

Meetings: Tuesdays and Thursdays, 10:30-12:00, HGS 180

Nature of the course: This course is an introduction to mathematical modeling as applied to problems in paleobiology and evolutionary biology. Topics include: basic probability theory; general approaches to modeling; model comparison using likelihood and other criteria; forward modeling of branching processes; sampling models; and inverse methods. A series of programming exercises and a term project are required. Programming in R or C is recommended, but any language may be used.

Requirements:

1. Short exercises
2. Readings to be assigned
3. Term paper: Original research, relevant to topics covered in course. Publication length and quality. Brief presentation of research.

Prerequisites: Mathematics through first-year calculus; basic computer programming skills (or willingness to learn)

URL for course materials: <http://geosci.uchicago.edu/~foote/MODEL>

Reading

General Reference Works

- Burnham, K.P., and D. R. Anderson. 1998. Model selection and inference: a practical information-theoretic approach. Springer, New York.
- Edwards, A.W.F. 1992. Likelihood. Johns Hopkins U. Press.
- Efron, B. and R.J. Tibshirani. 1993. An introduction to the bootstrap. Chapman and Hall, N.Y.
- Feller, W. 1968 (and other editions). An introduction to probability theory and its applications (two volumes). John Wiley and Sons, N.Y.
- Gilinsky, N.L., and P.W. Signor, eds. 1991. Analytical paleobiology. Short Courses in Paleontology Number 4. Paleontological Society, Knoxville, Tenn.
- Gumbel, E.J. 1958. Statistics of extremes. Columbia University Press, N.Y.
- Press, W.H., S.A. Teukolsky, W.T. Vetterling, B.P. Flannery. 1996. Numerical Recipes in C (2d. ed.). Cambridge U. Press. [See also FORTRAN edition of this text.]
- Rohlf, F.J., and R.R. Sokal. 1981. Statistical tables (2d. ed.) W.H. Freeman and Co., N.Y.
- Siegel, S., and N.J. Castellan, Jr. 1988. Nonparametric statistics for the behavioral sciences. McGraw-Hill, N.Y.
- Sokal, R.R., and F.J. Rohlf. 1981. Biometry (2d. ed.) W.H. Freeman and Co., N.Y.

Articles

- Alroy, J., C.R. Marshall, R.K. Bambach, K. Bezusko, M. Foote, F.T. Fürsich, T.A. Hansen, S.M. Holland, L.C. Ivany, D. Jablonski, D.K. Jacobs, D.C. Jones, M.A. Kosnik, S. Lidgard, S. Low, A.I. Miller, P.M. Novack-Gottshall, T.D. Olszewski, M.E. Patzkowsky, D.M. Raup, K. Roy, J.J. Sepkoski, Jr., M.G. Sommers, P.J. Wagner, and A. Webber. 2001. Effects of sampling standardization on estimates of Phanerozoic marine diversification. *Proceedings of the National Academy of Sciences, USA* 98:6261-6266.
- Bookstein, F.L. 1987. Random walk and the existence of evolutionary rates. *Paleobiology* 13:446-464.
- Connolly, S.R. and A.I. Miller. 2001a. Joint estimation of sampling and turnover rates from fossil databases: capture-mark-recapture methods revisited. *Paleobiology* 27:751-767.
- Connolly, S.R. and A.I. Miller. 2001b. Global Ordovician faunal transitions in the marine benthos: proximate causes. *Paleobiology* 27:779-785.
- Connolly, S.R. and A.I. Miller. 2002. Global Ordovician faunal transitions in the marine benthos: ultimate causes. *Paleobiology* 28:26-40.
- Foote, M. 1988. Survivorship analysis of Cambrian and Ordovician trilobites. *Paleobiology* 14:258-271.
- Foote, M. 1992. Rarefaction analysis of morphological and taxonomic diversity. *Paleobiology* 18:1-16.
- Foote, M. 1994. Morphological disparity in Ordovician-Devonian crinoids and the early saturation of morphological space. *Paleobiology* 20:320-344.
- Foote, M. 1996. On the probability of ancestors in the fossil record. *Paleobiology* 22:141-151.
- Foote, M. 1997. Estimating taxonomic durations and preservation probability. *Paleobiology* 23:278-300.
- Foote, M. 2000. Origination and extinction components of taxonomic diversity: general problems. *Paleobiology* 26 (supplement to No. 4): 74-102.
- Foote, M. 2001a. Evolutionary rates and the age distributions of living and extinct taxa. Pp. 245-294 in J. B. C. Jackson, S. Lidgard, and F. K. McKinney, eds. *Evolutionary patterns: growth form and tempo in the fossil record*. University of Chicago Press, Chicago.
- Foote, M. 2001b. Inferring temporal patterns of preservation, origination, and extinction from taxonomic survivorship analysis. *Paleobiology* 27:602-630.
- Foote, M. 2003. Origination and extinction through the Phanerozoic: a new approach. *Journal of Geology* 111:125-148; erratum p. 752-753.
- Foote, M. 2005. Pulsed origination and extinction in the marine realm. *Paleobiology* 31:6-20.
- Foote, M., and D. M. Raup. 1996. Fossil preservation and the stratigraphic ranges of taxa. *Paleobiology* 22:121-140.
- Foote, M., J. P. Hunter, C. M. Janis, and J. J. Sepkoski, Jr. 1999. Evolutionary and preservational constraints on origins of biologic groups: divergence times of eutherian mammals. *Science* 283:1310-1314 [plus online Technical Comments: *Science* 285:2031a].

- Gaines, S.D., and M. W. Denny. 1993. The largest, smallest, highest, lowest, longest, and shortest: extremes in ecology. *Ecology* 74:1677-1692.
- Gilinsky, N.L. 1994. Volatility and the Phanerozoic decline of background extinction intensity. *Paleobiology* 20:445-458.
- Gilinsky, N.L., and I.J. Good. 1991. Probabilities of origination, persistence, and extinction of families of marine invertebrate life. *Paleobiology* 17:145-166.
- Holland, S.M. 1995. The stratigraphic distribution of fossils. *Paleobiology* 21:92-109.
- Holland, S.M. 2000. The quality of the fossil record: a sequence-stratigraphic perspective. *Paleobiology* 26(suppl. to no. 4):148-168
- Holland, S.M. 2003. Confidence limits on fossil ranges that account for facies changes. *Paleobiology* 29:468-479.
- Hunt, G. 2004a. Phenotypic variation in fossil samples: modeling the consequences of time-averaging. *Paleobiology* 30:426-443.
- Hunt, G. 2004b. Phenotypic variance inflation in fossil samples: an empirical assessment. *Paleobiology* 30:487-506.
- Hunt, G., and R. E. Chapman. 2001. Evaluating hypotheses of instar-grouping in arthropods: a maximum likelihood approach. *Paleobiology* 27:466-484.
- Magallón, S., and M. J. Sanderson. 2001. Absolute diversification rates in angiosperm clades. *Evolution* 55:1762-1780.
- McConway, K. J., and H. J. Sims. 2004. A likelihood-based method for testing for nonstochastic variation of diversification rates in phylogenies. *Evolution* 58:12-23.
- Miller, A.I. and M. Foote. 1996. Calibrating the Ordovician radiation of marine life: implications for Phanerozoic diversity trends. *Paleobiology* 22:304-309.
- Miller, A. I., and M. Foote. 2003. Increased longevities of post-Paleozoic marine genera after mass extinctions. *Science* 302:1030-1032.
- Nee, S. 2004. Extinct meets extant: simple models in paleontology and molecular phylogenetics. *Paleobiology* 30:172-178.
- Patzkowsky, M.E. 1995. A hierarchical branching model of evolutionary radiations. *Paleobiology* 21:440-460.
- Przeworski, M., and J. D. Wall. 1998. An evaluation of a hierarchical branching process as a model for species diversification. *Paleobiology* 24:498-511.
- Raup, D.M. 1975. Taxonomic diversity estimation using rarefaction. *Paleobiology* 1:333-342.
- Raup, D.M. 1978. Cohort analysis of generic survivorship. *Paleobiology* 4:1-15.
- Raup, D.M. 1985. Mathematical models of cladogenesis. *Paleobiology* 11:42-52.
- Raup, D.M., and R.E. Crick. 1981. Evolution of single characters in the Jurassic ammonite *Kosmoceras*. *Paleobiology* 7:200-215.
- Roopnarine, P.D. 2001. The description and classification of evolutionary mode: a computational approach. *Paleobiology* 27:446-465.
- Sims, H.J., and K.J. McConway. 2003. Nonstochastic variation of species-level diversification rates within angiosperms. *Evolution* 57:460-479.