

POPULATION MATRIX MODELING

In Bio 559R – 005 (1 credit)
2nd Block of winter semester

601 WIDB
Theory: Friday 10:00 - 10:50 am
Lab: Friday 2:00 - 3:30 pm

Instructors

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Description and Course Objectives

Upon successfully completing this course, you should be able to use and interpret elementary matrix population models. You will acquire a set of tools currently used in demographic studies that have proven useful in addressing different aspects of the biology of populations, including evolutionary processes, management problems, and conservation issues.

Each lecture will focus on a specific topic in population matrix modeling. In this part of class we will review the underlying mathematical basis of matrix models, with emphasis on their construction and practical interpretation of results. In the lab we will go through empirical and hypothetical examples to come to a more complete understanding of each particular method. Throughout the course we will utilize both current and classical literature in this field (bibliography is found below).

Course grading

We expect each class participant to come up with a demography project that utilizes empirical data (yours or someone else's). These projects should address a real problem in population biology. Appropriate questions could involve problems in population dynamics, evolutionary processes, or management and conservation issues. The final report should be in publication format; our goal is to have you use this class to get something published!

Relevant Literature

Book:

Caswell, H. 2001. Matrix Population Models. 2nd Ed. Sinauer, Sunderland, Massachusetts.

Articles:

- Alvarez-Buylla, E. R., and M. Slatkin. 1991. Finding confidence limits on population growth rates. *Trends in Ecology and Evolution* 6:221-224.
- Benton, T. G., and A. Grant. 1999. Elasticity analysis as an important tool in evolutionary and population ecology. *Trends in Ecology and Evolution* 14:467-471.
- Bierzychudek, P. 1982. The demography of jack-in-the-pulpit, a forest perennial that changes sex. *Ecological Monographs* 52:335-351.
- Bierzychudek, P. 1999. Looking backwards: assessing the projections of a transition matrix model. *Ecological Applications* 9:1278-1287.
- Brault, S., and H. Caswell. 1993. Pod-specific demography of killer whales (*Orcinus orca*). *Ecology* 74:1444-1454.
- Caswell, H. 1978. A general formula for the sensitivity of population growth rate to changes in life history parameters. *Theoretical Population Biology* 14:215-230.
- Caswell, H. 2000. Prospective and retrospective perturbation analysis: their roles in conservation biology. *Ecology* 81:619-627.
- Caswell, H., and M. C. Trevisan. 1994. Sensitivity analysis of periodic matrix models. *Ecology* 75:1299-1303.
- Contreras, C., and T. Valverde. 2002. Evaluation of the conservation status of a rare cactus (*Mammillaria crucigera*) through the analysis of its population dynamics. *Journal of Arid Environments* 51:89-102.
- Crooks, K. R., M. A. Sanjayan, and D. F. Doak. 1998. New insights on cheetah conservation through demographic modeling. *Conservation Biology* 12:889-895.
- Crouse, D. T., L. B. Crowder, and H. Caswell. 1987. A stage-based population model for loggerhead sea turtles and implications for conservation. *Ecology* 68:1412-1423.
- de Kroon, H., A. Plaisier, J. M. van Groenendael, and H. Caswell. 1986. Elasticity: the relative contribution of demographic parameters to population growth rate. *Ecology* 67:1427-1431.
- de Kroon, H., J. van Groenendael, and J. Ehrlén. 2000. Elasticities: a review of methods and model limitations. *Ecology* 81:607-618.
- Esparza-Olguín, L., T. Valverde, and E. Vilchis-Anaya. 2002. Demographic analysis of a rare columnar cactus (*Neobuxbaumia macrocephala*) in the Tehuacan Valley, México. *Biological Conservation* 103:349-359.
- Franco, M., and J. Silvertown. 1997. Life history variation in plants: an exploration of the fast-slow continuum hypothesis. In: J. Silvertown, M.

- Franco, and J. L. Harper (eds.), *Plant Life Histories. Ecology, Phylogeny and Evolution*. Cambridge University Press, Cambridge, United Kingdom.
- Franco, M., and J. Silvertown. 2004. A comparative demography of plants based upon elasticities of vital rates. *Ecology* 85:531-538.
- Grant, A., and T.G. Benton. 2000. Elasticity analysis for density-dependent populations in stochastic environments. *Ecology* 81:680-693.
- Heppell, S. S., H. Caswell, and L. B. Crowder. 2000. Life histories and elasticity patterns: perturbation analysis for species with minimal demographic data. *Ecology* 81:654-665.
- Mandujano, M. C., C. Montaña, M. Franco, J. Golubov, and A. Flores-Martínez. 2001. Integration of demographic annual variability in a clonal desert cactus. *Ecology* 82:344-359.
- Mondragón, D., R. Durán, I. Ramírez, and T. Valverde. 2004. Temporal variation in the demography of the clonal epiphyte *Tillandsia brachycaulos* (Bromeliaceae) in the Yucatán Península, Mexico. *Journal of Tropical Ecology* 20:189-200.
- Oli, M. K., and F. S. Dobson. 2003. The relative importance of life-history variables to population growth rate in mammals: Cole's prediction revisited. *American Naturalist* 161:422-440.
- Saether, B. E., and O. Bakke. 2000. Avian life history variation and contribution of demographic traits to the population growth rate. *Ecology* 81:642-653.
- Silvertown, J., M. Franco, and E. Menges. 1996. Interpretation of elasticity matrices as an aid to the management of plant populations for conservation. *Conservation Biology* 10:591-597.
- Silvertown, J., M. Franco, I. Pisanty, and A. Mendoza. 1993. Comparative plant demography – relative importance of life-cycle components to the finite rate of increase in woody and herbaceous perennials. *Journal of Ecology* 81:465-476.
- Valverde, T., and J. Silvertown. 1997. A metapopulation model for *Primula vulgaris*, a temperate forest understory herb. *Journal of Ecology* 85:193-210.
- Valverde, T., and J. Silvertown. 1998. Variation in the demography of a woodland understory herb (*Primula vulgaris*) along the forest regeneration cycle: projection matrix analysis. *Journal of Ecology* 86:545-562.
- Valverde, T., S. Quijas, M. López-Villavicencio, and S. Castillo. 2004. Population dynamics of *Mammillaria magnimamma* Haworth (Cactaceae) in a lava-field in central Mexico. *Plant Ecology* 170:167-184.
- van Groenendael, J., H. de Kroon, and H. Caswell. 1988. Projection matrices in population biology. *Trends in Ecology and Evolution* 3:264-269.
- van Groenendael, J.M., H. de Kroon, S. Cáliz, and S. Tuljapurkar. 1994. Loop analysis: evaluating life history pathways in population projection matrices. *Ecology* 75:2410-2415.
- Wisdom, M. J., L. S. Mills, and D. F. Doak. 2000. Life stage simulation analysis: estimating vital rate effects on population growth for conservation. *Ecology* 81:628-641.

BlackBoard

Each class participant will be given access to a BlackBoard site for the course. PDF documents for all of the literature listed above are available on this site.

Course timetable

Date	Course topic	Reading (to be completed before class)
Mar 03	Introduction to demography. Life cycle graph and matrix construction	van Groenendael et al. 1988
Mar 10	Estimating demographic parameters using matrix models	Benton and Grant 1999
Mar 17	Sensitivity and elasticity analysis. Demographic triangle	Caswell 1978 de Kroon et al. 1986 Silvertown et al. 1993
Mar 24	Average and periodic matrix models	Caswell and Trevisan 1994
Mar 31	Loop analysis	van Groenendael et al. 1994
Apr 7	Stochastic simulations	Bierzychudek 1982
Apr 14	Case studies. Model limitations.	Crouse et al. 1987 Franco and Silvertown 1996 Silvertown et al. 1996 Caswell 2000 de Kroon et al. 2000