Foreword

Scientific disciplines are often judged by their success in translating ideas and principles into outcomes under future conditions. One of the greatest challenges faced by ecologists and conservation biologists of our time is to use our knowledge to understand how species, populations, and communities will behave, persist, and evolve in the future in a world with more people and a changing climate. Models are central to this undertaking.

Models have become an important tool for conservation planning and managing natural resources. In ecology and conservation biology as in other sciences, models have always driven the development of certain concepts and served a useful role in synthesizing knowledge and guiding research. Computer models also provided ways to gain new insights into modeled systems by running "virtual experiments." But now more than ever, mathematical and simulation models are being used to project future outcomes based on past, current, or projected conditions. Over the past 30 years, models have grown in use, prominence, and complexity with the advent of desktop computers that have become both more affordable and more powerful to run them and with the growth of specialized software to enable users to implement them.

Models are both familiar to us and scary. We unconsciously use models everyday in making life choices. For example, we often use simple "rule of thumb" models when we dress to determine which color combinations are complementary and which are clashing, and we take projections from complex weather models into consideration when choosing whether to wear a warm or cool fabric. Scientists have routinely used conventional statistical models or "frequentist models" when determining whether relationships differ by testing a null hypothesis to a specified confidence level (e.g., $p < 0.05$). Yet, models are not a panacea. Many ecologists, conservation biologists, and resource managers distrust models because they can be overly complex, use mathematical methods, and contain computer code that they do not understand, or they are based on uncertain relationships and parameter estimates. The accepted convention of a p value of 0.05 (or a 5% chance of wrongly rejecting the null hypothesis of no difference when it is true) is an artificial construct and perhaps too restrictive for gleaning useful information from nature to use in management.

Bayesian methods can address some of these concerns. They use data or hypothesized relationships about data to make inferences about ecological systems. Bayesian models have the advantage of making probabilistic

statements about the veracity of hypotheses or relationships, given the data. They can explicitly incorporate uncertainty in model structure and parameter estimates through both prior knowledge and expectations about data into models that produce posterior distributions of outcomes. Bayesian methods depend on resampling distributions, and their recent growth is a result of both their utility and the ease with which computers can implement numerical recipes using Markov Chain Monte Carlo (MCMC) sampling.

This book provides an accessible introduction to Bayesian methods as applied to analyzing populations. It covers a breadth of applications that are widely used in ecology and population management, from analysis of count data and demographic rates for understanding the fluctuations of single populations to estimation of patch occupancy, and metapopulation dynamics that characterize more widely distributed species. Moreover, it uses a practical approach to model building that recognizes most data obtained in field studies of population ecology will have associated sampling uncertainties that arise from hidden processes, so-called hierarchical models. These models account for both the ecological processes of interest and the additional uncertainty caused by unobserved processes that always accompany field sampling, such as variation in the detectability of individuals. The book also makes extensive use of the free and widely used computer programs R and WinBUGS to implement these models. It is the ideal combination for both beginning students and beginning modelers to learn these methods. Advanced users will find plenty of wisdom in these pages to gain new skills, as I have.

Wise use of a model to make decisions that prevent extinction and recover populations requires understanding the unique attributes of a model, determining whether the assumptions that underlie the model's structure are valid and testing the ability of the model to predict the future correctly. This book goes a long way toward building models that can address the first two goals. Ecologists and conservation biologists will still have much work to do to determine how well their models perform. Although the future remains unpredictable as always, there will undoubtedly be a great need to manage wildlife and plant populations by applying the kinds of models presented in this book and by conducting field studies to improve their performance, if the looming extinctions that are projected to be associated with growing human populations and a warming climate are to be prevented.

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