

Chapter 2

Dynamics of Biological Invasions

Abstract We provide an overview of mathematical tools and approaches for modeling the population dynamics of invasive species. We begin with a brief qualitative analysis of biological invasion to show how it can be split into different stages, each stage having its own determinants in terms of invasive species management. We then introduce the modeling framework that will be used in the rest of the book. A detailed description of relevant nonspatial population models is followed by a discussion of the spatial dynamics. We will show that a variety of mathematical techniques may be used to describe different aspects of invasion dynamics at different invasion stages.

2.1 Stages of Invasion

In the previous chapter, we showed that biological invasion is a complex phenomenon that can be driven by a variety of different mechanisms and can follow different scenarios. Biological invasion has a number of clearly distinguishable stages; see Table 2.1. Generally speaking, the biological processes involved at each stage of the invasion are different from those involved at the other stages; each stage has its own issues to address in terms of the management and control of the invading species [3,36]. For instance, at the establishment stage, adaptation and phenotypic evolution can be important, but they are unlikely to be important at the stage of introduction. Environmental heterogeneity can greatly affect the rate and pattern of invasive spread, but it will have less effect on establishment.

Biological invasion obviously starts with introduction. Indeed, nothing can possibly happen until an alien species is brought in. A comment on terminology seems to be necessary here. By *introduction* we mean the transport of a given species¹ to a new geographical location that would be inaccessible for this species because of natural reasons. Therefore, introduction is usually a result of human activity rather than of the action of natural mechanisms.

¹More precisely, of a number of individuals of a given species that are able to reproduce.

Dynamics Of Biological Invasions

**Odd Terje Sandlund, Peter Johan
Schei, Åslaug Viken**



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Dynamics of Biological Invasions Rob Hengeveld, 1989-06-30 This study of biological invasions introduces dynamic concepts into biogeography and spatial concepts into ecology By using mathematical models from epidemiology and human geography generalizations can be made and it is shown that apparently static species ranges contain dynamic internal parameters

Invasion Dynamics Cang Hui, David M. Richardson, 2017 An advanced textbook adopting a theoretical modeling approach to review and discuss the current range and distributions of alien species their rates of spread and their impact in human dominated ecosystems

Invasion Dynamics Cang Hui, David M. Richardson, 2017 *Invasion Dynamics* depicts how non native species spread and perform in their novel ranges and how recipient socio ecological systems are reshaped and how they respond to the new incursions It collects evidence for grouping patterns of spread into four types and three associated phenomena discusses candidate explanations for each pattern and introduces analytic tools for capturing and forecasting invasion dynamics Special attention is given to the potential mechanisms of boosted range expansion and nonequilibrium demographic dynamics during invasion The diverse mechanisms that drive direct and mediated biotic interactions between invaders and resident species are elucidated and triggers of potential regime shifts in recipient ecosystems are identified It further explores the ways in which local and regional species assemblages are reshuffled and reorganized Efficient management of invasions requires not only insights on invasion dynamics across scales but also objective assessment of ecological and economic impacts as well as sound protocols for prioritizing and optimizing management effort Biological invasions therefore involve more than the actions of invaders and reactions of invaded ecosystems they represent a co evolving complex adaptive system with emergent features of network complexity and invasibility Invasions are thus a formidable force that acts in concert with other facets of global change to initiate the adaptive wheel of panarchy and shape the altered biosphere in the Anthropocene Provided by publisher

The Mathematics Behind Biological Invasions Mark A. Lewis, Sergei V. Petrovskii, Jonathan R. Potts, 2016-05-05 This book investigates the mathematical analysis of biological invasions Unlike purely qualitative treatments of ecology it draws on mathematical theory and methods equipping the reader with sharp tools and rigorous methodology Subjects include invasion dynamics species interactions population spread long distance dispersal stochastic effects risk analysis and optimal responses to invaders While based on the theory of dynamical systems including partial differential equations and integrodifference equations the book also draws on information theory machine learning Monte Carlo methods optimal control statistics and stochastic processes Applications to real biological invasions are included throughout Ultimately the book imparts a powerful principle that by bringing ecology and mathematics together researchers can uncover new understanding of and effective response strategies to biological invasions It is suitable for graduate students and established researchers in mathematical ecology

Evolution Dynamics of Biological Systems with Spatial and Temporal Heterogeneities Yu Jin, 2008 Spatial-dynamics,

Micro-behavior, and Control of Biological Invasions, 2009 Bioinvasions spread in time and space causing ecological and economic damages Optimal management of invasions therefore requires deciding when where and how much to control in order to minimize the invasion s total costs and damages However most invasions occur in landscapes that are divided among multiple managers so control levels are determined by private decisions In this dissertation we develop integrated spatially explicit models of invasion spread and human behavior and employ interviews and surveys of land managers to address the questions of how biological invasions should be managed under an optimal framework how they are managed by private control decisions and how the divergence between these two outcomes can be reduced We find a range of interesting spatial dynamic optimal control strategies including the use of borders and landscape heterogeneities to slow invasions and interdependencies of control across invasion patches in the landscape Our findings extend previous understanding of controlling spatial dynamic processes by showing the importance of landscape geometry and of spatial characteristics of the initial invasion for control Results of our integrated behavioral spread models show how bioeconomic and social factors affect private incentives for control and the magnitude of invasion externalities For example greater subdivision of the landscape and larger potential invasion ranges both tend to increase the divergence between private and optimal control levels Our interview results show that negotiation and coordination are important parts of invasion management as managers want to prevent or delay the arrival of invasions onto their properties We examine types of bargaining that can arise in spatial dynamic systems when incomplete place based property rights exist We find that greater coordination can decrease the magnitude and occurrence of potential invasion externalities Furthermore smaller amounts of cooperation are needed to control invasions whose costs and damages otherwise lead to the largest externalities This research is the first to examine the spatial dynamics of biological invasions in complex social landscapes where invasion control is driven by the private incentives of numerous interacting agents We illustrate the importance of accounting for spatial dynamic processes and human behavior in understanding observed environmental patterns predicting management outcomes and determining optimal resource management

Invasion Ecology Julie L. Lockwood, Martha F. Hoopes, Michael P. Marchetti, 2013-04-05 This new edition of *Invasion Ecology* provides a comprehensive and updated introduction to all aspects of biological invasion by non native species Highlighting important research findings associated with each stage of invasion the book provides an overview of the invasion process from transportation patterns and causes of establishment success to ecological impacts invader management and post invasion evolution The authors have produced new chapters on predicting and preventing invasion managing and eradicating invasive species and invasion dynamics in a changing climate Modern global trade and travel have led to unprecedented movement of non native species by humans with unforeseen interesting and occasionally devastating consequences Increasing recognition of the problems associated with invasion has led to a rapid growth in research into the dynamics of non native species and their adverse effects on native biota and human economies This book

provides a synthesis of this fast growing field of research and is an essential text for undergraduate and graduate students in ecology and conservation management Additional resources are available at <http://www.wiley.com/go/invasioneecology>

Antibiotics and Antimicrobial Resistance Genes in the Environment Muhammad Zaffar Hashmi, 2019-11-22

Antibiotics and Antimicrobial Resistance Genes AMR in the Environment summarizes and updates information on antibiotic producing organisms and their resistance and entry routes in soil air water and sediment As antibiotic use continues to rise in healthcare their fate bioavailability and biomonitoring and impacts on environment and public health are becoming increasingly important The book addresses the impact of antibiotics and AMR to environment and public health and risk assessment Moreover it focused on the metagenomics and molecular techniques for the detection of antibiotics and antimicrobial genes Lastly it introduces management strategies such as treatment technologies for managing antibiotics and AMR ARGs impacted environment and bioremediation approaches Summarizes and updates information on antibiotics and AMR ARGs production and its fate and transport in the environment Includes phytoremediation and bioremediation technologies for environmental management Provides analysis of risk assessment of antibiotic resistance genes to help understand the environmental and socioeconomic impacts of antibiotics and AMR ARGs *Écoscience*, 2005 **Handbook**

of the Birds of the World Josep del Hoyo, Andrew Elliott, Jordi Sargatal, 1992 Cuckoo shrikes to Thrushes Pr logo sobre ecologia e impacto de aves no aut ctonas M s de 6000 referencias bibliogr ficas **Fundamentals of Tropical Freshwater**

Wetlands Tatenda Dalu, Ryan J. Wasserman, 2021-11-25 Fundamentals of Tropical Freshwater Wetlands From Ecology to Conservation Management is a practical guide and important tool for practitioners and educators interested in the ecology conservation and management of wetlands in tropical subtropical regions The book is written in such a way that in addition to scientists and managers it is accessible to non specialist readers Organized into three themed sections and twenty three chapters this volume covers a variety of topics exposing the reader to a full range of scientific conservation and management issues Each chapter has been written by specialists in the topic being presented The book recognizes that wetland conservation science and management are interlinked disciplines and so it attempts to combine several perspectives to highlight the interdependence between the various professions that deal with issues in these environments Within each chapter extensive cross referencing is included so as to help the reader link related aspects of the issues being discussed Contributed to by global experts in the field of tropical wetlands Includes case studies and worked examples enabling the reader to recreate the work already done Focuses on tropical systems not available in any other book **Movers and**

Shakers Kelly J. MacDonald, 2022 Human mediated introductions of non native species have provoked innumerable biological invasions which can have a suite of adverse effects on the communities into which they are introduced Despite extensive research there remains a need in invasion ecology for simple methods of predicting how an introduced species will spread and become established While I predicted that spread can be modelled simply using the characteristics of the

invading population establishment should be explained by the characteristics of the receiving ecosystem Using the brown trout *Salmo trutta* invasion on the Island of Newfoundland as a case study I fit a reaction diffusion model to brown trout population data to predict expected spread and test these predictions against extensive occurrence data I use statistical models to test the influence of a suite of environmental variables on the establishment of brown trout within the invasion range I find that observed spread in Newfoundland is slow compared to invasions elsewhere and that two landscape environmental variables show evidence of explaining establishment patterns but their influence is likely moderated by other factors My study contextualises the mechanisms contributing to slow aquatic invasions revealing that studies need to integrate a variety of methods to elucidate the processes governing biological invasions The American Naturalist ,2009

Proceedings of the National Academy of Sciences of the United States of America National Academy of Sciences (U.S.),2001 *Dynamics of Continuous, Discrete & Impulsive Systems* ,2005 *Invasive Species and Biodiversity Management* Odd Terje Sandlund, Peter Johan Schei, Åslaug Viken,1999 The invasive species problem will become increasingly important in the years to come Trade travel and tourism are rapidly globalized and border controls are reduced This affects natural ecosystems in which aggressive invaders may have disastrous effects New diseases affect human animal and crop health The Convention on Biological Diversity presents national authorities with a tall order in coping with this problem For the first time in one volume this book presents both ecological biological and epidemiological aspects of invasive species as well as the problem of disease organisms for agriculture and human health The book constitutes a comprehensive background to the global strategy for managing invasive alien species which now is being developed by SCOPE and UNEP

Proceedings ,2005 **Proceedings** New Zealand Geographical Society. Conference,1999 *Predicting Invasion Patterns of Nonindigenous Aquatic Species* Lucy Ann Jane Buchan,1997 **Journal of Physical Science** ,2005

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