

# **STAGE-STRUCTURED POPULATIONS**

**sampling, analysis and simulation**

**Bryan F.J. Manly**

**population and community biology series**

# Stage Structured Populations

**Robert A. Pastorok, Steven M.  
Bartell, Scott Ferson, Lev R. Ginzburg**

## **Stage Structured Populations:**

**Stage-Structured Populations** Bryan Manly, 2013-03-09 This book provides a review of methods for obtaining and analysing data from stage structured biological populations The topics covered are sampling designs Chapter 2 the estimation of parameters by maximum likelihood Chapter 3 the analysis of sample counts of the numbers of individuals in different stages at different times Chapters 4 and 5 the analysis of data using Leslie matrix types of model Chapter 6 and key factor analysis Chapter 7 There is also some discussion of the approaches to modelling and estimation that have been used in five studies of particular populations Chapter 8 There is a large literature on the modelling of biological populations and a multitude of different approaches have been used in this area The various approaches can be classified in different ways Southwood 1978 ch 12 but for the purposes of this book it is convenient to think of the three categories mathematical statistical and predictive modelling Mathematical modelling is concerned largely with developing models that capture the most important qualitative features of population dynamics In this case the models that are developed do not have to be compared with data from natural populations As representations of idealized systems they can be quite informative in showing the effects of changing parameters indicating what factors are most important in promoting stability and so on

**Stage-Structured Populations** Bryan F.J. Manly, 2014-03-14 This book provides a review of methods for obtaining and analysing data from stage structured biological populations The topics covered are sampling designs Chapter 2 the estimation of parameters by maximum likelihood Chapter 3 the analysis of sample counts of the numbers of individuals in different stages at different times Chapters 4 and 5 the analysis of data using Leslie matrix types of model Chapter 6 and key factor analysis Chapter 7 There is also some discussion of the approaches to modelling and estimation that have been used in five studies of particular populations Chapter 8 There is a large literature on the modelling of biological populations and a multitude of different approaches have been used in this area The various approaches can be classified in different ways Southwood 1978 ch 12 but for the purposes of this book it is convenient to think of the three categories mathematical statistical and predictive modelling Mathematical modelling is concerned largely with developing models that capture the most important qualitative features of population dynamics In this case the models that are developed do not have to be compared with data from natural populations As representations of idealized systems they can be quite informative in showing the effects of changing parameters indicating what factors are most important in promoting stability and so on

**Estimation of Mortality Rates in Stage-Structured Population** Simon N. Wood, Roger M. Nisbet, 2013-03-08 The stated aims of the Lecture Notes in Biomathematics allow for work that is unfinished or tentative This volume is offered in that spirit The problem addressed is one of the classics of statistical ecology the estimation of mortality rates from stage frequency data but in tackling it we found ourselves making use of ideas and techniques very different from those we expected to use and in which we had no previous experience Specifically we drifted towards consideration of some rather

specific curve and surface fitting and smoothing techniques We think we have made some progress otherwise why publish but are acutely aware of the conceptual and statistical clumsiness of parts of the work Readers with sufficient expertise to be offended should regard the monograph as a challenge to do better The central theme in this book is a somewhat complex algorithm for mortality estimation detailed at the end of Chapter 4 Because of its complexity the job of implementing the method is intimidating Any reader interested in using the methods may obtain copies of our code as follows

Intelligible Structured Code 1 Hutchinson and deHoog s algorithm for fitting smoothing splines by cross validation 2 Cubic covariant area approximating splines 3 Cubic interpolating splines 4 Cubic area matching splines 5 Hyman s algorithm for monotonic interpolation based on cubic splines Prototype User Hostile Code 6 Positive constrained interpolation 7 Positive constrained area matching 8 The full method from chapter 4 9 The simpler method from chapter 4

The Dynamics of Physiologically Structured Populations Johan A. Metz, Odo Diekmann, 2014-03-11

**Optimal Control of Age-structured Populations in Economy, Demography, and the Environment** Raouf Boucekkine, Natali Hritonenko, Yuri Yatsenko, 2013-05-13 This book covers a wide range of topics within mathematical modelling and the optimization of economic demographic technological and environmental phenomena Each chapter is written by experts in their field and represents new advances in modelling theory and practice These essays are exemplary of the fruitful interaction between theory and practice when exploring global and local changes The unifying theme of the book is the use of mathematical models and optimization methods to describe age structured populations in economy demography technological change and the environment Emphasis is placed on deterministic dynamic models that take age or size structures delay effects and non standard decision variables into account In addition the contributions deal with the age structure of assets resources and populations under study Interdisciplinary modelling has enormous potential for discovering new insights in global and regional development Optimal Control of Age structured Populations in Economy Demography and the Environment is a rich and excellent source of information on state of the art modelling expertise and references The book provides the necessary mathematical background for readers from different areas such as applied sciences management sciences and operations research which helps guide the development of practical models As well as this the book also surveys the current practice in applied modelling and looks at new research areas for a general mathematical audience This book will be of interest primarily to researchers postgraduate students as well as a wider scientific community including those focussing on the subjects of applied mathematics environmental sciences economics demography management and operations research

**Stage-structured Demography in Stochastic Environments** Raziel Joseph Davison, 2011 Populations living in natural environments experience fluctuations in environmental conditions that drive variability in demographic rates This dissertation develops new and existing mathematical methods for studying environmental stochasticity and uses these tools to investigate the role of environmental stochasticity in driving observed population dynamics and plant life history evolution In the first two chapters I develop new

approaches to a classic method in population biology the life table response experiment LTRE Whereas existing methods used time averaged demographic rates and deterministic sensitivities to decompose observed differences in population growth rates this new method allows estimation of the contributions to those differences made by variances in demographic rates as well as by mean rate values I use this stochastic LTRE to show how differential variability in the vital rates of *Anthyllis vulneraria* kidney vetch contribute to differences in the population growth rates of nine populations growing in southwest Belgium we also show how the effects of demographic rate variability depend on soil depth where the greater moisture retention of deeper soils buffers populations against the otherwise negative effects of demographic variability The second chapter provides a different approach to LTRE that uses an iterated two factor decomposition of the small noise approximation of the stochastic population growth rate to quantify contributions to that growth rate made by i mean vital rates ii temporal variability in vital rates iii elasticities of the population growth rate to individual vital rates and iv correlations between vital rates across the study period Contributions of elasticities tell us about differences in local selection pressures acting on distinct populations and contributions of correlations tell us about differences in the phenotypic tradeoffs associated with vital rates I use this new method to show how these differences drive dynamics in two species *Anthyllis vulneraria* the same populations studied in the first chapter and *Cypripedium calceolus* lady s slipper orchid In *Anthyllis vulneraria* variability in large adult fertility and seedling survival made the largest contributions there were also effects of differences in elasticities of large adult fertility and survival as well as differences in the correlations between rapid growth and survival in seedlings a survival cost of rapid early development between large adult fertility and survival a survival cost of reproduction and between large adult fertility and seedling survival In *Cypripedium calceolus* population growth rates were driven most by differences in the elasticities to the probabilities of adult stasis vs entering dormancy as well as by differences in the variability and tradeoffs associated with adult dormancy correlation played a role through differences in the survival payoff of dormancy vs the complimentary fertility cost of dormancy in terms of lost opportunity for reproduction The third and final chapter investigates the role of fire disturbance in driving the life histories and population level dynamics of five woody plant species growing in the Brazilian cerrado a savannah forest mosaic in which woody vegetation cover is primarily mediated by fire disturbance This study presents a set of diagnostics that use demographic responses to recurring disturbance to categorize species along a continuum of adaptation on one end we find resistant species that must weather disturbance in order to attain large sizes that are buffered against fire induced mortality on the other end we find resilient species that are relatively indifferent to disturbance and harness transient opportunities afforded by early post fire successional habitats in order to take advantage of increased nutrient availability and reduced competition Each of these chapters uses stochastic demographic analysis to extend theory describing the dynamics of populations in variable environments together these studies present a variegated perspective on the role of environmental stochasticity that

provides new methods and novel perspectives that should be useful in the study of population biology and life history evolution

**Size-Structured Populations** Bo Ebenman, Lennart Persson, 2012-12-06 At last both ecology and evolution are covered in this study on the dynamics of size structured populations How does natural selection shape growth patterns and life cycles of individuals and hence the size structure of populations This book will stimulate biologists to look into some important and interesting biological problems from a new angle of approach concerning life history evolution intraspecific competition and niche theory structure and dynamics of ecological communities

*Data-driven Modelling of Structured Populations* Stephen P. Ellner, Dylan Z. Childs, Mark Rees, 2016-05-13 This book is a How To guide for modeling population dynamics using Integral Projection Models IPM starting from observational data It is written by a leading research team in this area and includes code in the R language in the text and online to carry out all computations The intended audience are ecologists evolutionary biologists and mathematical biologists interested in developing data driven models for animal and plant populations IPMs may seem hard as they involve integrals The aim of this book is to demystify IPMs so they become the model of choice for populations structured by size or other continuously varying traits The book uses real examples of increasing complexity to show how the life cycle of the study organism naturally leads to the appropriate statistical analysis which leads directly to the IPM itself A wide range of model types and analyses are presented including model construction computational methods and the underlying theory with the more technical material in Boxes and Appendices Self contained R code which replicates all of the figures and calculations within the text is available to readers on GitHub Stephen P Ellner is Horace White Professor of Ecology and Evolutionary Biology at Cornell University USA Dylan Z Childs is Lecturer and NERC Postdoctoral Fellow in the Department of Animal and Plant Sciences at The University of Sheffield UK Mark Rees is Professor in the Department of Animal and Plant Sciences at The University of Sheffield UK

*Population Dynamics for Conservation* Louis W. Botsford, J. Wilson White, Alan Hastings, 2019-09-26 The management and conservation of natural populations relies heavily on concepts and results generated from models of population dynamics Yet this is the first book to present a unified and coherent explanation of the underlying theory This novel text begins with a consideration of what makes a good state variable progressing from the simplest models those with a single variable such as abundance or biomass to more complex models with other key variables of population structure including age size life history stage and space Throughout the book attention is paid to concepts such as population variability population stability population viability persistence and harvest yield Later chapters address specific applications to conservation such as recovery planning for species at risk fishery management and the spatial management of marine resources Population Dynamics for Conservation is suitable for graduate level students It will also be valuable to academic and applied researchers in population biology This overview of population dynamic theory can serve to further their population research as well as to improve their understanding of population management

**Structured-Population Models in Marine, Terrestrial, and Freshwater Systems** Shripad

Tuljapurkar, Hal Caswell, 2012-12-06 In the summer of 1993 twenty six graduate and postdoctoral students and fourteen lecturers converged on Cornell University for a summer school devoted to structured population models This school was one of a series to address concepts cutting across the traditional boundaries separating terrestrial marine and freshwater ecology Earlier schools resulted in the books Patch Dynamics S A Levin T M Powell a book on food webs is in preparation Models of population structure differences among individuals due to age size developmental stage spatial location or genotype have an important place in studies of all three kinds of ecosystem In choosing the participants and lecturers for the school we selected for diversity biologists who knew some mathematics and mathematicians who knew some biology field biologists sobered by encounters with messy data and theoreticians intoxicated by the elegance of the underlying mathematics people concerned with long term evolutionary problems and people concerned with the acute crises of conservation biology For four weeks these perspectives swirled in discussions that started in the lecture hall and carried on into the sweltering Ithaca night Diversity may not increase stability but it surely makes things interesting

Encyclopedia of Evolutionary Biology ,2016-04-14 Encyclopedia of Evolutionary Biology Four Volume Set is the definitive go to reference in the field of evolutionary biology It provides a fully comprehensive review of the field in an easy to search structure Under the collective leadership of fifteen distinguished section editors it is comprised of articles written by leading experts in the field providing a full review of the current status of each topic The articles are up to date and fully illustrated with in text references that allow readers to easily access primary literature While all entries are authoritative and valuable to those with advanced understanding of evolutionary biology they are also intended to be accessible to both advanced undergraduate and graduate students Broad topics include the history of evolutionary biology population genetics quantitative genetics speciation life history evolution evolution of sex and mating systems evolutionary biogeography evolutionary developmental biology molecular and genome evolution coevolution phylogenetic methods microbial evolution diversification of plants and fungi diversification of animals and applied evolution Presents fully comprehensive content allowing easy access to fundamental information and links to primary research Contains concise articles by leading experts in the field that ensures current coverage of each topic Provides ancillary learning tools like tables illustrations and multimedia features to assist with the comprehension process

Theory of Wildlife Population Ecology Bruce D. Leopold, 2018-10-25 Understanding wildlife population ecology is vital for all wildlife managers and conservation biologists Leopold draws on 30 years of research and teaching experience to give students and natural resource professionals the foundation they need to effectively manage wildlife populations He begins with the key statistical concepts and research approaches necessary to gain insight into various models of population dynamics The many factors that influence wildlife populations are thoroughly explored and their consequences are investigated In addition the author presents techniques for analyzing wildlife harvest data and a lucid discussion of valuable wildlife census methods Frequent examples of foundational literature supplement

each chapter with applications of the theories and provide a concise compendium of fundamental concepts of population ecology Abundant statistical exercises reinforce students learning throughout the text

**Ecological Modeling in Risk Assessment** Robert A. Pastorok, Steven M. Bartell, Scott Ferson, Lev R. Ginzburg, 2016-04-19 Expanding the risk assessment toolbox this book provides a comprehensive and practical evaluation of specific ecological models for potential use in risk assessment Ecological Modeling in Risk Assessment Chemical Effects on Populations Ecosystems and Landscapes goes beyond current risk assessment practices for toxic chemicals as applied to individual organism endpoints to describe ecological effects models useful at the population ecosystem and landscape levels The authors demonstrate the utility of a set of ecological effects models eventually improving the ecological relevance of risk assessments and making data collection more cost effective

**Encyclopedia of Ecology** Brian D. Fath, 2014-11-03 The groundbreaking Encyclopedia of Ecology provides an authoritative and comprehensive coverage of the complete field of ecology from general to applied It includes over 500 detailed entries structured to provide the user with complete coverage of the core knowledge accessed as intuitively as possible and heavily cross referenced Written by an international team of leading experts this revolutionary encyclopedia will serve as a one stop shop to concise stand alone articles to be used as a point of entry for undergraduate students or as a tool for active researchers looking for the latest information in the field Entries cover a range of topics including Behavioral Ecology Ecological Processes Ecological Modeling Ecological Engineering Ecological Indicators Ecological Informatics Ecosystems Ecotoxicology Evolutionary Ecology General Ecology Global Ecology Human Ecology System Ecology The first reference work to cover all aspects of ecology from basic to applied Over 500 concise stand alone articles are written by prominent leaders in the field Article text is supported by full color photos drawings tables and other visual material Fully indexed and cross referenced with detailed references for further study Writing level is suited to both the expert and non expert Available electronically on ScienceDirect shortly upon publication

Demographic Methods Across the Tree of Life Roberto Salguero-Gómez, Marlène Gamelon, 2021 This novel book provides the reader with the fundamentals of data collection model construction analyses and interpretation across a wide repertoire of demographic techniques and protocols clearly guided throughout with fully reproducible R scripts

*Encyclopedia of Theoretical Ecology* Alan Hastings, Louis J. Gross, 2012-05-31 A bold and successful attempt to illustrate the theoretical foundations of all of the subdisciplines of ecology including basic and applied and extending through biophysical population community and ecosystem ecology Encyclopedia of Theoretical Ecology is a compendium of clear and concise essays by the intellectual leaders across this vast breadth of knowledge Harold Mooney Stanford University A remarkable and indispensable reference work that also is flexible enough to provide essential readings for a wide variety of courses A masterful collection of authoritative papers that convey the rich and fundamental nature of modern theoretical ecology Simon A Levin Princeton University Theoretical ecologists exercise their imaginations to make sense of the astounding complexity of both real and



possible ecosystems Imagining a real or possible topic left out of the Encyclopedia of Theoretical Ecology has proven just as challenging This comprehensive compendium demonstrates that theoretical ecology has become a mature science and the volume will serve as the foundation for future creativity in this area Fred Adler University of Utah The editors have assembled an outstanding group of contributors who are a great match for their topics Sometimes the author is a key authoritative figure in a field and at other times the author has enough distance to convey all sides of a subject The next time you need to introduce ecology students to a theoretical topic you ll be glad to have this encyclopedia on your bookshelf Stephen Ellner Cornell University Everything you wanted to know about theoretical ecology and much that you didn t know you needed to know but will now Alan Hastings and Louis Gross have done us a great service by bringing together in very accessible form a huge amount of information about a broad complicated and expanding field Daniel Simberloff University of Tennessee Knoxville

*ICES Zooplankton Methodology Manual* Roger Harris, Peter Wiebe, Jurgen Lenz, Hein-Rune Skjoldal, Mark Huntley, 2000-02-14 The term zooplankton describes the community of floating often microscopic animals that inhabit aquatic environments Being near the base of the food chain they serve as food for larger animals such as fish The ICES International Council for the Exploration of the Sea Zooplankton Methodology Manual provides comprehensive coverage of modern techniques in zooplankton ecology written by a group of international experts Chapters include sampling acoustic and optical methods estimation of feeding growth reproduction and metabolism and up to date treatment of population genetics and modeling This book will be a key reference work for marine scientists throughout the world Sampling and experimental design Collecting zooplankton Techniques for assessing biomass and abundance Protozooplankton enumeration and biomass estimation New optical and acoustic techniques for estimating zooplankton biomass and abundance Methods for measuring zooplankton feeding growth reproduction and metabolism Population genetic analysis of zooplankton Modelling zooplankton dynamics This unique and comprehensive reference work will be essential reading for marine and freshwater research scientists and graduates entering the field

Basins of Attraction in Stage Structured Populations Georgia Waite Pfeiffer, 2011

**Topics in Functional Differential and Difference Equations** Teresa Faria, Pedro Freitas, 2001 This volume contains papers written by participants at the Conference on Functional Differential and Difference Equations held at the Instituto Superior Tcnico in Lisbon Portugal The conference brought together mathematicians working in a wide range of topics including qualitative properties of solutions bifurcation and stability theory oscillatory behavior control theory and feedback systems biological models state dependent delay equations Lyapunov methods etc Articles are written by leading experts in the field A comprehensive overview is given of these active areas of current research The book will be of interest to both theoretical and applied mathematical scientists

**Integrated Population Models** Michael Schaub, Marc Kéry, 2021-11-12 Integrated Population Models Theory and Ecological Applications with R and JAGS is the first book on integrated population models which constitute a powerful framework for

combining multiple data sets from the population and the individual levels to estimate demographic parameters and population size and trends These models identify drivers of population dynamics and forecast the composition and trajectory of a population Written by two population ecologists with expertise on integrated population modeling this book provides a comprehensive synthesis of the relevant theory of integrated population models with an extensive overview of practical applications using Bayesian methods by means of case studies The book contains fully documented complete code for fitting all models in the free software R and JAGS It also includes all required code for pre and post model fitting analysis Integrated Population Models is an invaluable reference for researchers and practitioners involved in population analysis and for graduate level students in ecology conservation biology wildlife management and related fields The text is ideal for self study and advanced graduate level courses Offers practical and accessible ecological applications of IPMs integrated population models Provides full documentation of analyzed code in the Bayesian framework Written and structured for an easy approach to the subject especially for non statisticians

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