Preface

Complex population dynamics such as limit cycles and chaos are intrinsically fascinating. Why do organisms become extremely abundant one year, and then apparently disappear a few years later? Why do population outbreaks in certain species in certain locations happen more or less regularly, while in other locations such eruptions are irregular, or never occur at all? One would not find a general and definitive answer to these questions in any of the standard ecology textbooks. Partly this is because population ecologists do not, as yet, have a definitive, as well as empirically tested, general theory of complex population dynamics. On the other hand, much progress toward such a theory has been made. One goal of *Complex Population Dynamics* is to review these developments, and proffer tentative answers to the question of why populations oscillate in at least some of the best-studied examples.

But there is a deeper reason for studying population oscillations. Could these complex dynamics have simple causes, at least in some cases? If we are successful in answering this question, then we shall surely gain a better understanding of population dynamics in general. Physicists were able to formulate general laws of physical motion by studying periodic orbits of planets. Perhaps ecologists will be able to formulate general laws of population dynamics by studying periodic oscillations in population density. I think this is actually the case; in fact, on closer examination, it turns out that there is a lot in common between the two disciplines—classical (Newtonian) mechanics and population dynamics. If so, then population ecology may be on the brink of maturity, rapidly becoming a quantitative and predictive science. Constructing and defending this argument is the second broad theme of the book.

The third and final theme is methodological. Population dynamics have been studied in a variety of ways: mathematical models, statistical analyses of time-series data, and field experiments. The paradigmatic approach of how one "does ecology" is the manipulative experiment. Yet, the actual experience of solving the puzzle of population cycles suggests that experiments in isolation do not result in serious progress. Significant progress in understanding population mechanisms occurs only when we combine the three major approaches in a synthetic whole.

Although this book is about a synthesis of mathematical models and empirical ecology, I am assuming very little mathematical background on the part of readers. Essentially, readers need to know what a derivative is, and have some experience with differential and difference equations. There is little explicit algebraic manipulation in the text, and what there is focuses almost completely on model development. This does not mean that this is an elementary text, however. There is too much ground to cover, and therefore I assume that readers are conversant with basic ecological concepts such as functional responses, Allee effects, and general types of species interactions. (I do, however, provide definitions of these concepts in the glossary.)

Complex Population Dynamics can serve two functions. First, it is intended for the audience of working scientists: graduate students and researchers in ecology. It is to their judgment that I submit my view of how the synthesis in population dynamics is shaping up. I hope that they will find the developments I review in the book as I exciting as I find them, and will join in the endeavor of making the "grand synthesis" a reality.

Second, it can be used as a textbook for a course in population dynamics or population ecology. True, the main focus is on population oscillations, but on the way to complex dynamical behaviors the book covers the basics of simple dynamics. And, I argue, the study of complex dynamics advances us substantially along the road of figuring out general principles of population ecology.

Finally, I need to say what this book is not about. First, and most important, I barely touch on the spatial aspects of population ecology. I wish I could review the recent exciting developments in complex spatiotemporal dynamics, but there is simply not enough space to do that in this volume. Second, although all general approaches discussed in the book are based on an explicit incorporation of stochasticity, my main focus is on *endogenous* mechanisms (those that involve population density feedbacks). Thus, dynamics in which populations largely respond to exogenous perturbations are relatively neglected. Again, the main reason is not because I think such dynamics are uninteresting or unimportant, but because I lack space to do full justice to this topic. Third, this is not a text on ecological theory. Although I extensively review certain classes of population models, I included only those parts of theory that are useful to me in studying population oscillations. And, as mentioned above, my main focus in the theoretical part is on model development. Thus, I devote little space to the discussion of how to solve the developed models. And, fourth, I limit the empirical case studies to the terrestrial field ones, because excellent summaries of fisheries (Quinn and Deriso 1999) and laboratory (Mueller and Joshi 2000) dynamics already exist.

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