispersal success, this is one area of climate change and conservation studies in which landscape ecology should play a key role.*]

Wednesday, April 25 – Future directions in landscape ecology

Manel, S. and R. Holderegger. 2013. Ten years of landscape genetics. TREE 28:614-621. [*Landscape genetics has become a big deal with lots of potential remaining. This literature has grown tremendously, and the application of molecular techniques to understand species distributions and migration patterns, or to assess local selective forces, is very promising.]*

Knowlton, J. L. and C. H. Graham 2010. Using behavioral landscape ecology to predict species' responses to land-use and climate change. Biological Conservation 143:1342-1354. [*There are many opportunities to continue to link behavior to landscape patterns and employ different types of study methods. Many of the primary data papers focus on organism movement and/or interactions between species, such as predator-prey dynamics.*]

Pardini, R., A. de Arruda Bueno, T. A. Gardner, P. I. Prado and J. P. Metzger. 2010. Beyond the fragmentation threshold hypothesis: regime shifts in biodiversity across fragmented landscapes. PLoS ONE 5(10): e13666. doi:10.1371/journal.pone.0013666. [*The concept of regime shifts in spatial landscapes is receiving increased attention; more generally, understanding when qualitative landscape changes are expected is a research frontier. This is one representative and accessible paper that focuses on fragmentation thresholds, but there is a rich recent literature.*]

Turner, M. G., D. C. Donato and W. H. Romme. 2013. Consequences of spatial heterogeneity for ecosystem services in changing forest landscapes: priorities for future research. Landscape Ecology 28:1081-1097. [*There are key questions about how landscapes will respond to changing global change drivers. This paper uses two illustrative landscapes to develop several key research priorities.*]

2016

TEXT

Turner, M. G. and R. H. Gardner. 2015. LANDSCAPE ECOLOGY IN THEORY AND PRACTICE, 2nd edition. Springer-Verlag, New York. (*See syllabus for chapter assignments.*)

Gergel, S. E. and M. G. Turner, editors. 2016. LEARNING LANDSCAPE ECOLOGY, 2nd edition. Springer-Verlag, New York. (for lab)

WEEKLY DISCUSSION READINGS

Friday, January 22 – Scope of landscape ecology, conceptual issues, scale, foundations

McIntyre, N. E., L. R. Iverson, and M. G. Turner. 2013. A 27-yr perspective on landscape ecology from the US-IALE annual meeting. (Editorial) Landscape Ecology 28:1845-1848. *[Short, entertaining (perhaps?) editorial on trends in US-IALE meetings.]*

Eros, T., and E. H. Campbell Grant. 2015. Unifying research on the fragmentation of terrestrial and aquatic habitats: patches, connectivity and the matrix in riverscapes. Freshwater Biology 60:1487-1501. *[Landscape ecology is not all "land;" the concepts developed in landscape ecology are also applied in aquatic and marine systems. This paper talks generally about landscape ecology concepts and applications, but in a different system.]*

Jelinski, D. E. 2015. On a landscape ecology of a harlequin environment: the marine landscape. (Editorial) Landscape Ecology 30:1-6. [*Another treatment of landscape ecology concepts from a non-terrestrial viewpoint.]*

Jenerette, G. D., and W. Shen. 2012. Experimental landscape ecology. Landscape Ecology 27:1237-1248. [*Nice overview of the role of experimentation in landscape ecology, and a good theme to keep in mind throughout the semester.*]

Wednesday, January 27 – Causes of landscape pattern

Background:

Hermy, M. and K. Verheyen. 2007. Legacies of the past in the present-day forest biodiversity: a review of past land-use effects on forest plant species composition and diversity. Ecological Research 22:361-271. *[There is a large and fascinating body of European work focused on the very long-term legacies of historical land use on contemporary ecosystems, and this review provides an excellent entrée into that literature. Some studies have even documented land-use legacies that date back 1000 yrs to land use during Roman occupation!]*

For discussion:

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

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

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. [*Nice synthesis of multiple factors that drive species assemblages and are themselves changing; addresses a shifting template and requires a landscape perspective.*]

Boucher, Y., P. Grondin, and I. Auger. 2014. Land use history (1840-2005) and physiography as determinants of southern boreal forests. Landscape Ecology 29:437-450. *[Example of an empirical study that evaluates causes of landscape pattern, here the distribution of forest age structure and species composition.]*

Wednesday, February 3 Quantifying pattern I

Good 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; older paper, but good food for thought on what is being quantified.]*

Gustafson, E. J. 1998. Quantifying landscape spatial pattern: What is the state of the art? Ecosystems 1:143-156. [*Relatively recent article addressing spatial analyses recognizing both categorical and continuous measures.]*

For discussion:

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.]*

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.]*

Wedding, L. M., C. A. Lepczyk, S. J. Pittman, A. M. Friedlander and S. Jorgensen. 2011. Quantifying seascape structure: extending terrestrial spatial pattern metrics to the marine realm. Marine Ecology Progress Series 427:219-232. [*Applications are not only terrestrial!*]

Símová, P. and K. Gdulová. 2012. Landscape indices behavior: A review of scale effects. Applied Geography 34:385-394. [*There are a fair number of empirical papers documenting the consequences of changing grain and extent on landscape metrics, and this paper provides an overview.*]

Wednesday, February 10 – Quantifying pattern II

Burnicki, A. C. 2012. Impact of error on landscape pattern analyses performed on land-cover change maps. Landscape Ecology 27:713-729. [*Accuracy of the data used in any landscape analysis will influence the results, and this is especially important when you want to quantify how landscapes change over time.*]

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

Remmel, T. K. and F. Csillag. 2003. When are two landscape pattern indices significantly different? Journal of Geographical Systems 5:331-351. [*Addresses the key issue of statistical significance when comparing metrics, which has been problematic in many studies.*]

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.*]

Wednesday, February 17 – Spatial statistics

Gundale, M. J., K. L. Metlen, C. E. Fiedler and T. H. DeLuca. 2006. Nitrogen spatial heterogeneity influences diversity following restoration in a ponderosa pine forest, Montana. Ecological Applications 16:479-489. [*Uses spatial statistics to relate resource heterogeneity to plant community patterns.*]

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

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.*]

McGuire, K. J., C. E. Torgersen, G. E. Likens, D. C. Buso, W. H. Lowe, and S. W. Bailey. 2014. Network analysis reveals multiscale controls on streamwater chemistry. Proceedings of the National Academy of Sciences 111:7030-7035. [*Uses spatial statistics to explore land-water relationships in a stream network setting.*]

Wednesday, February 24 – 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 issues associated with introducing spatial complexity into models.*]

For discussion:

Gardner, R. H., and D. L. Urban. 2007. Neutral models for testing landscape hypotheses. Landscape Ecology 22:15-29. [*Gardner was lead author of the original neutral landscape model paper; this is a nice summary of the current state of those models, which you will run in lab.*]

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. This is really important to consider as scientists try to model no-analog future conditions.]*

Keane, R. E., D. McKenzie, D. A. Falk, E. A. H. Smithwick, C. Miller, and L-K B. Kellogg. 2015. Representing climate, disturbance and vegetation interactions in landscape models. Ecological Modelling 309-310:33-47. [*Nice review of landscape models in context of a current/timely topic in landscape modeling and management.]*

Daniel, C. J., and L. Frid. 2012. Predicting landscape vegetation dynamics using state-and-transition simulation models. Proceeding of the First Landscape Stand-and-Transition Simulation Modeling Conference. USFS General Technical Report PNW-GTR-869. [*State-and-transition models are another type of simulation model that can be used for landscape projections.*]

Wednesday, March 2 – Landscape scenarios and ecosystem services

Gagne, S. A., F. Eigenbrod, D. G. Bert, G. M. Cunnington, L. T Olson, A. C. Smith, and L. Fahrig. 2015. A simple landscape design framework for biodiversity conservation. Landscape and Urban Planning 136:13-27. [*Current example of how researchers (and managers) are using quantitative landscape analyses and models for landscape planning and design.]*

Eigenbrod, F., V. A. Bell, H. N Davies, A. Heinemeyer, P. R. Armsworth and K. J. Gaston. 2011. The impact of projected increases in urbanization on ecosystem services. Proc. Roy. Soc. B 278:3201-3208. [*Uses two contrasting landscape scenarios of urbanization, densification vs. sprawl in the UK, through 2031, then evaluates their implications for selected ecosystem services. Illustrates the approach of looking at each extreme to see where differences may lie, rather than a complex set of alternatives. Good first step to take in many studies.*]

Byrd, K. B., L. E. Flint, P. Alvarez, C. F. Casey, B. M. Sleeter, C. E. Soulard, A. L. Flint, and T. L. Sohl. 2015. Integrated climate and land-use change scenarios for California ecosystem services:

wildlife habitat, soil carbon, and water supply. Landscape Ecology 30:729-750. [*West-coast example of comparing among different landscape scenarios to anticipate supply of a set of ecosystem services under alternate conditions.*]

Blank, P. J., C. L. Williams, D. W. Sample, T. D. Meehan, and M. G. Turner. 2016. Alternative scenarios of bioenergy crop production in an agricultural landscape and implications for bird communities. Ecological Applications (In press). [*Wisconsin-based example of quantitative landscape scenarios in which landscape composition and configuration are varied, and ecosystem services are considered along with biodiversity responses (grassland birds).]*

Wednesday, March 9 – Disturbance and landscapes I

Paritsis, J., A. Holz, T. T. Veblen, and T. Kitzberger. 2013. Habitat distribution modeling reveals vegetation flammability and land use as drivers of wildfire in SW Patagonia. Ecosphere DOI: 10.1890/ES12-00378.1. [*Vulnerability to disturbance may vary with landscape position; this paper considers a variety of independent variables that may aid spatial prediction of probability of fire occurrence.*]

Meentemeyer, R. K., S. E. Haas, and T. Vaclavik. 2012. Landscape epidemiology of emerging infectious diseases in natural and human-altered ecosystems. Annual Review of Phytopathology 50:379-402. [*Landscape or spatial epidemiology has emerged as an interesting area of research that overlaps with landscape ecology and disturbance.*]

Parks, S. A., L. M. Holsinger, C. Miller, and C. R. Nelson. 2015. Wildland fire as a self-regulating mechanism: the role of previous burns and weather in limiting fire progression. Ecological Applications 25:1478-1492. [*Effects of landscape pattern on the spread of disturbance, as well as how disturbances interact on the landscape, are long-standing themes in landscape ecology*.]

Hessburg, P. F., D. J. Churchill, A. J. Larson, R. D. Haugo, C. Miller, T. A. Spies, M. P. North, N. A. Povak, R. T. Belote, P. H. Singleton, W. L. Gaines, R. E. Keane, G. H. Aplet, S. L. Stephens, P. Morgan, P. A. Bisson, B. E. Rieman, R. B. Salter, and G. H. Reeves. 2015. Restoring fire-prone Inland Pacific landscapes: seven core principles. Landscape Ecology 30:1805-1835. [*Thoughtful paper focused on landscape-level prescriptions for restoration planning.*]

Wednesday, March 16 – Disturbance and landscapes II

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.*]

For discussion:

Pickell, P. D., D. W. Andison, and N. C. Coops. 2013. Characterizations of anthropogenic disturbance patterns in the mixedwood boreal forest of Alberta, Canada. Forest Ecology and Management 304:245-253. [*Evaluates forest landscapes relative to attempts to mimic natural disturbances and remain within the HRV.*]

Duncan, S. L., B. C. McComb, and K. N. Johnson. 2010. Integration ecological and social ranges of variability in conservation of biodiversity: past, present, and future. Ecology and Society Vol15/iss1/art5/. [*Adds the social part of the equation to the HRV concept.*]

Seidl, R., W. Rammer, and T. A. Spies. 2014. Disturbance legacies increase the resilience of forest ecosystem structure, composition, and functioning. Ecological Applications 24:2063-2077. [*Uses a spatially explicit simulation model to evaluate effects of different proportions of study landscape in remnant patches on vegetation trajectories. Considers stand and landscape-level responses.*]

Bowman, D. M. J. S., G. L. W. Perry, and J. B. Marston. 2015. Feedbacks and landscape-level vegetation dynamics. TREE 30:255-260. [*Feedbacks on the landscape between post-disturbance vegetation and future disturbance occurrence/severity is a hot topic.*]

Wednesday, March 30 – Organisms and landscapes I

Background reading (great FYI for those interested in these topics):

Fahrig L. 2003. Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution and Systematics 34:487-15. [*Classic reference on relative importance of habitat area vs. configuration (i.e., loss vs. fragmentation); also, there are many excellent publications from Fahrig and her students that include modeling and empirical study and a large variety of taxa.]*

Thornton, D. H., L. C. Branch and M. E. Sunquist. 2011. The influence of landscape, patch, and within-patch factors on species presence and abundance: a review of focal patch studies. Landscape Ecology 26:7-18. *[Excellent review of published studies, highlights importance of study design.]*

Fahrig, L., J. Baudry, L. Brotons, F. G. Burel, T. O Crist, R. J. Fuller, C. Sirami, G. M. Siriwardena and J.-L. Martin. 2011. Functional landscape heterogeneity and animal biodiversity in agricultural landscapes. Ecology Letters 14:101-112. [*Considers quantifying landscape pattern for a given purpose, and does a nice job describing structural vs. functional connectivity. This is a key distinction – landscape structure does not equate to how an organism uses the landscape.*]

For discussion:

Villard, M.-A., and J. P. Metzger. 2014. Beyond the fragmentation debate: a conceptual model to predict when habitat configuration really matters. Journal of Applied Ecology 51:309-318. [*On ongoing issue remains – is it landscape composition or configuration that is important? When does fragmentation per se matter? Recent follow up to ideas in Fahrig 2003.*]

Driscoll, D. A., S. C. Banks, P. S. Barton, D. B. Lindenmayer, and A. L. Smith. 2013 Conceptual domain of the matrix in fragmented landscapes. TREE 28:605-613. [*Interesting because of the emphasis on the matrix, which is sometimes overlooked when focus is on habitat patches.]*

McCune J. L. and M. Vellend. 2016. Using plant traits to predict the sensitivity of colonizations and extirpations to landscape context. Oecologia 178:511-524. [*Landscape ecology has long focused on how composition and configuration affect species or guilds; the recent emphasis on plant traits offers additional response variables to consider in analyses. This study also illustrate effects of landscape context.*]

Saura S., O. Bodin, and M.-J. Fortin. 2014. Stepping stones are crucial for species' long-distance dispersal and range expansion through habitat networks. Journal of Applied Ecology 51:171-182. [*Network analysis and methods for assessing or restoring habitat connectivity for different species continues to get attention, especially in highly modified settings. This also illustrates an application of the network approaches we will explore in lab.*]

Wednesday, April 6 – Organisms and landscapes II (landscape genetics; species interactions)

Background reading:

Manel, S. and R. Holderegger. 2013. Ten years of landscape genetics. TREE 28:614-621. [*Landscape genetics has become a big deal with lots of potential remaining. This literature has grown tremendously, and the application of molecular techniques to understand species distributions and migration patterns, or to assess local selective forces, is very promising.]*

Dormann, C. F., O. Schweiger, I. Augenstein and many others. 2007. Effects of landscape structure and land-use intensity on similarity of plant and animal communities. Global Ecology and Biogeography 16:774-787. [*Example of recent studies moving beyond single-species analysis to consider communities.*]

Tscharntke, T., J. M. Tylianakis, T. A. Rand, R. K. Didham, L. Fahrig, et al. 2012. Landscape moderation of biodiversity patterns and processes – eight hypotheses. Biological Reviews 87:661-685. [*Synthesizing landscape effects on biodiversity, good ideas within!*]

For discussion:

Hall, L. A., and S. R. Beisinger. 2014. A practical toolbox for design and analysis of landscape genetics studies. Landscape Ecology 29:1487-1504. [*It is important to be aware of the capabilities offered by landscape genetics studies.*]

Jackson, N. D. and L. Fahrig. 2014. Landscape context affects genetic diversity at a much larger spatial extent than population abundance. Ecology 95:871-881. [*Nice integration of landscape genetics, population abundance, and scale.*]

Martin, E. A., B. Reineking, B. Seo, and I. Steffan-Dewenter. 2013. Natural enemy interactions constrain pest control in complex agricultural landscapes. Proceedings of the National Academy of Sciences 110:5534-5539. [*Landscape research on species interactions has been growing. This is an interesting study demonstrating effects of landscape complexity on the interactions between different natural enemies; also demonstrates an experimental approach.*]

Thaker, M., A. T. Vanak, C. R. Owen, M. B. Ogden, S. M. Niemann and R. Slotow. 2011. Minimizing predation risk on a landscape of multiple predators: effects on the spatial distribution of African ungulates. Ecology 92:398-407. [*Paper on how spatial heterogeneity influences pred-prey interaction in an African landscape with multiple predators and multiple prey.*]

Wednesday, April 13 – Ecosystem processes

Massol, F., D. Gravel, N. Mouquet, M. W. Cadotte, T. Fukami and M. A. Liebold. 2011. Linking community and ecosystem dynamics through spatial ecology. Ecology Letters 14:313-323. [*Conceptual paper attempting to bridge distinct avenues of inquiry.*]

Murray, B. D., C. R. Webster, and J. K. Bump. 2014. A migratory ungulate facilitates cross-boundary nitrogen transport in forested landscapes. Ecosystems 17:1002-1013. [*Animals are often vectors of nutrient movements across heterogeneous landscapes, affecting heterogeneity of nutrient pools and transformations.*]

Cheruvelil, K. S., P. A. Soranno, K. E. Webster, and M. T. Bremigan. 2013. Multi-scaled drivers of ecosystem state: quantifying the importance of the regional spatial scale. Ecological Applications 23:1603-1618. [*A lot of work has been conducted on understanding landscape effects on surface waters and the scales and predictors of variation among lakes.*]

Buffam, I., M. G. Turner, A. Desai, P. J. Hanson, J. Rusak, N. Lottig and S. R. Carpenter. 2011. Integrating aquatic and terrestrial components to construct a complete carbon budget for a north temperate lake district. Global Change Biology 17:1193-1211. [*Example of building a regional budget that includes all major ecosystem types; focus here is on spatial heterogeneity of vertical fluxes.*]

Wednesday, April 20 —Landscape management and sustainability

Background reading:

Turner, B. L., II, and P. Robbins. 2008. Land-change science and political ecology: similarities, differences and implications for sustainability science. Annual Review of Environmental Resources 33:295-316. [*Great review that compares what we typically think of in landscape ecology with a social-science perspective.*]

For discussion:

Wiens, J. A. 2013. Is landscape sustainability a useful concept in a changing world? Landscape Ecology 28:1047-1052. [*John Wiens has been a leading thinker for >40 yrs, and these are some of his current thoughts.*]

Lindenmayer, D. B. and S. A. Cunningham. 2013. Six principles for managing forests as ecologically sustainable ecosystems. Landscape Ecology 28:1099-1110. [*Lindenmayer has done a lot of excellent and creative work; this conceptual paper nicely highlights lessons from landscape ecology for forest landscape management.*]

Del Castillo, R. F. 2015. A conceptual framework to describe the ecology of fragmented landscapes and implications for conservation and management. Ecological Applications 25:1447-1455. [*More thoughts on managing "working landscapes" and addressing tradeoffs.*]

Renard, D., J. M. Rhemtulla, and E. M. Bennett. 2015. Historical dynamics in ecosystem service bundles. Proceedings of the National Academy of Sciences 112:13411-13416. [*Nice study integrating land-use change, supply of ecosystem services, and consideration of variation over both space and time in a mixed-use landscape. These issues are fundamental to studies of landscape sustainability.*]

Friday, April 22 – Future directions in landscape ecology

Groffman, P. M., and many others. 2014. Ecological homogenization of the urban USA. Frontiers in Ecology and the Environment 12:74-81. [*Urban landscape ecology offers many opportunities for landscape ecologists to contribute to understanding how spatial patterns change, and how patterns in the urban landscape influence ecological processes.*]

Turrini, T., and E. Knop. 2015. A landscape ecology approach identifies important drivers of urban biodiversity. Global Change Biology 21:1652-1667. [*Pattern-process interactions can be explored in urban settings; here the focus is on biodiversity.*]

Hahn, M. B., E. S. Gurley, J. E. Epstein, M. S. Islam, J. A. Patz, P. Daszak, and S. P. Luby. 2014. The role of landscape composition and configuration on *Pteropus giganteus* roosting ecology and Nipah virus spillover risk in Bangladesh. American Journal of Tropical Medicine and Hygiene 90:247-255. [*The intersection of landscape ecology and human health issues, including infectious diseases, is an exciting interdisciplinary frontier. Again, lots of opportunity to explore these new dimensions!]*

Heffernan, J. B. and many others. 2014. Macrosystems ecology: understanding ecological patterns and processes at continental scales. Frontiers in Ecology and the Environment 12:5-14. [*Macrosystems ecology builds quite a bit on foundations of landscape ecology, including scaling issues and studies of large areas. Macrosystems is on the rise as NEON data come online and agencies like NSF emphasize continental-scale ecology. Where does landscape ecology fit in?*]

2018

TEXT

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

Gergel, S. E. and M. G. Turner, editors. 2016. LEARNING LANDSCAPE ECOLOGY, 2nd edition. Springer-Verlag, New York. (for lab)

WEEKLY DISCUSSION READINGS

(1) Friday, January 26 – Scope of landscape ecology, conceptual issues, scale, foundations

Nice background for landscape ecology of aquatic and marine systems:

Eros, T., and E. H. Campbell Grant. 2015. Unifying research on the fragmentation of terrestrial and aquatic habitats: patches, connectivity and the matrix in riverscapes. Freshwater Biology 60:1487-1501. *[Landscape ecology is not all "land;" the concepts developed in landscape ecology are also applied in aquatic and marine systems. This paper talks generally about landscape ecology concepts and applications, but in a different system.]*

Jelinski, D. E. 2015. On a landscape ecology of a harlequin environment: the marine landscape. (Editorial) Landscape Ecology 30:1-6. [*Another treatment of landscape ecology concepts from a non-terrestrial viewpoint.]*

For discussion:

Jenerette, G. D., and W. Shen. 2012. Experimental landscape ecology. Landscape Ecology 27:1237-1248. [*Nice overview of the role of experimentation in landscape ecology, and a good theme to keep in mind throughout the semester.*]

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. [*Jumping ahead a bit, but this paper is nice because it references diverse concepts, in landscape ecology; good reminders of foundational work.*]

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 the new "buzz word", but it builds directly on foundational work in landscape ecology. What is different? What is the same? How does scale factor in?]*

Wu, J. 2017. Thirty years of *Landscape Ecology* (1987-2017): retrospects and prospects. Landscape Ecology 32:2225-2239. [*Current EIC of the journal reflects back on its growth; interesting to compare and contrast Tables 1 and 2.*]

(2) Wednesday, January 31 – Causes of landscape pattern

Good background (highly recommended):

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

For discussion:

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

Bürgi, M., L. Östlund, and D. J. Mladenoff. 2017. Legacy effects of human land use: ecosystems as time-lagged systems. Ecosystems 20:94-103. [*Recent perspective on the importance of historical perspective in understanding contemporary systems*.]

Finsinger, W., T. Giesecke, S. Brewer, and M. Leydet. 2017. Emergence patterns of novelty in European vegetation assemblages over the past 15,000 years. [*A paleo perspective, appreciating how landscapes have changed through deep time, is important. This is one example, but there are many…and you should know the long-term history of your study region, wherever it is.*]

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. [*Nice synthesis of multiple factors that drive species assemblages and are themselves changing; addresses a shifting template and requires a landscape perspective.*]

(3) Wednesday, February 7– Quantifying pattern I

Good 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; older paper, but 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!]*

For discussion:

Burnicki, A. C. 2012. Impact of error on landscape pattern analyses performed on land-cover change maps. Landscape Ecology 27:713-729. [*Accuracy of the data used in any landscape analysis will influence the results, and this is especially important when you want to quantify how landscapes change over time.*]

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.]*

Almeida, D., J. Rocha, C. Neto, and P. Arsénio. 2016. Landscape metrics applied to formerly reclaimed saltmarshes: A tool to evaluate ecosystem services? Estuarine, Coastal and Shelf Science 181:100-113. [*Landscape metrics are used in a wide range of settings, not only in terrestrial landscapes, here, in salt marshes.*]

Liu, Z., C. He, and J. Wu. 2016. General spatiotemporal patterns of urbanization: an examination of 16 world cities. Sustainability 8:41. [*Landscape metrics often accompany studies of land use/land cover change; this analysis looks at urbanization.*]

(4) Wednesday, February 14 – Quantifying pattern II

Remmel, T. K. and F. Csillag. 2003. When are two landscape pattern indices significantly different? Journal of Geographical Systems 5:331-351. [*Addresses the key issue of statistical significance when comparing metrics, which has been problematic in many studies. Does reading this change your assessment of last week's readings on LULC change?*]

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*]

Gage, E. A. and D. J. Cooper. 2017. Relationships between landscape pattern metrics, vertical structure and surface urban heat island formation in a Colorado suburb. Urban Ecosystems 20:1229-1238. [*A bit out of the ordinary, an example showing ways in which landscape metrics can be used as predictors—last week's readings had them as the descriptors of change.*]

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.*]

(5) Wednesday, February 21 – Spatial statistics

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 the 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.*]

Berry, L. E., D. A. Driscoll, J. A. Stein, W. Blanchard, S. C. Banks, R. A. Bradstock, and D. B Lindemayer. 2015. Identifying the location of fire refuges in wet forest ecosystems. Ecological Applications 25:2337-2348. [*Variograms are only one method used in this study, but it demonstrates how they can contribute to a broader approach.*]

Smithwick, E. A. H., K. J. Naithani, T. C. Balser, W. H. Romme, and M. G. Turner. 2012. Post-fire spatial patterns of soil nitrogen mineralization and microbial abundance PLoS ONE 7(11):e50597. [*Down in the weeds on the methods, but demonstrates how spatial statistics can be run across multiple variables to generate insights on pattern-process.*]

(6) Wednesday, February 28 – 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.*]

Gardner, R. H., and D. L. Urban. 2007. Neutral models for testing landscape hypotheses. Landscape Ecology 22:15-29. [*Gardner was lead author of the original neutral landscape model paper; this is a nice summary of the those models, which you will run in lab.*]

For discussion:

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

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.]*

Sleeter, B. M., T. S. Wilson, E. Sharygin, and J. T. Sherba. 2017. Future scenarios of land change based on empirical data and demographic trends. Earth's Future 5: 1068-1983. [*Example of how land-cover change models can be developed and applied; there many kinds of landscape model.]*

Daniel, C. J., L. Frid, B. M. Sleeter, and M-J Fortin. 2016. State-and-transition simulation models: a framework for forecasting landscape change. Methods in Ecology and Evolution 7:1413-1423. [*Overview of the STSM approach for spatial modeling; more sophisticated approach compared to the first order Markov chain.*]

(7) Wednesday, March 7 – 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:

Paritsis, J., A. Holz, T. T. Veblen, and T. Kitzberger. 2013. Habitat distribution modeling reveals vegetation flammability and land use as drivers of wildfire in SW Patagonia. Ecosphere DOI: 10.1890/ES12-00378.1. [*Vulnerability to disturbance may vary with landscape position; this paper considers a variety of independent variables that may aid spatial prediction of probability of fire occurrence.*]

Harvey, B. J., D. C. Donato and M. G. Turner. 2016. Drivers and trends in spatial patterns of burn severity in forests of the US Northern Rocky Mountains (1984-2010). Landscape Ecology 31:2367-2383. [*Uses landscape metrics to test for changing disturbance-generated spatial patterns in burned forests of the Northern Rockies.*]

Bebi, P., R. Seidl, R. Motta, M. Fuhr, D. Firm, F. Krumm, M. Conedera, C. Ginzler, T. Wohlgemuth, and D. Kulakowski. 2017, Changes of forest cover and disturbance regimes in the mountain forests of the Alps. Forest Ecology and Management 388:43-56. [*Analyzes forest cover and disturbance regimes over the past millennia in the Alps.*]

Meentemeyer, R. K., S. E. Haas, and T. Vaclavik. 2012. Landscape epidemiology of emerging infectious diseases in natural and human-altered ecosystems. Annual Review of Phytopathology 50:379-402. [*Landscape or spatial epidemiology has emerged as an interesting area of research that overlaps with landscape ecology and disturbance.*]

(8) Wednesday, March 14 – 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.*]

For discussion:

Duncan, S. L., B. C. McComb, and K. N. Johnson. 2010. Integration ecological and social ranges of variability in conservation of biodiversity: past, present, and future. Ecology and Society Vol15/iss1/art5/. [*Adds the social part of the equation to the historical range of variability concept.*]

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. [*Current thinking on how forest resilience could be compromised in the future as climate and disturbance regimes change.*]

Bowman, D. M. J. S., G. L. W. Perry, and J. B. Marston. 2015. Feedbacks and landscape-level vegetation dynamics. TREE 30:255-260. [*Feedbacks on the landscape between post-disturbance vegetation and future disturbance occurrence/severity is a hot topic.*]

Seidl, R., D. C. Donato, K. A Raffa, and M. G. Turner. 2016. Spatial variability in tree regeneration after wildfire delays and dampens future bark beetle outbreaks. Proceedings of the National Academy of Sciences 113:13075-13080. [*Disturbance interactions remains a hot topic, and most are implicitly considered as negative; this highlights a dampening interaction.*]

(9) Wednesday, March 21 – Organisms and landscapes I

Good background:

Tscharntke, T., J. M. Tylianakis, T. A. Rand, R. K. Didham, L. Fahrig, et al. 2012. Landscape moderation of biodiversity patterns and processes – eight hypotheses. Biological Reviews 87:661-685. [*Synthesizing landscape effects on biodiversity, good ideas within!*]

Dormann, C. F., O. Schweiger, I. Augenstein and many others. 2007. Effects of landscape structure and land-use intensity on similarity of plant and animal communities. Global Ecology and Biogeography 16:774-787. [*Example of recent studies moving beyond single-species analysis to consider communities.*]

Thaker, M., A. T. Vanak, C. R. Owen, M. B. Ogden, S. M. Niemann and R. Slotow. 2011. Minimizing predation risk on a landscape of multiple predators: effects on the spatial distribution of African ungulates. Ecology 92:398-407. [*Paper on how spatial heterogeneity influences pred-prey interaction in an African landscape with multiple predators and multiple prey.*]

McCune J. L. and M. Vellend. 2015. Using plant traits to predict the sensitivity of colonizations and extirpations to landscape context. Oecologia 178:511-524. [*Landscape ecology has long focused on how composition and configuration affect species or guilds; the recent emphasis on plant traits offers additional response variables to consider in analyses. This study also illustrate effects of landscape context.*]

For discussion:

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; her earlier paper on the Habitat Amount Hypothesis triggered spirited discussion.*]

Haddad, N. M., A. Gonzalez, L. A. Brudvig, M. A. Burt, D. J. Levey, and E. I Damschen. 2017. Experimental evidence does not support the Habitat Amount Hypothesis. Ecography 40:48-55. [*Current debate about the relative importance of composition (amount) vs. configuration on organisms, specifically Fahrig's 2013 paper advancing the Habitat Amount Hypothesis.]*

Prevedello, J. A., N. J. Gotelli, and J. P. Metzger. 2016. A stochastic model for landscape patterns of biodiversity. Ecological Monographs. [*Modeling approach, how does this inform debate about the Habitat Amount Hypothesis?*]

Ferrante, L., F. B. Baccaro, E. B. Ferreira, M. F de Oliveira Sampaio, T. Santos, R. C. Justino and A. Angulo. 2017. The matrix effect: how agricultural matrices shape forest fragment structure and amphibian composition. Journal of Biogeography 44:1911-1922. *[Landscape context, or the matrix, can influence presence or abundance of many species, and local and surrounding features are typically considered in resource selection functions or occupancy models.*]

(10) Wednesday, April 4 – Organisms and landscapes II

Good background:

Manel, S. and R. Holderegger. 2013. Ten years of landscape genetics. TREE 28:614-621. [*Landscape genetics has become a big deal with lots of potential remaining. This literature has grown tremendously, and the application of molecular techniques to understand species distributions and migration patterns, or to assess local selective forces, is very promising.]*

For discussion:

Hall, L. A., and S. R. Beisinger. 2014. A practical toolbox for design and analysis of landscape genetics studies. Landscape Ecology 29:1487-1504. [*It is important to be aware of the capabilities offered by landscape genetics studies.*]

Auffret, A. G., Y. Rico, J. M. Bullock, D. A. P. Hooftman, R. J Pakeman, M. B. Soons, A. Suarez-Esteban, A. Traveset, H. H. Wagner, and S. A. O. Cousins. 2017. Plant functional connectivity – integrating landscape structure and effective dispersal. Journal of Ecology 105:1648-1656. [*Connectivity has to be related to the particular organism or process being considered. Good recent perspective on plant dispersal.*]

Leonard, P. B., R. W. Sutherland, R. F. Baldwin, D. A. Fedak, R. G. Carnes, and A. P. Montgomery. 2017. Landscape connectivity losses due to sea level rise and land use change. Animal Conservation 20:80-90. [*Sticking with the theme of connectivity and networks, this is an interesting study of how landscape structure changes with two different drivers, has an applied bent.]*

Samsing, F., I. Johnsen, T. Dempster, F. Oppedal, and E. A. Treml. 2017. Network analysis reveals strong seasonality in the dispersal of a marine parasite and identifies areas for coordinated management. Landscape Ecology 32:1953-1967. [*Example of how network modeling is used in an important spatial marine system.*]

(11) Wednesday, April 11 – Ecosystem processes

Crum, S. M., L. L. Liang, and G. D. Jenerette. 2016. Landscape position influences soil respiration variability and sensitivity to physiological drivers in mixed-use lands of Southern California, USA. JGR: Biogeosciences 121:2530-2543. [*Example of how landscape position can influence an ecosystem process rate.*]

Buffam, I., M. G. Turner, A. Desai, P. J. Hanson, J. Rusak, N. Lottig and S. R. Carpenter. 2011. Integrating aquatic and terrestrial components to construct a complete carbon budget for a north temperate lake district. Global Change Biology 17:1193-1211. [*Example of building a regional C budget by including all major ecosystem types, which is seldom done; focus here is on spatial heterogeneity of vertical fluxes.*]

Murray, B. D., C. R. Webster, and J. K. Bump. 2014. A migratory ungulate facilitates cross-boundary nitrogen transport in forested landscapes. Ecosystems 17:1002-1013. [*Animals are often vectors of nutrient movements across heterogeneous landscapes, affecting heterogeneity of nutrient pools and transformations.*]

Turetsky, M. R., J. L. Baltzer, J. F. Johnstone, M. C. Mack, K. McCann, and E.A.G. Schuur. 2017. Losing legacies, ecological release, and transient responses: key challenges for the future of northern ecosystem science. Ecosystems 20:23-30. [*Although this focuses on the boreal, the general questions illustrate frontiers at the interface of landscape ecology and ecosystem ecology.*]

(12) Wednesday, April 18 —Landscape pattern and ecosystem services

Boesing, A. L., E. Nichols, and J. P. Metzger. 2017. Effects of landscape structure on avian-mediated insect pest control services: a review. Landscape Ecology 32:931-944. [*Effects of landscape pattern on species interactions, here pest control, is an area of much current interest.]*

Renard, D., J. M. Rhemtulla, and E. M. Bennett. 2015. Historical dynamics in ecosystem service bundles. Proceedings of the National Academy of Sciences 112:13411-13416. [*Nice study integrating land-use change, supply of ecosystem services, and consideration of variation over both space and time in a mixed-use landscape. These issues are fundamental to studies of landscape sustainability.*]

Qiu, J., S. R. Carpenter, E. C. Booth, M. Motew, S. C. Zipper, C. J. Kucharik, X. Chen, S. P. Loheide II, J. Seifert, and M. G. Turner. 2018. Scenarios reveal pathways to sustain future ecosystem services in an agricultural landscape. Ecological Applications 28:119-134. [*One of the synthetic papers from a 5-yr research project focused on the Yahara Watershed.*]

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.*]

(13) Friday, April 20 – Future directions in landscape ecology

Wu, J. 2014. Urban ecology and sustainability: The state-of-the-science and future directions. Landscape and Urban Planning 125:209-221. [*Overview of urban ecology, which is a growing direction within landscape ecology.*]

Hahn, M. B., E. S. Gurley, J. E. Epstein, M. S. Islam, J. A. Patz, P. Daszak, and S. P. Luby. 2014. The role of landscape composition and configuration on *Pteropus giganteus* roosting ecology and Nipah virus spillover risk in Bangladesh. American Journal of Tropical Medicine and Hygiene 90:247-255. [*The intersection of landscape ecology and human health issues, including infectious diseases, is an exciting interdisciplinary frontier. Again, lots of opportunity to explore these new dimensions!]*

Standish, R. J., R. J. Hobbs, M. M. Mayfield, B. T. Bestelmeyer, K. N. Suding, L. L. Battaglia, V. Eviner, C. V. Hawkes, V. M. Temperton, V. A. Cramer, J. A. Harris, J. L. Funk, and P. A. Thomas. 2014. Resilience in ecology: Abstraction, distraction, or where the action is? Biological Conservation 177:43-51. [*Thresholds, regime shifts, and 'new normals' will continue to challenge landscape ecologists in the decades ahead.*]

Van Zanten, B. T., D. B. Van Berkel, R. K. Meentemeyer, J. W. Smith, K. F. Tieskens, and P. H Verburg. 2016, Continental-scale quantification of landscape values using social media data. Proceedings of the National Academy of Sciences 113:12974-12979. [*Data from social media are increasingly used for landscape assessments, especially of cultural ecosystem services. What are pros and cons of this kind of data?*]

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TEXT

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

Gergel, S. E. and M. G. Turner, editors. 2016. LEARNING LANDSCAPE ECOLOGY, 2nd edition. Springer-Verlag, New York. (for lab)

WEEKLY DISCUSSION READINGS

(1) Friday, January 24 – Contemporary landscape ecology ✓

Nice background for landscape ecology of aquatic/marine systems.

Eros, T., and E. H. Campbell Grant. 2015. Unifying research on the fragmentation of terrestrial and aquatic habitats: patches, connectivity and the matrix in riverscapes. Freshwater Biology 60:1487-1501. *[Landscape ecology is not all "land;" the concepts developed in landscape ecology are also applied in aquatic and marine systems. This paper talks generally about landscape ecology concepts and applications, but in a different system.]*

Jelinski, D. E. 2015. On a landscape ecology of a harlequin environment: the marine landscape. (Editorial) Landscape Ecology 30:1-6. [*Another treatment of landscape ecology concepts from a non-terrestrial viewpoint.]*

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

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, so it offers good reminders of foundational work.*]

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 new 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.]*

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. [*Nice synthesis of multiple factors that drive species assemblages and are changing; addresses a shifting template, which is a big deal now, and requires a landscape perspective. Contemporary landscape ecology has to acknowledge the role of changing drivers (e.g., climate warming).*]

Beller, E.E., E. N. Spotswood, A. H. Robinson, M. G. Anderson, E. S. Higgs, R. J. Hobbs, K. N. Suding, E. S. Zavaleta, J. L. Grenier, and R. M. Grossinger. 2019. Building ecological resilience in highly modified landscapes. BioScience 69:80-92. *[Enjoyable, readable paper that touches on lots of landscape ecology concepts in the context of a contemporary issue.]*

(2) Wednesday, January 29 – Causes of landscape pattern ✓

Good background (highly recommended):

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

Bürgi, M., L. Östlund, and D. J. Mladenoff. 2017. Legacy effects of human land use: ecosystems as time-lagged systems. Ecosystems 20:94-103. [*Recent perspective on the importance of historical perspective in understanding contemporary systems*.]

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

Phillips, J. D. 2007. The perfect landscape. Geomorphology 84:159-169. [*Conceptual paper that makes the point that every landscape is unique, and many contingencies lead to the development of any particular landscape pattern. This paper makes a very fundamental point!*]

Williams,, J. W., K. D. Burke, M. S. Crossley, D. A. Grant, and V. C. Radeloff. 2019. Land-use and climatic causes of environmental novelty in Wisconsin since 1890. Ecological Applications 29(7):e01955. *[Example from our local Wisconsin landscape that incorporates historical land-use data and here relates the past to "novelty" in the environment.]*

Depauw, L., D. Landuyt, M. P. Perring, H Blondeel, S. L. Maes, M. Kopecky, F. Malis, M. Vanhellemont, and K. Verheyen. 2019. A general framework for quantifying the effects of land-use history on ecosystem dynamics. Ecological Indicators 107. 10-5395. *[Lots of land-use history studies have been conducted in Europe; here, the authors examine forest understory diversity and use a Markov model to explore drivers.]*

Godfree, R. C., N.Knerr, D. Godfree, J. Buxby, B. Robertson, and F. Encinas-Viso. 2019. Historical reconstruction unveils the risk of mass mortality and ecosystem collapse during pancontinental megadrought. Proceedings of the National Academy of Sciences 116:15580-15589. *[As with historical land use, extreme events can shape landscapes for decades to centuries.]*

(3) Wednesday, February 5– Quantifying pattern I ✓

Good 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; older paper, but 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 application:

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.]*

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. *[Reviews development of landscape metrics, includes a nice example that illustrates effect of grain size and the long-time goal of having scaling rules.]*

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.]*

Grafius, D. R., R. Corstanje, and J. A. Harris. 2018. Linking ecosystem services, urban form and green space configuration using multivariate landscape metric analysis. Landscape Ecology 33:557-

573. *[Contemporary application of landscape metrics, calculated using Fragstats, and used to assess urban landscapes, which are themselves still a frontier in landscape ecology.]*

(4) Wednesday, February 12 – Quantifying pattern II ✓

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.]*

San-Miguell, I., D. W. Andison, and N C. Coops. 2017. Characterizing historical fire patterns as a guide for harvesting planning using landscape metrics derived from long-term satellite imagery. Forest Ecology & Management 399:155-165. *[Another example of how landscape metrics are applied, to aerial photo and satellite data, here to assess fire-created patterns in boreal Canada.]*

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.*]

(5) Wednesday, February 26 – 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.]*

Aston, E. A., G. J. Williams, J. A. Mattias Green, A. J. Davies, L. M. Wedding, J. M. Gove, J.-B. Jouffray, T. T. Jones, and J. Clark. 2019. Scale-dependent spatial patterns in benthic communities around a tropical island seascape. Ecography 42:578-590. *[Relates gradients in physical drivers to patterns of coral reefs. Uses Moran's I as measure of spatial dependence across scales.]*

(6) Wednesday, Mar 4 – 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.*]

Gardner, R. H., and D. L. Urban. 2007. Neutral models for testing landscape hypotheses. Landscape Ecology 22:15-29. [*Gardner was lead author of the original neutral landscape model paper; this is a nice summary of the those models, which you will run in lab.*]

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.]*

For discussion–overview of spatial models and examples of landscape modeling:

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

Duveneck and J. R. Thompson. 2019. Modeling future forests in New England Gobal Environmental Change xxx – LANDIS II example. *[Example of widely used process-based model, Landis II, initially developed here at UW-Madison in the Mladenoff lab.]*

Thom, D., W. Rammer, T. Dirnbock, J. Muller, J. Kobler, K. Katzensteiner, N. Helm, and R. Seidl. 2017. The impacts of climate change and disturbance on spatial-temporal trajectories of biodiversity in a temperate forest landscape. Journal of Applied Ecology 54:28-38. *[Uses a process-based simulation model, iLand, to generate future landscapes, then link to indicators of biodiversity.]*

Donato, D. C., J. A. Halofsky, and M. J. Reilly. 2019. Corralling a black swan: natural range of variation in a forest landscape driven by rare, extreme events. Ecological Applications e02013. *[Example of using aspatial state-and-transition models to answer landscape questions and provide context for interpreting contemporary dynamics; nice segue to disturbance topic, also.]*

(7) Wednesday, March 11 – 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 patterns, changing disturbance regimes):

Paritsis, J., A. Holz, T. T. Veblen, and T. Kitzberger. 2013. Habitat distribution modeling reveals vegetation flammability and land use as drivers of wildfire in SW Patagonia. Ecosphere DOI: 10.1890/ES12-00378.1. [*Vulnerability to disturbance may vary with landscape position; this paper considers a variety of independent variables that may aid spatial prediction of probability of fire occurrence.*]

Bebi, P., R. Seidl, R. Motta, M. Fuhr, D. Firm, F. Krumm, M. Conedera, C. Ginzler, T. Wohlgemuth, and D. Kulakowski. 2017. Changes of forest cover and disturbance regimes in the mountain forests of the Alps. Forest Ecology and Management 388:43-56. [*Analyzes forest cover and disturbance regimes over the past millennia in the Alps.*]

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. Linednmayer, 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.]*

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.]*

(8) Wednesday, March 25 – 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 concepts):

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.]*

Jogiste, K., H. Korjus, J. A. Stanture, L. E. Frelich, E. Baders, J. Donis, A. Jansons, A. Kangur, K. Koster, D. Laarmann, T. Maaten, V. Marozas, M. Metslaid, K. Nigul, O. Polyachenko, T. Randverr, and F. Vodde. 2017. Hemiboreal forest: natural disturbances and the importance of ecosystem legacies to management. Ecosphere 8(2), e01706. [*The role of legacies, how forest resilience could be compromised in the future as climate, disturbance regimes and management change in the future are addressed here from European perspective. Disturbance is emerging as a more important issue in Europe in recent years.*]

Van de Leemput, I. A., V. Dakos, M. Scheffer, and E. H. van Nes. 2018. Slow recovery from local disturbances as an indicator for loss of ecosystem resilience. Ecosystems 21:141-152.low response to disturbance? *[Ties to resilience theory, which is an important and rich body of work related to disturbances, and the disruption of natural cycles of disturbance-recovery.]*

Hansen, W. D., D. Abendroth, W. Rammer, R. Seidl, and M. G. Turner. Can wildland fire management alter 21st-century fire patterns and forests in Grand Teton National Park? Ecological Applications (In press). *[Example of using scenarios and process-based models to explore effects of changing fire regimes and climate on a forested landscape.]*

(9) Wednesday, April 1 – 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–understanding a contemporary debate:

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.*]

Thompson, S. E. D., R. A. Chisholm, and J. Rosindell. 2019. Characterising extinction debt following habitat fragmentation using neutral theory. Ecology Letters 22:2087-2096. *[Recent study that builds on the debate, touches on extinction debt concepts, and here proposes new metrics that relate landscape patterns to diversity. This study also considers habitat loss and scale.]*

(10) Wednesday, April 8 – Organisms and landscapes II ✓

For discussion-climate change, species interactions, biotic communities:

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, has been a fruitful direction. This is deals with perceived predation risk.]*

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. Assuming static climate isn't going to be very effective, yet many studies have not yet integrated climate change.]*

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, natural enemies and especially the amount and arrangement of semi-natural habitats in Europe. Example of considering communities, not just single populations.]*

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

(11) Wednesday, April 15 – Ecosystem processes ✓

Background reference:

Lovett, G. M., C. G. Jones, M. G. Turner and K. C. Weathers, editors. 2005. ECOSYSTEM FUNCTION IN HETEROGENEOUS LANDSCAPES. Springer-Verlag, New York.

For discussion- lateral transfers and process rates:

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.]*

Leroux, S. J., E. Vander Wal, Y. F. Wiersma, L. Charron, J. D. Ebel, N. M. Ellis, C. Hart, E. Kissler, P. W. Saunders, L. Moudra, A. L. Tanner, and S. Yalcin. 2017. Stoichiometric distribution models: ecological stoichiometry at the landscape extent. Ecology Letters 20:1495-1506. *[Understanding landscape-level variation in a wide range of 'traditional' ecosystem process rates or indicators, such as nutrient ratios, remains somewhat less developed.]*

Walker, X. J., B. M. Rogers, J. L. Baltzer, S. G. Cumming, N. J. Day, S. J. Goetz, J. F. Johnstone, E. A. G. Schuur, M. R. Turetsky, and M. C. Mack. 2018. Cross-scale controls on carbon emissions from boreal forest megafires. Global Change Biology 24:4251-4265. *[Disturbances can change ecosystem processes over whole landscapes. This paper uses field work and spatial modeling to estimate C emissions.]*

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 proposals that have examined lakes over large areas. This paper raises interesting ideas on variation in time and space.]*

(12) Wednesday, April 22 —Ecosystem services ✓

For discussion – focus on working landscapes, different approaches; 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.*]

Qiu, J., S. R. Carpenter, E. C. Booth, M. Motew, S. C. Zipper, C. J. Kucharik, X. Chen, S. P. Loheide II, J. Seifert, and M. G. Turner. 2018. Scenarios reveal pathways to sustain future ecosystem services in an agricultural landscape. Ecological Applications 28:119-134. [*Modeling ecosystem service supply across scenarios; synthetic paper from a 5-yr UW-Madison research project focused on the Yahara Watershed.*]

Johnson, J. A., S. K. Jones, S. L. R. Wood, R. Chaplin-Kramer, P. L. Hawthorne, M. Mulligan, D. Pennington, and F. A. DeClerck. 2019. Mapping Ecosystem Services to Human wellbeing: a toolkit to support integrated landscape management for the SDGs. Ecological Applications, e01985. *[Linking to the US sustainable development goals is providing useful guidelines for ecosystem services work.]*

Tribot, A.-S., J. Deter, and N. Mouquet. 2018. Integrating the aesthetic value of landscapes and biological diversity. Proc. R. Soc. B 285:20180971. *[Cultural ecosystem services have been challenging to integrate into landscape analyses.]*

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TEXT

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

Gergel, S. E. and M. G. Turner, editors. 2016. LEARNING LANDSCAPE ECOLOGY, 2nd edition. Springer-Verlag, New York. (for lab)

WEEKLY DISCUSSION READINGS

(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.]*

(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 concepts):

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 Evolution 35:919-930. *[Conservation in agricultural landscapes is important.]*

2024

(Week 1) Tuesday, January 23 – 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 and macroecology became buzz words, but both rely on foundational work in landscape ecology. What is different? What is the same? Does the Banks-Leite paper add value to what is known? This paper also offers a brief refresher on scale concepts, which underpin much of landscape ecology.]*

Wiersma, Y. F. 2022. Experimental Landscape Ecology. Springer, New York. [*The first 5 chapters of this book offer an overview of landscape concepts and the role of experiments in landscape ecology. Approaches to experimentation are then discussed from small model landscapes to large experiments, and experiments using computer simulation models.*]

(1a) For discussion—current takes on landscape ecology and scale:

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

Fletcher, R. J. Jr., M. G. Betts, E. I. Damschen, T. J. Hefley, J. Hightower, T. A. H. Smith, M.-J. Fortin, and N. M. Haddad. 2023. Addressing the problem of scale that emerges with habitat fragmentation. Global Ecology and Biogeography 10.1111/geb.13658. *[Nice review of scale concepts, illustrated from the viewpoint of habitat fragmentation (which we will re-visit later in the semester). Table 1 is very useful, also ties into neutral landscape models. But key here is distinction between scales of mechanism, scales of sampling and scales of analysis.]*

Banks-Leite, C., M. G. Betts, R. M. Ewers, C. D. L. Orme, and A. L. Pigot. 2022. The macroecology of landscape ecology. TREE 37(6):480-487. [*Thought-provoking – is macroecology coming to the rescue? How does macroecology add value to LE (or does it?) Does the emphasis on biodiversity limit generality of the ideas presented in this paper?]*

(1b) Thursday, January 25–ways of studying landscapes:

For discussion:

Watch the TED Talk by Greg Asner: Ecology from the air
https://www.ted.com/talks/greg_asner_ecology_from_the_air

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 of 3D data, which complements the TED talk and is increasingly used in landscape studies as data become more widely available.]*

Markham, K., A. E. Frazier, K. K. Singh, and M. Madden. 2023. A review of methods for scaling remotely sensed data for spatial pattern analysis. Landscape Ecology 38:619-635. *[Ties issues of scale to the practical side of having to upscale or downscale; timeline for science of scaling; context for quantifying spatial pattern.]*

Depauw, L., H. Blondeel, E. De Lombaerde, K. De Pauw, D. Landuyt, E. Lorer, P. Vangansbeke, T. Vanneste, K. Verheyen, and P. De Frenne. 2022. The use of photos to investigate ecological change. J. Ecol. 110:1220-1236. *[Interesting application of how repeat photography can be useful in landscape studies.]*

(Week 2) Tuesday, January 31 – 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. [*Such a well written essay. Good thinking on long-term change and links to paleoecology, which provides landscape ecology with a deep time perspective.*]

(2a) For discussion—contingencies, legacies, and path-dependence

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. Every landscape ecologist should read this!*]

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.]*

Johnson-Bice et al. 2022. Relics of beavers past: time and population density drive scale-dependent patterns of ecosystem engineering. Ecography e05814. *[Recent example of a classic ecosystem engineer creating persistent landscape patterns in the Upper Midwest that also deals with legacies -- but instead of land-use or disturbance, it's beavers!]*

Lembrechts, J. L. and I. Nijs. 2020. Microclimate shifts in a dynamic world. Science 368:711-712. *[This quick read is an introduction the recent surge in studies focused on microclimate and microtopography; these are currently hot topics, and this commentary accompanied an excellent paper by Zellweger et al.]*

(2b) Thursday, February 22–For discussion–persistent anthropogenic legacies

Watch the TED Talk by Eric Sanderson, New York before the city
https://www.ted.com/talks/eric_sanderson_new_york_before_the_city

Meyfroidt, P. et al. 2022. Ten facts about land systems for sustainability. PNAS 119(7)e2109217118. *[Thought-provoking article that leans on landscape ecology and emphasizes sustainability challenges and social-ecological systems.]*

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; an important paper that offers context for the TED talk on New York.]*

Sutherland, I. J., K. Copes-Gerbitz, L. Parrott, and J. M. Rhemtulla. 2023. Dynamics in the landscape ecology of institutions: lags, legacies, and feedbacks drive path-dependency of forest landscapes in British Columbia, Canada, 1958-2020. Landscape Ecology https://doi.org/10.1007/s10980-023-01721-y. *[Considers the linked social-ecological system and an example of path-dependence in a specific landscape.]*

(Week 3) Tuesday, Feb 22 – Landscape models and landscape change

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.]*

For discussion–Current examples of landscape modeling:

Bugmann, H. and R. Seidl. 2022. The evolution, complexity and diversity of models of long-term forest dynamics. Journal of Ecology 110:2288-2307. [*Overview of forest models providing context for where forest landscape models fit in. Good entrée for those who do not yet have experience with process-based models. Landscape models sit between stand and global models.*]

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 research focused on emerald ash borer across 2-million ha of northern WI; uses LANDIS-II, a forest landscape model originally developed by emeritus FWE professor David Mladenoff and still very widely used.]*

Etherington, T. R., F. J. Morgan, D. O'Sullivan. 2022. Binary space partitioning generates hierarchical and rectilinear neutral landscape models suitable for human dominated landscapes. Landscape Ecology 37:1761-1769. [*NLMs are very useful whenever you need replicated landscapes that share similar statistical properties, and this is a recent example of using them for anthropogenic landscapes.*]

Daniel, C. J., L. Frid, B. M. Sleeter, and M.-J. Fortin. 2016. State-and-transition simulation models: a framework for forecasting landscape change. Methods in Ecology and Evolution 7:1413-1423. *[This presents an overview of how transition models can be used for studying landscape change.]*

(Week 4) Tuesday, February 15 – Ecosystem services in heterogeneous landscapes

Background:

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.]*

For discussion –working agricultural and urban landscapes; rich and growing literature

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; we are covering this topic and reading this paper before Lisa visits UW-Madison.*]

Qiu, J., C. Queiroz, E. M. Bennett, A. F. Cord, E. Crouzat, S. Lavorel, J. Maes, M. Meacham, A. V. Norstrom, G. D. Peterson, R. Seppelt, and M. G. Turner. 2021. Land-use intensity mediates ecosystem service tradeoffs across regional social-ecological systems. Ecosystems and People 17:264-278. [*Tradeoffs and synergies among ecosystem services reflect current research – how can a portfolio of services be sustained?*]

Jha, S., M. Egerer, P. Bichier, H. Cohen, H. Liere, B. Lin, A. Lucatero, and S. M. Philpott. 2023. Multiple ecosystem service synergies and landscape mediation of biodiversity within urban agroecosystems. Ecology Letters 26:369-383. [*We will read several papers dealing with urban landscapes and the spatial heterogeneity within them. Most of the world's population lives in cities, and understanding how to sustain ES in urban settings is important.*]

Ha, J., H. J. Kim, and K. A. With. 2022. Urban green space alone is not enough: A landscape analysis linking the spatial distribution of urban green space to mental health in the city of Chicago. Landscape and Urban Planning 218:104309. [*This is another urban example, here tying landscape patterns to mental health.*]

(Week 5) 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.*]

(Week 6) 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!*]

Ramirez-Arce et al. 2022. Effects of landscape composition and configuration on biodiversity at multiple scales: a case study with amphibians from Sierra Madre del Sur, Oaxaca, Mexico. Landscape Ecology 37:1973-1986. *[Recent example of how landscape metrics are used as predictor variables when trying to explain another ecological response.]*

Iskin, E. P. and E. Whohl. 2023. Quantifying floodplain heterogeneity with field observation, remote sensing, and landscape ecology: Methods and metrics. River Research and Applications 39:911-929. *[While this is a more descriptive study, the paper gives a nice application in the aquatic environment. Shows how they arrived at six metrics to use and how they interpreted these.]*

Curd et al. 2022. Applying landscape metrics to species distribution model predictions to characterize internal range structure and associated changes. Global Change Biology 29:631-647. *[Interesting application that calculates species distributions then uses landscape metrics to describe changes. Novel approach for getting at spatial dimensions of SDMs.]*

*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.]*

(Week 7) 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.*]

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.]*

DiFalco, S., A. T. Morzillo, and D. Ghosh. 2022. Interpolating resident attitudes toward exurban roadside management. Landscape Ecology https://doi.org/10.1007/s10980-022-01537-2. *[Landscape studies are increasingly incorporating people's attitudes or perceptions, or proxies for human activities. This paper includes spatial stats when analyzing social science data.]*

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

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:

Leitold, V., et al. 2022. Tracking the rates and mechanisms of canopy damage and recovery following Hurricane Maria using multitemporal Lidar data. Ecosystems 25:892-910. *[Uses continuous variables to assess measuring disturbance severity after Hurricane Maria in Puerto Rico and ties to the growing use of lidar data.]*

Senf, C., and R. Seidl 2021. Storm and fire disturbances in Europe: Distribution and trends. GCB 27:3605-3619. [*As disturbance activity increases globally, there is great interest in understanding the spatial patterns and temporal dynamics; in Europe, back in the day, I was often told that they have no natural disturbances…not the case any more!]*

Rodman, K. C., et al. 2023. Refuge-yeah or refuge-nah? Predicting locations of forest resistance and recruitment in a fiery world. Global Change Biology 001-22. [*Understanding what landscape positions may be shielded from disturbances and serve as a seed source or stepping stone is of high interest*.]

Harvey, B. J., M. Buonaduci, and M. G. Turner. 2023. Spatial interactions among short-interval fires reshape forest landscapes. Global Ecology and Biogeography DOI: 10.1111/geb.13634 [*Interactions among disturbances has been a hot topic for the past decade; this is an example of how such interactions generate novel landscape patterns.*]

(Week 9) Tuesday, March 22 – Disturbance and landscapes II

Good background:

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.]*

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.]*

For discussion–disturbance interactions, resilience concept):

Pausas, J. G., and W. J. Bond. 2020. Alternative biome states in terrestrial ecosystems. Trends in Plant Science 25:250-263. [*Understanding what conditions (including disturbances) lead to alternative states in landscapes is necessary to predict future landscape patterns under climate change. This is an easy entrée into a big literature.*]

Walden, L., J. B. Fontaine, K. X. Ruthrof, G. Matusick, and R. J. Harper. 2023. Drought then wildfire reveals a compound disturbance in a resprouting forest. Ecological Applications 33:32775. [*Empirical study testing for disturbance interactions in Australia and how such interactions may destabilize systems.*]

LeBreton, T. D., M. B. Lyons, R. H. Nolan, T. Penman, G. J. Williamson, and M. J. K. Ooi. 2022. Mega-fire induced interval squeeze threatens vegetation at landscape scales. Frontiers in Ecology and the Environment 20:327-334. [*Example from Australia of the potential for losing unique vegetation communities as disturbances intensify.*]

Turner, M. G., and R. Seidl. 2023. Novel disturbance regimes and ecological responses. Annual Review of Ecology, Evolution and Systematics 54:63-83. [*Broad treatment of how to conceptualize novelty in disturbance regimes and think beyond the extremes of transitions from one ecosystem type to another.*]

(Week 10) 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.*]

Valente, J. J., D. G. Gannon, J. Hightower, H. Kim, K. G. Leimberger, R. Macedo, J. S. Rousseau, M. J. Weldy, R. A. Zitomer, L. Fahrig, R. J. Fletcher, J. Wu, and M. G. Betts. 2023. Toward conciliation in the habitat fragmentation and biodiversity debate. Landscape Ecology 38:2717-2730. [*Recent paper trying to reconcile these divergent views together.*]

(Week 11) 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 and conservation

Berger, M., et al. 2022. Demystifying ecological connectivity for actionable spatial conservation planning. TREE 37(12):1079-1091.*[Useful discussion of the importance of ecological connectivity and the need to incorporate it into planning.]*

Belote, R. T., K. Barnett, K. Zeller, A. Brennan, and J. Gage. 2022. Examining local and regional ecological connectivity throughout North America. Landscape Ecology 37:2977-2990. *[Travis Belote of the Wilderness Society has been leading a major set of studies of connectivity in the US; this is one of the recent papers.]*

Suraci, J. P., C. E. Littlefield, C. C. Nicholson, M. C. Hunter, A. Sorensen, and B. G. Dickson. 2023. Mapping connectivity and conservation opportunity on agricultural lands across the conterminous United States. Biological Conservation 278:209896. *[The ag lands are so often ignored! This paper looks for areas that have potential; did a CONUS-wide analysis.]*

Cumming, G. S. and D. R. Bellwood. 2022. Broad-scale analysis of fish community data suggests critical need to support regional connectivity of coral reefs. Ecological Applications 33:e2849. *[Nice marine example that uses connectivity metrics in a system; Graeme Cumming has also done a lot in landscape ecology, including disease spread.]*

(Week 12) 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:

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.]*

Smith, A. J., K. McGlathery, Y. Chen, C. J. Ewers, S. C. Doney, K. Gedan, C. K. LaRoche, P. Berg, M. L. Pace, J. C. Zinnert, and M. L. Kirwan. 2023. Compensatory mechanisms absorb regional carbon losses within a rapidly shifting coastal mosaic. Ecosystems (early view). *[Understanding landscape changes and how this affects C sources and sinks, here in a coastal landscape.*]

Harvey, E. et al. 2023. A general meta-ecosystem model to predict ecosystem functions at landscape extents. Ecography 306790.] *[Recent paper trying to generalize approaches for representing ecosystem fluxes, uses a watershed example.*

(Week 13) Tuesday, April 26 —Frontiers in landscape ecology

Turner, M. G. and R. H. Gardner. 2016. Conclusions and future directions. Chapter 10: In: Landscape Ecology in Theory and Practice. Springer. [*The book concludes with perspectives on frontiers in landscape ecology.]*

Wiersma, Y. F. 2022. What is it about landscape ecology that makes experimentation a particular challenge? Chapter 3: In: Experimental Landscape Ecology. Springer. [*What is the role of experiments in landscapes? How to take experimental approaches at large scales?*]

Day, C. J., A. I. Rego, J. D. Midwood, and M. A. Koops. 2020. A review and meta-analysis of collaborative research prioritization studies in ecology, biodiversity conservation and environmental science. Proc. Roy. Soc. B 287:20200012. *[Perspectives on the process of prioritizing research agendas; see Table 2 for research priorities that were common among the studies reviewed.]*

Malhi, Y., et al. 2023. The future of ecological research in the UK. A research agenda for the next 25 years. British Ecological Society, London. [*Recent horizon scanning exercise of the BES provides a good 30,000-ft overview; where/how should landscape ecology make its greatest contribution?*]