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A Primer of Ecological Statistics. Gotelli, Nicholas J. and Aaron M. Ellison. 2004. ISBN 0-87893-269-0 (Paper US$34.95) 510 pp. Sinauer Associates Inc., P.O. Box 407, Sunderland, MA 01375-0407. Introductory statistics textbooks aimed at ecologists tend to be dumbed-down versions of statistics textbooks for statisticians. This isn't really surprising, since for the most part they are written by statisticians who must daily address the dumb questions ecologists ask them. However, this approach has its drawbacks. What we need as ecologists is not a simplified subset of the tools available to real statisticians; what we need is an understanding of the foundational concepts necessary to frame ecological questions in a statistical context.

Gotelli and Ellison wrote their primer to address this issue. They are not statisticians - they are ecologists with a strong grasp of statistics. In place of the usual watered-down statistics, they present a distillation of those fundamentals of the discipline that are of particular interest to practicing ecologists. The writing is clear and engaging, and unlike many other textbook writers they make no attempts to present an unbiased treatment of their subject. They have strong opinions on the practice of ecological statistics, and they don't shy away from controversial ideas. This combination of content and style makes for a very engaging, readable book.

Part I of the book is devoted to basic probability theory, summary statistics and hypothesis testing. For the most part this is a clearly presented version of the standard treatment given these topics. The final two chapters of the section are of most interest. Chapter four presents framing and testing hypotheses. In addition to the usual summary of the hypothetico-deductive method, they include discussions of deduction vs. induction and Bayesian inference. Bayesian analysis is further developed in chapter five, where it is contrasted with Monte Carlo and traditional parametric techniques. While the presentation of analytical methods later in the book emphasizes parametric tests, Gotelli and Ellison balance this with Monte Carlo and Bayesian alternatives. Their explanation of permutational testing is very successful, and they argue persuasively for the use of such tests in place of standard non-parametric approaches. However, despite their best efforts I am still unclear on the concepts underlying Bayesian analysis. I would have happily traded a few pages of probability theory for a better explanation of this increasingly popular approach.

The second section of the book provides a very practical guide to designing and managing experiments. We all know that more samples are always better, but Gotelli and Ellison provide some useful hints and tips to use when making the inevitable trade-offs between number of replicates, number of treatments, and number of dollars. Remarkably, experimental and sampling designs are introduced without the aid of a single formula. Instead, they discuss the possibilities and pitfalls of regression, ANOVA, and tabular designs. By delaying the nuts and bolts of calculating sums of squares etc. they give themselves the time to consider the decisions that need to be made before any data is collected. I found the discussion of experimental regression as an alternative to ANOVA especially interesting in this regard.

Another great aid for the neophyte ecologist is the chapter on managing and curating data. Having just gone through this process with my first seasons' field data, I found myself ticking off their suggestions as I read: did that, did that, wish I'd thought of that! Data management is perhaps the most undervalued aspect of ecological research. Gotelli and Ellison try to address this problem, stressing the need to plan, and budget, for this component from the beginning of any project.

Data analysis forms the final section of the book, with chapters on regression, ANOVA, contingency tables, and multivariate analysis. With the underlying principles already established, the authors present a selection of specific methods that are frequently used in ecological studies. While I would be hesitant to try and publish a paper without having checked Gotelli and Ellison's suggestions against a more thorough reference (such as Sokal and Rohlf, 1995), they do help narrow down the options. I also found their explanations of various aspects of regression and ANOVA very helpful – I have a better, more intuitive understanding of these techniques after reading these sections. On the other hand, I'm not sure how a statistician would feel about their claim that there is no need for correlation analysis in ecological studies, as regression is always preferred. They also present an intriguing argument against using the Bonferroni correction for multiple tests. Whether or not they convince ecologists, and editors, to accept their position, the point that intelligent interpretation of data is more important than blind adherence to significance tests is well made.

Unfortunately, this wonderful little book ends on a sour note. Their emphasis on underlying principles and selecting the best model to test the problem at hand did not carry through to the final chapter on multivariate analysis. Their discussion of the interpretation of ordination diagrams contains troubling inaccuracies and misleading statements. They refer to the joint plots of correspondence analysis as biplots, and don't mention the biplots available with principal component analysis; they claim that the rescaling of principal axes precludes their being related back to the original variables, when in fact the rescaling (as distance or correlation biplots) is what makes such a comparison possible; correspondence analysis is presented as a special case of principal component analysis, when the underlying calculations are actually quite different, and, more importantly, PCoA cannot be used to produce joint plots. Most troubling were the recommendations, where they state "it is rarely obvious which ordination technique you should choose", and then recommend PCoA for general use. PCoA is the most limited form of ordination in terms of plotting options, and each of the methods described has particular requirements and assumptions that need to be met. None of ter Braak's contributions to ordination theory (such as ter Braak and Prentice, 1988; ter Braak and Smilauer, 1998) were cited in the book, which is a shame because his concept of linear vs. unimodal ordination models would have nicely complimented the approach Gottelli and Ellison take in exploring univariate techniques.

The remainder of the twelfth chapter consists of a rather cursory treatment of clustering, discriminant analysis, and canonical or constrained ordination techniques. Perhaps this section wouldn't seem so disappointing had the authors not done such a good job presenting univariate techniques. Their treatment of ANOVA and regression displays an impressive grasp not only of the how's, but also of the why's of univariate statistics. In contrast, the multivariate chapter is a poorly summarized collection of commonly used techniques without any insightful commentary. It certainly should be possible to present a useful 60 page introduction to multivariate statistics. Sadly, this isn't it. Legendre and Legendre's "Numerical Ecology" (1998) provides a solid treatment of this topic, but as a comprehensive manual rather than a primer.

Overall, I would heartily recommend "A Primer of Ecological Statistics" as eleven chapters of essential reading for graduate students in ecology. This clearly written and very practical manual will be very helpful in allowing us to make more efficient use of the weightier tomes on our bookshelves. It provides sound advice for all stages of an ecological research project, from framing questions and managing data through to conducting rigorous analyses.

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