Mathematical Models In Population Biology And Epidemiology Texts In Applied Mathematics

Linear and non-linear models of populations, molecular evolution, phylogenetic tree construction, genetics, and infectious diseases are presented with minimal prerequisites.

This book is an introduction to mathematical biology for students with no experience in biology, but who have some mathematical background. The work is focused on population dynamics and ecology, following a tradition that goes back to Lotka and Volterra, and includes a part devoted to the spread of infectious diseases, a field where mathematical modeling is extremely popular. These themes are used as the area where to understand different types of mathematical modeling and the possible meaning of qualitative agreement of modeling with data. The book also includes a collections of problems designed to approach more advanced questions. This material has been used in the courses at the University of Trento, directed at students in their fourth year of studies in Mathematics. It can also be used as a reference as it provides up-to-date developments in several areas.

This book describes the evolution of several socio-biological systems using mathematical kinetic theory. Specifically, it deals with modeling and simulations of biological systems whose dynamics follow the rules of mechanics as well as rules governed by their own ability to organize movement and biological functions. It proposes a new biological model focused on the analysis of competition between cells of an aggressive host and cells of a corresponding immune system. Proposed models are related to the generalized Boltzmann equation. The book may be used for advanced graduate courses and seminars in biological systems modeling.

An introduction to mathematical methods used in the study of population phenomena including models of total population and population age structure, models of random population events presented in terms of Markov chains, and methods used to uncover qualitative behavior of more complicated difference equations.
Mathematical and computational modeling approaches in biological and medical research are experiencing rapid growth globally. This Special Issue Book intends to scratch the surface of this exciting phenomenon. The subject areas covered involve general mathematical methods and their applications in biology and medicine, with an emphasis on work related to mathematical and computational modeling of the complex dynamics observed in biological and medical research. Fourteen rigorously reviewed papers were included in this Special Issue. These papers cover several timely topics relating to classical population biology, fundamental biology, and modern medicine. While the authors of these papers dealt with very different modeling questions, they were all motivated by specific applications in biology and medicine and employed innovative mathematical and computational methods to study the complex dynamics of their models. We hope that these papers detail case studies that will inspire many additional mathematical modeling efforts in biology and medicine.

In this new century mankind faces ever more challenging environmental and public health problems, such as pollution, invasion by exotic species, emergence of new diseases or the emergence of diseases into new regions (West Nile virus, SARS, Anthrax, etc.), and the resurgence of existing diseases (influenza, malaria, TB, HIV/AIDS, etc.). Mathematical models have been successfully used to study many biological, epidemiological and medical problems, and nonlinear and complex dynamics have been observed in all of those contexts. Mathematical studies have helped us not only to better understand these problems but also to find solutions in some cases, such as the prediction and control of SARS outbreaks, understanding HIV infection, and the investigation of antibiotic-resistant infections in hospitals.

Structured population models distinguish individuals from one another according to characteristics such as age, size, location, status, and movement, to determine the birth, growth and death rates, interaction with each other and with environment, infectivity, etc. The goal of structured population models is to understand how these characteristics affect the dynamics of these models and thus the outcomes and consequences of the biological and epidemiological processes. There is a very large and growing body of literature on these topics. This book deals with the recent and important advances in the study of structured population models in biology and epidemiology. There are six chapters in this book, written by leading researchers in these areas.

Mathematical Models of Life Support Systems is a component of Encyclopedia of Mathematical Sciences in which is part of the global Encyclopedia of Life Support Systems (EOLSS), an integrated compendium of twenty one Encyclopedias. The Theme is organized into several topics which represent the main scientific areas of the theme: The first topic, Introduction to Mathematical Modeling discusses the foundations of mathematical modeling and computational experiments, which are formed to support new methodologies of scientific research. The succeeding topics are Mathematical Models in - Water Sciences; Climate; Environmental Pollution and Degradation; Energy Sciences; Food and Agricultural Sciences; Population; Immunology; Medical Sciences; and Control of Catastrophic Processes. These two volumes are aimed at the following five major target audiences: University and College students, Educators, Professional practitioners, Research personnel and Policy analysts, managers, and decision makers and NGOs.

This carefully structured laboratory manual explores, by means of computer simulations, the key areas of population dynamics through time. Using simply presented exercises, it teaches the programming and analysing skills students need for creating their own models of population change. In this way, readers can contribute constructively to the conservation of endangered species and the control of pest species. Focus on biology rather than mathematical procedures introduces new techniques and shortcuts gradually with carefully explained commands. Includes an extensive glossary. Undergraduates and postgraduates taking courses in population ecology, behavioural ecology and conservation will find this an ideal accompaniment.

Population biology has had a long history of mathematical modeling. The 1920s and 1930s saw major strides with the work of Lotka and Volterra in ecology and Fisher, Haldane, and Wright in genetics. In recent years, much more sophisticated mathematical techniques have been brought to bear on questions in population biology. Simultaneously, advances in experimental and field work have produced a wealth of new data. While this growth has tended to fragment the field, one unifying theme is that similar mathematical questions arise in a range of biological contexts. This volume contains the proceedings of a symposium on Some Mathematical Questions in Biology, held in Chicago in 1987. The papers all deal with different aspects of population biology, but there are overlaps in the mathematical techniques used; for example, dynamics of nonlinear differential and difference equations form a common theme. The topics covered are cultural evolution, multilocus population genetics, spatially structured population genetics, chaos and the dynamics of epidemics, and the dynamics of ecological communities.

Population dynamics is an important subject in mathematical biology. A central problem is to study the long-term behavior of modeling systems. Most of these systems are governed by various evolutionary equations such as difference, ordinary, functional, and partial differential equations (see, e.g., [165, 142, 218, 119, 55]). As we know, interactive populations often live in a fluctuating environment. For example, physical environmental conditions such as temperature and humidity and the availability of food, water, and other resources usually vary in time with seasonal or daily variations. Therefore, more realistic models should be nonautonomous systems. In particular, if the data in a model are periodic functions of time with commensurate period, a periodic system arises; if these periodic functions have different (minimal) periods, we get an almost periodic system. The existing reference books, from the dynamical systems point of view, mainly focus on autonomous biological systems. The book of Hess [106] is an excellent reference for periodic parabolic boundary value problems with applications to population dynamics. Since the publication of this book there have been extensive investigations on periodic, asymptotically periodic, almost periodic, and even general nonautonomous biological systems, which in turn have motivated further development of the theory of dynamical systems. In order to explain the dynamical systems approach to periodic population problems, let us consider, as an illustration, two species periodic competitive systems

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d\mathbf{U}/dt = \mathbf{f}(t,\mathbf{U}), \quad \mathbf{U}(0) = \mathbf{U}_0.\]

Population biology has been investigated quantitatively for many decades, resulting in a rich body of scientific literature. Ecologists often avoid this literature, put off by its apparently formidable mathematics. This textbook provides an introduction to the biology and ecology of populations by emphasizing the roles of simple mathematical models in explaining the growth and behavior of populations. The author only assumes acquaintance with elementary calculus, and provides tutorial explanations where needed to develop mathematical concepts. Examples, problems, extensive marginal notes and numerous graphs enhance the book's value to students in classes ranging from population biology and population ecology to mathematical biology and mathematical ecology. The book will also be useful as a supplement to introductory courses in ecology.

This book is an outgrowth of one phase of an upper-division course on quantitative ecology, given each year for the past eight at Berkeley. I am most grateful to the students in that course and to many graduate students in the Berkeley Department of Zoology and Colleges of Engineering and Natural Resources whose spirited discussions inspired much of the book's content. I also am deeply grateful to those faculty colleagues with whom, at one time or another, I have shared courses or seminars in ecology or population biology, D.M. Auslander, L. Demetrius, G. Oster, O.H. Paris, F.A. Pitelka, A.M. Schultz, Y. Takahashi, D.B. Tyler, and P. Vogelhut, all of whom contributed substantially to the development of my thinking in those.
fields, to my department colleagues E. Polak and A.J. Thomasian, who guided me into the literature on numerical methods and stochastic processes, and to the graduate students who at one time or another have worked with me on population-biology projects, L.M. Brodnax, S-P. Chan, A. Elterman, G.C. Ferrell, D. Green, C. Hayashi, K-L. Lee, W.F. Martin Jr., D. May, J. Stammes, G.E. Swanson, and I. Weeks, who, together, undoubtedly provided me with the greatest inspiration. I am indebted to the copy-editing and production staff of Springer-Verlag, especially to Ms. M. Muzeniek, for their diligence and skill, and to Mrs. Alice Peters, biomathematics editor, for her patience.

This volume represents the edited proceedings of the International Symposium on Mathematical Biology held in Kyoto, November 10-15, 1985. The symposium was organized by an international committee whose members are: E. Teramoto, M. Yamaguti, S. Amari, S.A. Levin, H. Matsuda, A. Okubo, L.M. Ricciardi, R. Rosen, and L.A. Segel. The symposium included technical sessions with a total of 11 invited papers, 49 contributed papers and a poster session where 40 papers were displayed. These Proceedings consist of selected papers from this symposium. This symposium was the second Kyoto meeting on mathematical topics in biology. The first was held in conjunction with the Sixth International Biophysics Congress in 1978. Since then this field of science has grown enormously, and the number of scientists in the field has rapidly increased. This is also the case in Japan. About 80 young Japanese scientists and graduate students participated this time. The sessions were divided into 4 categories: 1) Mathematical Ecology and Population Biology, 2) Mathematical Theory of Developmental Biology and Morphogenesis, 3) Theoretical Neurosciences, and 4) Cell Kinetics and Other Topics. In every session, there were stimulating and active discussions among the participants. We are convinced that the symposium was highly successful in transmitting scientific information across disciplines and in establishing fruitful contacts among the participants. We owe this success to the cooperation of all participants.

This volume is based on the proceedings of the International Workshop on Dynamical Systems and their Applications in Biology held at the Canadian Coast Guard College on Cape Breton Island (Nova Scotia, Canada). It presents a broad picture of the current research surrounding applications of dynamical systems in biology, particularly in population biology. The book contains 19 papers and includes articles on the qualitative and/or numerical analysis of models involving ordinary, partial, functional, and stochastic differential equations. Applications include epidemiology, population dynamics, and physiology. The material is suitable for graduate students and research mathematicians interested in ordinary differential equations and their applications in biology. Also available by Ruan, Wolkowicz, and Wu is Differential Equations with Applications to Biology, Volume 21 in the AMS series Fields Institute Communications.

Mathematical Models for Society and Biology, 2e, is a useful resource for researchers, graduate students, and post-docs in the applied mathematics and life science fields. Mathematical modeling is one of the major subfields of mathematical biology. A mathematical model may be used to help explain a system, to study the effects of different components, and to make predictions about behavior. Mathematical Models for Society and Biology, 2e, draws on current issues to engagingly relate how to use mathematics to gain insight into problems in biology and contemporary society. For this new edition, author Edward Beltrami uses mathematical models that are simple, transparent, and verifiable. Also new to this edition is an introduction to mathematical notions that every quantitative scientist in the biological and social sciences should know. Additionally, each chapter now includes a detailed discussion on how to formulate a reasonable model to gain insight into the specific question that has been introduced. Offers 40% more content – 5 new chapters in addition to revisions to existing chapters Accessible for quick self study as well as a resource for courses in molecular biology, biochemistry, embryology and cell biology, medicine, ecology and evolution, bio-mathematics, and applied math in general Features expanded appendices with an extensive list of references, solutions to selected exercises in the book, and further discussion of various mathematical methods introduced in the book.

Single-species growth; Pedration and parasitism; Predator-prey systems; Lotka-volterra systems for predator-prey interactions; Intermediate predator-prey models; Continuous models; Discrete models; The kolmogorov model; Related topics and applications; Related topics; Applications; competition and cooperation (symbiosis); Lotka-volterra competition models; Higher-oder competition models; cooperation
Mathematical Epidemiology of Infectious Diseases Model Building, Analysis and Interpretation O. Diekmann University of Utrecht, The Netherlands. J. A. P. Heesterbeek Centre for Biometry Wageningen, The Netherlands.
The mathematical modelling of epidemics in populations is a vast and important area of study. It is about translating biological assumptions into mathematics, about mathematical analysis aided by interpretation and about obtaining insight into epidemic phenomena when translating mathematical results back into population biology. Model assumptions are formulated in terms of, usually stochastic, behaviour of individuals and then the resulting phenomena, at the population level, are unravelled. Conceptual clarity is attained, assumptions are stated clearly, hidden working hypotheses are attained and mechanistic links between different observables are exposed. Features: * Model construction, analysis and interpretation receive detailed attention * Uniquely covers both deterministic and stochastic viewpoints * Examples of applications given throughout * Extensive coverage of the latest research into the mathematical modelling of epidemics of infectious diseases * Provides a solid foundation of modelling skills.
The reader will learn to translate, model, analyse and interpret, with the help of the numerous exercises. In literally working through this text, the reader acquires modelling skills that are also valuable outside of epidemiology, at theoretical biologists and epidemiologists. Previous exposure to epidemic concepts is not required, as all background information is given. The book is primarily aimed at self-study and ideally suited for small discussion groups, or for use as a course text.

Environmental variation plays an important role in many biological and ecological dynamical systems. This monograph focuses on the study of oscillation and the stability of delay models occurring in biology. The book presents recent research results on the qualitative behavior of mathematical models under different physical and environmental conditions, covering dynamics including the distribution and consumption of food. Researchers in the fields of mathematical modeling, mathematical biology, and population dynamics will be particularly interested in this material.

This book uses fundamental ideas in dynamical systems to answer questions of a biologic nature, in particular, questions about the behavior of populations given a relatively few hypotheses about the nature of their growth and interaction. The principal subject treated is that of coexistence under certain parameter ranges, while asymptotic methods are used to show competitive exclusion in other parameter ranges. Finally, some problems in genetics are posed and analyzed as problems in nonlinear ordinary differential equations.


The emphasis throughout the present volume is on the practical application of theoretical mathematical models helping to unravel the underlying mechanisms involved in processes from mathematical physics and biosciences. It has been conceived as a unique collection of abstract methods dealing especially with nonlinear partial differential equations (either stationary or evolutionary) that are applied to understand concrete processes involving some important applications related to phenomena such as: boundary layer...
phenomena for viscous fluids, population dynamics, dead core phenomena, etc. It addresses researchers and post-graduate students working at the interplay between mathematics and other fields of science and technology and is a comprehensive introduction to the theory of nonlinear partial differential equations and its main principles also presents their real-life applications in various contexts: mathematical physics, chemistry, mathematical biology, and population genetics. Based on the authors' original work, this volume provides an overview of the field, with examples suitable for researchers but also for graduate students entering research. The method of presentation appeals to readers with diverse backgrounds in partial differential equations and functional analysis. Each chapter includes detailed heuristic arguments, providing thorough motivation for the material developed later in the text. The content demonstrates in a firm way that partial differential equations can be used to address a large variety of phenomena occurring in and influencing our daily lives. The extensive reference list and index make this book a valuable resource for researchers working in a variety of fields and who are interested in phenomena modeled by nonlinear partial differential equations.

As Eugene Wigner stressed, mathematics has proven unreasonably effective in the physical sciences and their technological applications. The role of mathematics in the biological, medical and social sciences has been much more modest but has recently grown thanks to the simulation capacity offered by modern computers. This book traces the history of population dynamics—a theoretical subject closely connected to genetics, ecology, epidemiology and demography—where mathematics has brought significant insights. It presents an overview of the genesis of several important themes: exponential growth, from Euler and Malthus to the Chinese one-child policy; the development of stochastic models, from Mendel's laws and the question of extinction of family names to percolation theory for the spread of epidemics, and chaotic populations, where determinism and randomness intertwine. The reader of this book will see, from a different perspective, the problems that scientists face when governments ask for reliable predictions to help control epidemics (AIDS, SARS, swine flu), manage renewable resources (fishing quotas, spread of genetically modified organisms) or anticipate demographic evolutions such as aging.

Mathematical Models in Biology is an introductory book for readers interested in biological applications of mathematics and modeling in biology. A favorite in the mathematical biology community, it shows how relatively simple mathematics can be applied to a variety of models to draw interesting conclusions. Connections are made between diverse biological examples linked by common mathematical themes. A variety of discrete and continuous ordinary and partial differential equation models are explored. Although great advances have taken place in many of the topics covered, the simple lessons contained in this book are still important and informative. Audience: the book does not assume too much background knowledge—essentially some calculus and high-school algebra. It was originally written with third- and fourth-year undergraduate mathematical-biology majors in mind; however, it was picked up by beginning graduate students as well as researchers in math (and some in biology) who wanted to learn about this field.

This volume discusses the rich and interesting properties of dynamical systems that appear in ecology and environmental sciences. It provides a fascinating survey of the theory of dynamical systems in ecology and environmental science. Each chapter introduces students and scholars to the state-of-the-art in an exciting area, presents new results, and inspires future contributions to mathematical modeling in ecology and environmental sciences.

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chaos and the dynamics of epidemics, and the dynamics of ecological communities.

The aim of this book is to build a fundamental understanding in Mathematical Biology, Epidemiology and Ecology. Written for biologists, mathematicians, applied statisticians and physicists, Mathematical Models in Population Biology: Essential Concepts in Biomathematics provides a coverage of different topics in mathematical biology from vector-borne diseases, fractional calculus, and stochastic differential equations to neuro-dynamics, illustrating some important models used for real data.

The goal of this book is to search for a balance between simple and analyzable models and unsolvable models which are capable of addressing important questions on population biology. Part I focusses on single species simple models including those which have been used to predict the growth of human and animal population in the past. Single population models are, in some sense, the building blocks of more realistic models -- the subject of Part II. Their role is fundamental to the study of ecological and demographic processes including the role of population structure and spatial heterogeneity -- the subject of Part III. This book, which will include both examples and exercises, is of use to practitioners, graduate students, and scientists working in the field.

KEY BENEFIT: This reference introduces a variety of mathematical models for biological systems, and presents the mathematical theory and techniques useful in analyzing those models. Material is organized according to the mathematical theory rather than the biological application. Contains applications of mathematical theory to biological examples in each chapter. Focuses on deterministic mathematical models with an emphasis on predicting the qualitative solution behavior over time. Discusses classical mathematical models from population, including the Leslie matrix model, the Nicholson-Bailey model, and the Lotka-Volterra predator-prey model. Also discusses more recent models, such as a model for the Human Immunodeficiency Virus - HIV and a model for flour beetles. KEY MARKET: Readers seeking a solid background in the mathematics behind modeling in biology and exposure to a wide variety of mathematical models in biology.

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Students often find it difficult to grasp fundamental ecological and evolutionary concepts because of their inherently mathematical nature. Likewise, the application of ecological and evolutionary theory often requires a high degree of mathematical competence. This book is a first step to addressing these difficulties, providing a broad introduction to the key methods and underlying concepts of mathematical models in ecology and evolution. The book is intended to serve the needs of undergraduate and postgraduate ecology and evolution students who need to access the mathematical and statistical modelling literature essential to their subjects. The book assumes minimal mathematics and statistics knowledge whilst covering a wide variety of methods, many of which are at the forefront of ecological and evolutionary research. The book also highlights the applications of modelling to practical problems such as sustainable harvesting and biological control. Key features: Written clearly and succinctly, requiring minimal in-depth knowledge of mathematics Introduces students to the use of computer models in both fields of ecology and evolutionary biology Market: senior undergraduate students and beginning postgraduates in ecology and evolutionary biology.

The lecture notes contained in this volume were presented at the AMS Short Course on Population Biology, held August 6-7, 1983, in Albany, New York in conjunction with the summer meeting of the American Mathematical Society. These notes will acquaint the reader with the mathematical ideas that
pervade almost every level of thinking in population biology and provide an introduction to the many applications of mathematics in the field. Research mathematicians, college teachers of mathematics, and graduate students all should find this book of interest. Population biology is probably the oldest area in mathematical biology, but remains a constant source of new mathematical problems and the area of biology best integrated with mathematical theory. The need for mathematical approaches has never been greater, as evolutionary theory is challenged by new interpretations of the paleontological record and new discoveries at the molecular level, as world resources for feeding populations become limiting, as the problems of pollution increase, and as both animal and plant epidemiological problems receive closer scrutiny. A background of advanced calculus, introduction to ordinary and partial differential equations, and linear algebra will make the book accessible. All of the papers included have high research value. A list of the contents follows.

This book covers tutorial and research contributions on the use of dynamical systems and stochastic models in disease dynamics. Beginning graduate students in applied mathematics, scientists, or mathematicians who want to enter the fields of mathematical and theoretical epidemiology will find this book useful.

Thirty years ago, biologists could get by with a rudimentary grasp of mathematics and modeling. Not so today. In seeking to answer fundamental questions about how biological systems function and change over time, the modern biologist is as likely to rely on sophisticated mathematical and computer-based models as traditional fieldwork. In this book, Sarah Otto and Troy Day provide biology students with the tools necessary to both interpret models and to build their own. The book starts at an elementary level of mathematical modeling, assuming that the reader has had high school mathematics and first-year calculus. Otto and Day then gradually build in depth and complexity, from classic models in ecology and evolution to more intricate class-structured and probabilistic models. The authors provide primers with instructive exercises to introduce readers to the more advanced subjects of linear algebra and probability theory. Through examples, they describe how models have been used to understand such topics as the spread of HIV, chaos, the age structure of a country, speciation, and extinction. Ecologists and evolutionary biologists today need enough mathematical training to be able to assess the power and limits of biological models and to develop theories and models themselves. This innovative book will be an indispensable guide to the world of mathematical models for the next generation of biologists. A how-to guide for developing new mathematical models in biology Provides step-by-step recipes for constructing and analyzing models Interesting biological applications Explores classical models in ecology and evolution Questions at the end of every chapter Primers cover important mathematical topics Exercises with answers Appendixes summarize useful rules Labs and advanced material available

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