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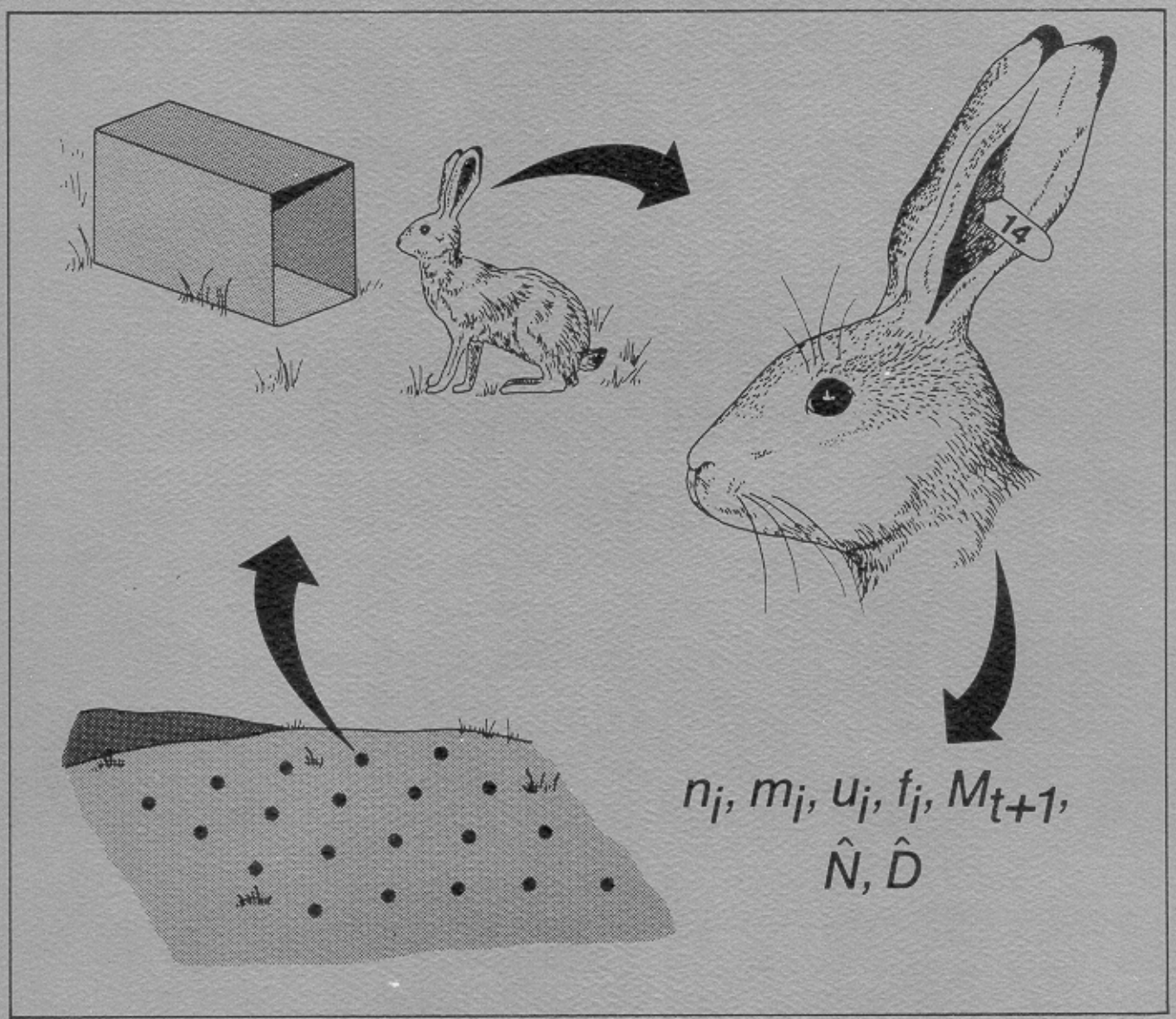
Capture-Recapture and Removal Methods for Sampling Closed Populations



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Capture-Recapture and Removal Methods for Sampling Closed Populations

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ABSTRACT

The problem of estimating animal abundance is common in wildlife management and environmental impact assessment. Capture-recapture and removal methods are often used to estimate population size. *Statistical Inference From Capture Data On Closed Animal Populations,* a monograph by *Otis et al. (1978)*, provides us with a comprehensive synthesis of much of the wildlife and statistical literature on the methods, as well as some extensions of the general theory. In our primer, we focus on capture-recapture and removal methods for trapping studies in which a population is assumed to be closed and do not treat open-population models, such as the Jolly-Seber model, or catch-effort methods in any detail. The primer, written for students interested in population estimation, is intended for use with the more theoretical monograph.

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PREFACE

The problem of estimating animal abundance is common in wildlife management and environmental impact assessment. Capture-recapture and removal methods are often used to estimate population size. *Statistical Inference From Capture Data On Closed Animal Populations,* a monograph by *Otis et al. (1978)*, provides us with a comprehensive synthesis of much of the wildlife and statistical literature on the methods, as well as some extensions of the general theory. In our primer, we focus on capture-recapture and removal methods for trapping studies in which a population is assumed to be closed and do not treat open-population models, such as the Jolly-Seber model, or catch-effort methods in any detail. The primer, written for students interested in population estimation, is intended for use with the more theoretical monograph.

In the monograph, we attempted to produce a state-of-the-art document related to model building, rigorous statistical treatment, and exact maximum likelihood estimators of model parameters. We developed an algorithm, or computational method, to automate model selection and implemented the entire analytical procedure in a computer program called CAPTURE. CAPTURE contains many features and options, including new algorithms for density estimation and simulation experiments. The monograph was intended for biologists as well as applied biometricians. However, at recent workshops and seminars with biologists and students, we found that they frequently did not understand the monograph's key points fully and therefore could not use the methods effectively.

In this primer, we present the basic concepts and methods of sampling. Readers should read *Otis et al. (1978)* for derivations of the methods and tests and for other technical material that is not included here; we have cited specific pages and sections of the monograph to enable ready access to the relevant material. Our emphasis here is on concepts and practical information useful to biologists.

In designing sampling studies, biologists must be aware of what the assumptions are and must make proper transitions from model assumptions to field problems. The design of effective sampling studies requires some familiarity both with the random (or stochastic) nature of the sampling process and with such fundamentals as sampling variation, bias, precision, parameter identifiability, and the criteria for selection of an estimator. We therefore have included an extensively illustrated review of important statistical concepts; an understanding of these is fundamental to an understanding of the rest of the material presented here. We urge a careful study of Chapter 2. Throughout the primer, figures and their captions are used to emphasize key concepts. To further facilitate understanding of the main points, we present the more technical material in small type; figures that involve more technical aspects are denoted by an asterisk. On a first reading one can ignore the small type.

The primer is intended for classroom use by college seniors and graduate students. Suitable for biologists and ecologists, it does not require substantial quantitative training beyond a course in basic statistics. Details on the use of program CAPTURE are given by *White et al. (1978)*, and the uses of some program features are given here in Appendix A. A set of questions and exercises appears at the end of most chapters; answers are provided in Appendix B. Appropriate sections of *Seber (1973)* should be considered auxiliary to the present work, and the General Reading List (Appendix C) should be consulted for closely related material.

The theory and practice of capture-type studies have had a long history, and many people have contributed to our present understanding of the subject. To recognize these individuals and to stimulate the reader's interest in capture-type studies, we have selected for special attention the people whose contributions at the time were most significant. Although our selections involved some arbitrary judgment, we feel that readers will benefit from knowing something about each of these 21 people. We

attempted to obtain a photograph of each person at the time he or she was active in the subject of capture-type studies; for this reason, the quality of the photographs is not ideal in some cases. Some photographs were made from published half-tones or small passport pictures, and one was made from a mid 1960s South African driver's license.

In a sobering review of a sample of the biological literature *Hayne (1978)* suggests that biologists often have not thought deeply enough about the most fundamental question relating to their research—why it is being undertaken. Unless this basic question is thought through, the material presented in this primer can be of little value.

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