BI592 Theoretical Ecology - Readings

(recommended readings are optional, others are required)

Philosophy of modeling

Levins R. 1966 The strategy of model building in population biology. *Am Sci* **54**(4), 421-431.

Hilborn, R. and M. Mangel. 1997. The Ecological Detective. Confronting models with data. Princeton University Press. Chapter 2. Alternative views of the scientific method and modeling.

May R.M. 2004 Uses and Abuses of Mathematics in Biology. *Science* **303**(5659), 790-793. (doi: 10.1126/science.1094442).

Recommended readings:

Jackson, et al. (2000). "An Introduction to the Practice of Ecological Modeling." BioScience **50**(8): 694-706.

Getz, W. M. 1998. An Introspection on the Art of Modeling in Population Ecology. Bioscience **48**:540-552.

Gunawardena. Some lessons about models from Michaelis and Menten. Molecular biology of the cell, 23(4):517–519, 2012.

Gunawardena. Biology is more theoretical than physics. Molecular Biology of the Cell, 24(12): 1827– 1829, 2019/09/19 2013.

Single-Species Models

Density-independent deterministic growth

Case (2000) IGTE. Ch. 1, pages 1-13.

Crawley (2007) The R Book. Ch. 2, pages: 9-18, 20-38, 47-48, 58-63.

Density-independent stochastic growth

Case (2000) IGTE Ch. 2 pages 30-43

Crawley (2007) The R Book. Ch. 3

R Supplement of Ch. 3 in Bolker (2008) Ecological Models and Data in R. (pg 100-102 in hard copy, 135-137 in pdf)

Recommended readings:

Lande, R. 1993. Risks of Population Extinction from Demographic and Environmental Stochasticity and Random Catastrophes. The American Naturalist **142**:911-927.

Bolnick, D. I., P. Amarasekare, M. S. Araújo, R. Bürger, J. M. Levine, M. Novak, V. H. W. Rudolf, S. J. Schreiber, M. C. Urban, and D. A. Vasseur. 2011. Why intraspecific trait variation matters in community ecology. Trends in Ecology & Evolution **26**:183-192.

Density-dependent growth

Case (2000) IGTE Ch 5 pages 103-111, 126-128 (Box 5.3) & Ch 10 pages 232-242

Kot (2001) pg. 10-11 - History hiatus (exponential and logistic growth)

Stevens (2009) A Primer of Ecology with R pg 366-369 - Numerical integration of ODEs

Recommended readings:

Krebs, C. J. 2002. Beyond population regulation and limitation. Wildlife Research 29:1-10.

Roughgarden, J. and F. Smith. 1996. Why fisheries collapse and what to do about it. Proceedings of the National Academy of Sciences of the United States of America 93:5078-5083.

Hixon, M. A., S. W. Pacala, and S. A. Sandin. 2002. Population regulation: Historical context and contemporary challenges of open vs. closed systems. Ecology **83**:1490-1508.

Model-fitting & comparison

Bolker book (pages 446-457 of Ch 11)

Morris and Doak Ch. 3 pages 52-58 , Ch. 4 pages 100-118

Hilborn & Mangel, pg 131-143

Burnham and Anderson Chp 2 pages 60-64, 66-75

Anderson, D. R., K. P. Burnham, and W. L. Thompson. 2000. Null Hypothesis Testing: Problems, Prevalence, and an Alternative. The Journal of Wildlife Management **64**:912-923.

Stephens, P. A., S. W. Buskirk, G. D. Hayward, and C. Martinez Del Rio. 2005. Information theory and hypothesis testing: a call for pluralism. Journal of Applied Ecology **42**:4-12.

Recommended readings:

Sibly, R. M., D. Barker, M. C. Denham, J. Hone, and M. Pagel. 2005. On the Regulation of Populations of Mammals, Birds, Fish, and Insects. Science 309:607-610.

Ward, E. J. 2008. A review and comparison of four commonly used Bayesian and maximum likelihood model selection tools. Ecological Modelling 211:1-10.

Bolker book (Pg. 459-475)

Perretti, C. T., S. B. Munch, and G. Sugihara. 2013. Model-free forecasting outperforms the correct mechanistic model for simulated and experimental data. Proceedings of the National Academy of Sciences **110**:5253-5257.

1D Stability analysis

Case (2000) IGTE Ch 5 pages 111-128

May, R. M. 1974. Biological Populations with Non-overlapping Generations: Stable Points, Stable Cycles, and Chaos. Science **186**:645-647.

Hassell, M. P., J. H. Lawton, and R. May. 1976. Patterns of dynamical behaviour in single-species populations. The Journal of Animal Ecology:471-486.

Recommended readings:

May, R. M. and G. F. Oster. 1976. Bifurcations and Dynamic Complexity in Simple Ecological Models. The American Naturalist **110**:573-599.

Shelton, A. O. and M. Mangel. 2011. Fluctuations of fish populations and the magnifying effects of fishing. Proceedings of the National Academy of Sciences **108**:7075-7080.

Arino, J., L. Wang, and G. S. K. Wolkowicz. 2006. An alternative formulation for a delayed logistic equation. Journal of Theoretical Biology 241:109-119.

Two-Species Models

Graphical Analysis - Lotka-Volterra Competition

Case (2000) IGTE Ch 14 pg 316-328, 333-336, 338-341

Recommended readings:

Volterra, V. 1926. Fluctuations in the abundance of a species considered mathematically. Nature **118**:558-560.

Gause, G. F. 1934. Chapter IV. On the mechanism of competition in yeast cells. Pages 59-89 The Struggle for Existence. Hafner Publishing Company, New York.

Tilman D. (1980). Resources: A Graphical-Mechanistic Approach to Competition and Predation. The American Naturalist, 116, 362-393.

2D Stability analysis - Consumer-Resource Interactions

Case (2000) IGTE Ch. 11 pg 243-253; Ch. 12 pg 261-291

Recommended readings:

Oaten, A. and W. W. Murdoch. 1975. Functional response and stability in predator-prey systems. American Naturalist 109:289-298.

Murdoch, W. W. and A. Oaten. 1975. Predation and population stability. Advances in Ecological Research 9:1-130.

Rosenzweig, M. L. 1971. Paradox of Enrichment: Destabilization of Exploitation Ecosystems in Ecological Time. Science 171:385-387.

Holling, C. S. 1959. Some characteristics of simple types of predation and parasitism. Canadian Entomologist 91:385-398.

Hassell, M. P., J. H. Lawton, and J. R. Beddington. 1977. Sigmoid functional responses by invertebrate predators and parasitoids. The Journal of Animal Ecology 46:249-262.

Multi-Species Models

Stability analysis cont. - Pulse perturbations

Case (2000) IGTE Ch. 14 pg 328-333,336-339, Ch. 13 pg 293-310

Ives, A. R. and S. R. Carpenter. 2007. Stability and Diversity of Ecosystems. Science 317:58-62.

May, R. M. 1972. Will a Large Complex System Be Stable. Nature **238**:413-414.

Recommended readings:

Allesina S. & Tang S. (2012). Stability criteria for complex ecosystems. *Nature*, 483, 205-208.

Network modules

Case (2000) IGTE Chp 15 pages 345-367

Diehl, S., and M. Feißel. 2000. Effects of enrichment on three-level food chains with omnivory. American Naturalist 155:200-218.

Recommended readings:

Armstrong, R. A. and R. Mcgehee. 1980. Competitive-Exclusion. American Naturalist 115:151-170.

Holt, R. D. 1977. Predation, apparent competition, and the structure of prey communities. Theoretical Population Biology 12:197-229.

Hairston, N. G., F. E. Smith, and L. B. Slobodkin. 1960. Community structure, population control, and competition. American Naturalist 94:421-425.

Abrams, P. A. 1993. Effect of increased productivity on the abundances of trophic levels. American Naturalist 141:351-371.

Oksanen, L., S. D. Fretwell, J. Arruda, and P. Niemela. 1981. Exploitation Ecosystems in Gradients of Primary Productivity. The American Naturalist 118:240-261.

Press perturbations

Case (2000) IGTE Ch. 15

Dambacher J.M., Li H.W. & Rossignol P.A. (2002). Relevance of community structure in assessing indeterminacy of ecological predictions. *Ecology*, 83, 1372-1385.

Recommended readings:

Bender, E. A., T. J. Case, and M. E. Gilpin. 1984. Perturbation experiments in community ecology: theory and practice. Ecology **65**:1-13.

Yodzis, P. 1988. The indeterminacy of ecological interactions as perceived through perturbation experiments. Ecology **69**:508-515.

Novak M., Wootton J.T., Doak D.F., Emmerson M., Estes J.A. & Tinker M.T. (2011). Predicting community responses to perturbations in the face of imperfect knowledge and network complexity. *Ecology*, 92, 836-846.

Catastrophe theory

Scheffer M., Carpenter S., Foley J.A., Folke C. & Walkerk B. (2001). Catastrophic shifts in ecosystems. *Nature*, 413, 591-596.

Recommended readings:

Noy-Meir I. (1975). Stability of grazing systems - application of predator-prey graphs. *J. Ecol.*, 63, 459-481.

Dudgeon, S., R. Aronson, J. Bruno, and W. Precht. 2010. Phase shifts and stable states on coral reefs. Marine Ecology Progress Series **413**:201-216.

Lewontin, C. 1969. The meaning of stability. Pages 13-23 *in* Brookhaven Symposia in Biology, Upton, NY.

Scheffer M., Bascompte J., Brock W.A., Brovkin V., Carpenter S.R., Dakos V., Held H., van Nes E.H., Rietkerk M. & Sugihara G. (2009). Early-warning signals for critical transitions. *Nature*, 461, 53-59.

Estimating "interaction strengths"

Wootton, J. T. and M. Emmerson. 2005. Measurement of interaction strength in nature. Annual Review of Ecology, Evolution, and Systematics 36:419-444.

Recommended readings:

Ives, A. R., B. Dennis, K. L. Cottingham, and S. R. Carpenter. 2003. Estimating community stability and ecological interactions from time-series data. Ecological Monographs 73:301-330.

Novak M. & Wootton J.T. (2010). Using experimental indices to quantify the strength of species interactions. *Oikos*, 119, 1057-1063.

De Valpine P. & Hastings A. (2002). Fitting population models incorporating process noise and observation error. Ecol. Monogr., 72, 57-76

Parting thoughts

Writing theoretical ecology papers

Aber J.D. 1997 Why Don't We Believe the Models? *Bull Ecol Soc Am* **78**(3), 232-233. (doi: 10.2307/20168170).

Ellner S.P. (2206) How to write a theoretical ecology paper that people will cite. *unpubl. ms.*

Sand-Jensen K. (2007). How to write consistently boring scientific literature. *Oikos*, 116, 723-727.

Fawcett T.W. & Higginson A.D. (2012). Heavy use of equations impedes communication among biologists. *Proc. Natl. Acad. Sci.*, 109, 11735-11739.

Recommended readings:

Ellison, A. M. and B. Dennis. 2010. Paths to statistical fluency for ecologists. Frontiers in Ecology and the Environment **8**:362-370.

Edwards, AM, Auger−Méthé, M. Some guidance on using mathematical notation in ecology. Methods Ecol Evol. 2019; 10: 92– 99. https://doi.org/10.1111/2041-210X.13105