Preface

Beyond the Null Hypothesis

ABOUT THE TITLE

First, a word about the phrase "ecological detective," which we owe to our colleague Jon Schnute:

> I once found myself seated on an airplane next to a charming woman whose interests revolved primarily around the activities of her very energetic family. At one point in the conversation came the inevitable question: "What sort of work do you do?" I confess that I rather hate that question. . . . I replied to the woman: "Well, I work with fish populations. The trouble with fish is that you never get to see the whole population. They're not like trees, whose numbers could perhaps be estimated by flying over the forest. Mostly, you see fish only when they're caught. . . . So, you see, if you study fish populations, you tend to get little pieces of information here and there. These bits of information are like the tip of the iceberg; they're part of a much larger story. My job is to try to put the story together. I'm a detective, really, who assembles clues into a coherent picture." (Schnute 1987, 210)

As we began outlining the present volume, we realized that the phrase the "ecological detective" was most appropriate for what we are trying to accomplish. Some reviewers agreed, and some found it a bit too cute. After serious consideration, we decided to leave references to the ecological detective in the text, with apologies to readers who are offended. We find it preferable to "the reader."

It is our view that the ecological detective goes beyond the null hypothesis. As the revolution in physics in the twentieth century showed, there are few cases in science in which absolute truth exists. Models are metaphorical (albeit sometimes accurate) descriptions of nature, and there can never be a "correct" model. There may be a "best" model, which is more consistent with the data than any of its competitors, or several models may be contenders because each is consistent in some way with the data and none clearly dominates the others. It is the job of the ecological detective to determine the support that the data offer for each competing model or hypothesis. The techniques that we introduce, particularly maximum likelihood methods and Bayesian analysis, are the beginning of a new kind of toolkit for doing the job of ecological detection.

THE AUDIENCE AND ASSUMED BACKGROUND

In a very real way, this book began in October 1988, when we participated in an autumn workshop on mathematical ecology at the International Center for Theoretical Physics. Most of the participants were scientists who had been students in the two previous autumn courses. As these former students presented their work, we realized that although they had received excellent training in ecological modeling and the analysis of ecological models (cf. Levin et al. 1989), they were almost completely inexperienced in the process of connecting data to those models. For scientists in third-world countries, who will work on practical and important problems faced by their nations, such connections are essential, because real answers are needed. We decided then to try to provide the connection.

We envision that readers of this book will be third-year students in biology and upward. Thus, we expect the reader to have had a year of calculus, some classical statistics (typically regression, standard sampling theory, hypothesis testing, and analysis of variance) and some of the classical ecological models (logistic equation, competition equations) equivalent to the material in Krebs's (1994) textbook. Therefore, we will not explain either these classical statistical methods or the classical ecological models. Some readers of drafts took us to task, writing comments such as, "I took my last mathematics and statistics courses four years ago—how dare you expect me to remember any of it." Well, we expect you to remember it and use it. You should not expect to make progress with an attitude of "I learned it once, promptly forgot it, and don't want to learn it again." We worked hard to make the material accessible and understandable, but the motivation rests with you. The more effectively you can deal with data, the greater your contribution to ecology.

This book has equations in it. The equations correspond to real biological situations. There are three levels at which one can understand the equations. The first (lowest) level occurs when you read our explanation of the meaning of the equations. We have tried to do this as effectively as possible, but success can only really be guaranteed in that regard when there is interpersonal contact between student and teacher. The second (middle) occurs when you are able to convert the equation to words—and we encourage you to do so with *every* equation that you encounter. The third (highest) occurs when you explain the origin and meaning of the equation to a colleague. We also encourage you to strive for that.

COMPUTER PROGRAMMING

Computing is essential for ecological detection. We expect that you have access to a computer. Early drafts of the book, read by many reviewers, had computer programs (rather than pseudocodes) embedded in the text. Virtually all reviewers told us that this was a terrible idea, so we removed them. To really use the methods that we describe here, you must be computer-literate. It does not have to be a fancy computer language: Mangel does all of his work in TrueBASIC and Hilborn does all of his in QuickBASIC or Excel. We recommend that you become familiar with some computer environment that offers nonlinear function minimization, and that you program the examples as you go through the book. For complete neophytes, Mangel and Clark (1988) wrote an introduction to computer programming, focusing on behavioral ecology. In any case, this material will be learned much more effectively if you actually stop at various points and program the material that we are discussing. To be helpful, we give an algorithmic description, which we call a pseudocode, showing how to compute the required quantities. You cannot use these descriptions directly for computation, but they are guides for programming in whatever language you like. Understanding ecological data requires practice at computation, and if you read this book without trying to do any of the computations, you will get much less out of it.

REALISM AND PROFESSIONALISM

Each of the case studies we use to illustrate a particular point is a bona fide research study conducted by one of us. Even so, some readers of drafts accused us of the unpleasant and unprofessional, but too common (especially in evolutionary biology), behavior of setting up "strawpersons" just to knock them down or of misrepresenting opponent positions (see Selzer 1993 for an example). For example, we were told to

> treat each case study like a real research study and do not spend time rejecting obviously silly models. For example, no one should seriously try to fit a simple logistic equation to the data shown in Figure 8.1. Similarly, one would not need any formal analysis to reject the constant clutch model when presented with the data in Table 6.1. . . .

> This would get away from what our class came to call your "toy example" approach—illustrating models or techniques with silly examples, and then not explaining the hard decisions associated with the more interesting and complicated questions.

This charge is unfair. These apparently ridiculous models were *in fact proposed and used by pretty smart people.* Why? Because they had no alternative model. Our view is that the confrontation between more than one model arbitrated by the data underlies science. If there is only one model, it will be used, whether the questions concern management (as in the Serengeti example) or basic science (as in the insect oviposition example). Without multiple models, there is no alternative. Furthermore, in the case studies used here, the data are moderately simple and mainly one-dimensional. This allows us to "eyeball" the data and draw conclusions such as those given above. But in more complicated situations, this may not be possible.

Another side of professionalism is the development of a professional library. As described above, we consider this book a link between standard ecological modeling or theoretical ecology and serious statistical texts. After reading *The Ecological Detective*, the latter should be accessible to you. We consider that a good detective's library includes the following:

Efron, B., and R. Tibshirani. 1993. *An Introduction to the Bootstrap.* Chapman and Hall, New York.

Gelman, A., J. B. Carlin, H. S. Stern, and D. B. Rubin. 1995. *Bayesian Data Analysis.* Chapman and Hall, New York.

McCullagh, P., and J. A. Nelder. 1989. *Generalized Linear Models.* Chapman and Hall, New York.

Press, W. H., B. P. Flannery, S. A. Teukolsky, and W. T. Vetterling. 1986. *Numerical Recipes.* Cambridge University Press, Cambridge, U.K.

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The Ecological Detective