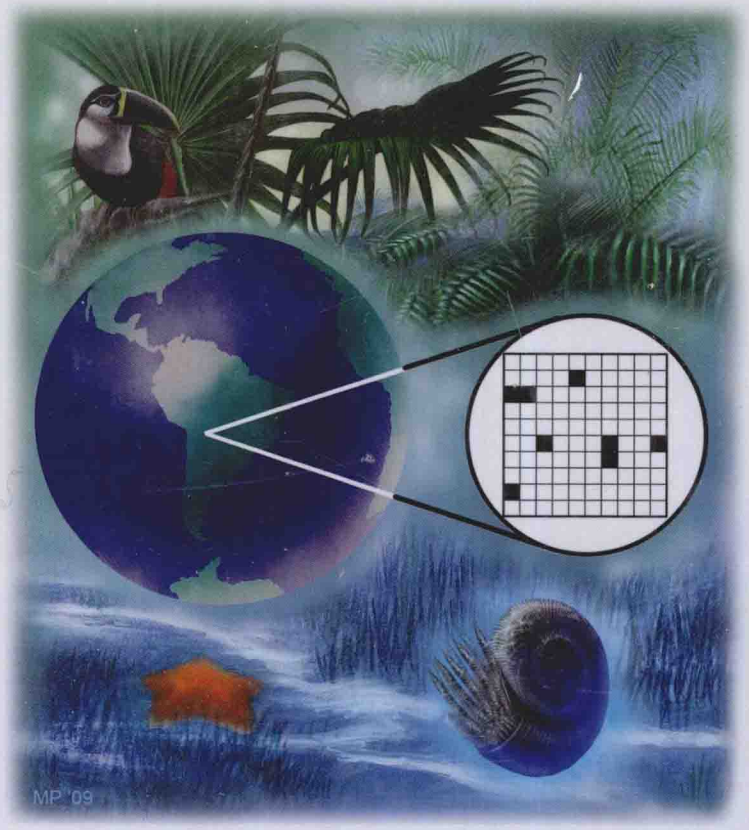
SURVEYING NATURAL POPULATIONS

Quantitative Tools for Assessing Biodiversity

SECOND EDITION



LEE-ANN C. HAYEK & MARTIN A. BUZAS

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To Christine, Matthew, Katherine, Aron, and my new daughter Kate

and

To Barbara, Pamela, Jeffrey, and Thomas

PREFACE

We began this work as a revision of our text *Surveying Natural Populations* published in 1997. Fortunately, our colleagues at many universities and colleges kindly identified textual errors or misleading writing that we incorporated. Those who used the book as a classroom text and/or reference gave especially helpful advice. However, as we began this updating and especially when writing about the exciting new and newly developed material on SHE analysis, we realized that this book would require not just a major revision, but also new chapters. In particular, we incorporated entire developmental chapters on quantitative biodiversity. This book now contains 7 chapters on the analysis and interpretation of the quantitative results that are obtained from a study of biodiversity. Chapters 12 through 18 provide a synthesis of the entire field of biodiversity assessment. Most importantly, in this book all of the major ecological and biodiversity indices have been related mathematically under the umbrella of information measures. We show how the use of a single measure is not a solitary numerical calculation but a purposeful selection of a member of a mathematical family, each selection having repercussions for the interpretation of the resultant biodiversity data. We also demonstrate how many suggested diversity indices must be rejected because they lack vital properties and they do not follow an information–theoretic scheme wherein all measures are mathematically linked. Use of such a scheme not only relates all measures within a study but also provides the standardization necessary for individual studies to be related over time or space allowing for more insight and stronger generalizations from biodiversity analyses.

In the intervening decade since the first book was published, the plight of both humans and other species has been brought more clearly to the attention of both scientists and the public. Our declining global conditions of anthropogenic origin are sending imperatives to those who study natural populations; we can no longer utilize qualitative assessments of biodiversity. We must use the latest and most mathematically useful methods for the evaluation of affected and potentially affected species assemblages and related environmental conditions. We believe that this book is needed now more than ever.

As we stated in the Preface to our original book, the degradation of environments and the fate of natural populations that inhabit them has become a topic of paramount concern throughout the world. Obtaining collections from the field along with pertinent observations, as well as the identification and enumeration of organisms, falls

within the domain of field biologists. Because of the enormous quantities involved, all organisms cannot be directly counted and population parameters must be estimated. Estimation from sample to population falls within the domain of mathematical statisticians. Unfortunately, the two groups of researchers often do not communicate well. This book attempts to bridge the gap.

One author (LCH) is a mathematical statistician with extensive experience in statistical theory and practice for developing and interpreting statistical science for solving ecological, natural history, and biodiversity problems; the other (MAB) is a researcher in quantitative ecology–paleoecology who is familiar with statistics usage. Their knowledge and experience form overlapping sets. Together, they integrate the intuition of the experienced field researcher with the statistical rationale required to survey natural populations.

This is not a book for statisticians. The authors do not offer mathematical proofs of their results. Statistical knowledge is extrapolated without the type of documentation that mathematical statisticians expect. The concepts and complexities contained in the area of mathematical application are, however, requisite knowledge for field biologists and conservation biologists with marine or terrestrial specialties as well as for site managers, paleontologists, and archaeologists. This book is for you.

No prior statistical knowledge is assumed, and only a familiarity with, or, at least not an aversion to algebra is required. This is a versatile book that can be used at many levels: (1) serious students can learn biological and statistical principles fundamental to sound quantitative surveys; (2) experienced researchers can, for the first time in a single readable source, find the underlying statistical theory for their commonly used field approaches; and (3) graduate students and researchers can discover many new relationships, derivations, and measures that can open new research areas suggested throughout the book. For field researchers in natural systems, this book is a reference, a text, a tool, and a guide.

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Without J. Jett this book could never have been completed; we thank her for her invaluable assistance, organization, checking, for her exceptional effort of compiling the index and for putting up with us and our hectic schedule. A. Hayek entered data for some of the problems and ran some analyses for the solutions. We thank M. Parrish from the NMNH Department of Paleobiology for the cover and interior artwork.

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