Preface

This book was written for students taking their first undergraduate course in ecology. I have assumed that students in this one-semester course have some knowledge of basic chemistry and mathematics and have had a course in general biology, which included introductions to physiology, biological diversity, and evolution.

Organization of the Book

An evolutionary perspective forms the foundation of the entire textbook, as it is needed to support understanding of major concepts. The textbook begins with a brief introduction to the nature and history of the discipline of ecology, followed by section I, which includes two chapters on natural history—life on land and life in water and a chapter on population genetics and natural selection. Sections II through VI build a hierarchical perspective through the traditional subdisciplines of ecology: section II concerns adaptations to the environment; section III focuses on population ecology; section IV presents the ecology of interactions; section V summarizes community and ecosystem ecology; and finally, section VI discusses large-scale ecology and includes chapters on landscape, geographic, and global ecology. These topics were first introduced in section I within a natural history context. In summary, the book begins with the natural history of the planet, considers portions of the whole in the middle chapters, and ends with another perspective of the entire planet in the concluding chapter. The features of this textbook were carefully planned to enhance the students' comprehension of the broad discipline of ecology.

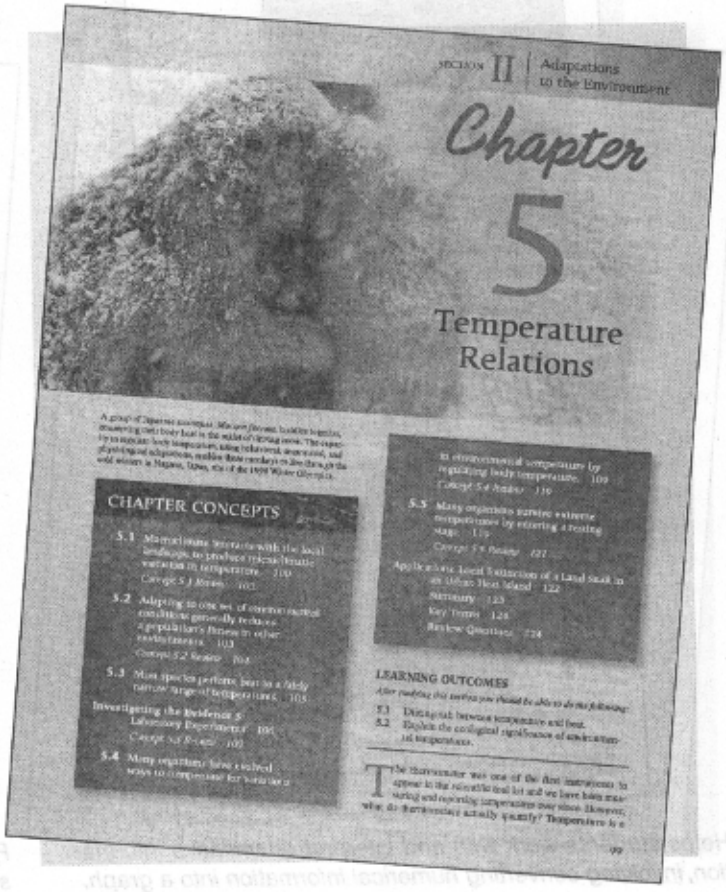
Features Designed with the Student in Mind

All chapters are based on a distinctive learning system, featuring the following key components:

Student Learning Outcomes: Educators are being asked increasingly to develop concrete student learning outcomes for courses across the curriculum. In response to this need and to help focus student progress through the content, all sections of each chapter in the seventh edition begin with a list of detailed student learning outcomes.

Introduction: The introduction to each chapter presents the student with the flavor of the subject and important background information. Some introductions include historical events related to the subject; others present an example of an ecological process. All attempt to engage students and draw them into the discussion that follows.

Concepts: The goal of this book is to build a foundation of ecological knowledge around key concepts. I have found that while beginning ecology students can absorb a few central concepts well, they can easily get lost in a sea of details. The key concepts are listed at the beginning of each chapter to alert the student to the major topics to follow and to provide a place where the student can find a list of the important points covered in each chapter. The sections in which concepts are discussed focus on published studies and, wherever possible, the scientists who did the research are introduced. This case-study approach supports the concepts with evidence, and introduces students to the methods and people that have created the discipline of ecology. Each concept discussion ends with a series of concept review questions to help students test their knowledge and to reinforce key points made in the discussion.



Illustrations: A great deal of effort has been put into the development of illustrations, both photographs and line art. The goal has been to create more effective pedagogical tools through skillful design and use of color, and to rearrange the traditional presentation of information in figures and captions. Much explanatory material is located within the illustrations, providing students with key information where they need it most. The approach also provides an ongoing tutorial on graph interpretation, a skill with which many introductory students need practice.

Detailed Explanations of Mathematics: The mathematical aspects of ecology commonly challenge many students taking their first ecology course. This text carefully explains all mathematical expressions that arise to help students overcome these challenges. In some cases, mathematical expressions are dissected in illustrations designed to complement their presentation in the associated narrative.

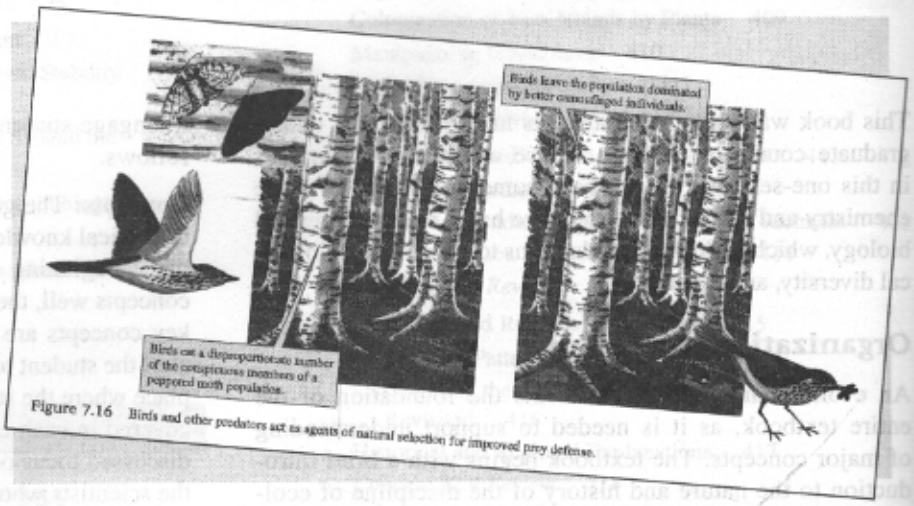


Figure 7.16 Birds and other predators act as agents of natural selection for improved prey defense.

Visualizing a process involving a predator and its prey.

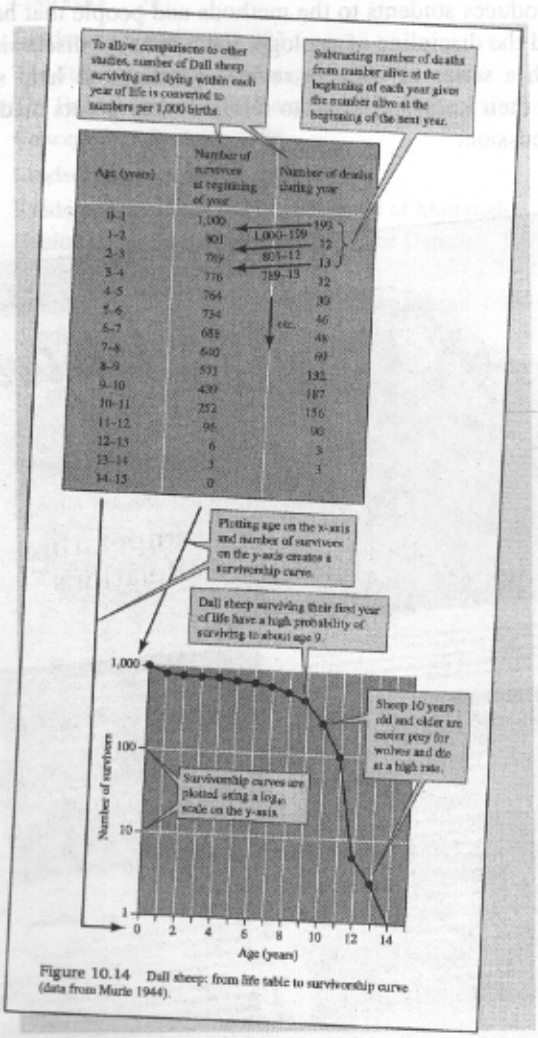


Figure 10.14 Dall sheep: from life table to survivorship curve (data from Murie 1944).

Helps students work with and interpret quantitative information, involving converting numerical information into a graph.

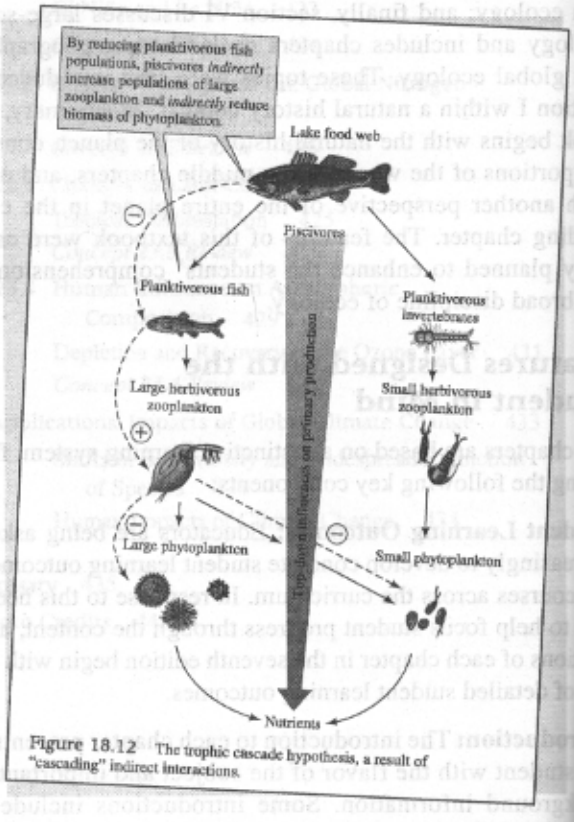


Figure 18.12 The trophic cascade hypothesis, a result of "cascading" indirect interactions.

Provides a visual representation of a hypothesis involving a set of complex ecological interactions.

"Investigating the Evidence" Boxes: These readings offer "mini-lessons" on the scientific method, emphasizing statistics and study design. They are intended to present a broad outline of the process of science, while also providing step-by-step explanations. The series of boxes begins in chapter 1 with an overview of the scientific method, which establishes a conceptual context for more specific material in the next 20 chapters. The last reading wraps up the series with a discussion of electronic literature searches. Each Evidence box ends with one or more questions, under the heading "Critiquing the Evidence." This feature is intended to stimulate critical thinking about the box content.

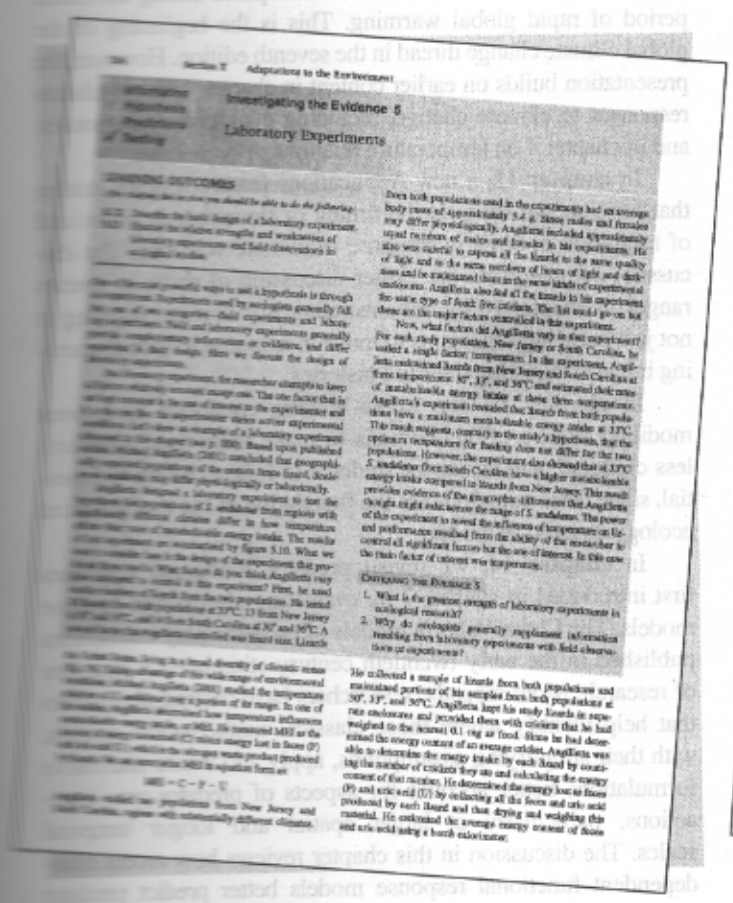
Applications: Many undergraduate students want to know how abstract ideas and general relationships can be applied to the ecological problems we face in the contemporary world. They are concerned with the practical side of ecology and want to know more about how the tools of science can be applied. Including a discussion of applications in each chapter motivates students to learn more of the underlying principles of ecology. In addition, it seems that environmental problems are now so numerous and so pressing that they have erased a once easy distinction between general and applied ecology.

End-of-Chapter Material:

- ***Summary*** The chapter summary reviews the main points of the content. The concepts around which each chapter is organized are boldfaced and redefined in the summary to reemphasize the main points of the chapter.
- ***Key Terms*** The listing of key terms provides page numbers for easy reference in each chapter.
- ***Review Questions*** The review questions are designed to help students think more deeply about each concept and to reflect on alternative views. They also provide a place to fill in any remaining gaps in the information presented and take students beyond the foundation established in the main body of the chapter.

End-of-Book Material:

- ***Appendixes*** One appendix, "Statistical Tables," is available to the student for reference. Answers to Concept Review questions and answers to Critiquing the Evidence are now available with the book's instructor resources.
- ***Glossary*** List of all key terms and their definitions.
- ***References*** References are an important part of any scientific work. However, many undergraduates are distracted by a large number of references within the text. One of the goals of a general ecology course should be to introduce these students to the primary literature without burying them in citations. The number of citations has been reduced to those necessary to support detailed discussions of particular research projects.
- ***Index***


Investigating the Evidence 5

Laboratory Experiments


Applications

Local Extinction of a Land Snail in an Urban Heat Island

New to the Seventh Edition

The seventh edition expands the pedagogy by beginning all sections of every chapter with a list of student learning outcomes—over 450 student learning outcomes in all. These outcomes are largely based on fundamental learning outcomes for material covered in the text:

1. Define key terms.
2. Explain the main concepts.
3. Evaluate the strength of research presented in support of main concepts, including a critique of study design.
4. Interpret statistical evidence bearing on concepts, expressed in graphical and numerical form.
5. Apply the main concepts to interpretation of new situations.

A content thread focused on global change has been developed and distributed across chapters, emphasizing global climate change. Students and instructors increasingly look for ways to connect the concepts and practice of ecological science to environmental issues arising from global climate change. The present edition explores how species are adjusting their distributions and their critical life history events as climate changes. The final chapter ends with a review of projected impacts of climate change on ecosystems and human populations, infrastructure, and economic systems.

This edition also builds on previous discussions of human disturbance of ecosystems to consider how damaged ecosystems can be restored. The extent and intensity of human impact on the biosphere grows with our population and expanding global economy. While climate change is the most prominent aspect of contemporary global change, other facets, such as damage or destruction of ecosystems, also call for solutions. As a result, there is greater need to restore damaged communities and ecosystems. In this context, the new edition adds an introduction to the practice of ecological restoration, focusing on how the process of restoring ecosystems can benefit from concepts developed in academic studies of community and ecosystem succession.

The relationship between biodiversity and ecosystem function is introduced through the positive influence of primary producer diversity on rates of primary production. Studies of biodiversity and ecosystem function are key elements in ecology's foundation. Connecting these elements helps create conceptual coherence across the discipline. A growing body of recent research does just that. Therefore, this edition includes a new section on the connection between biodiversity and ecosystem function.

The seventh edition introduces developments in trophic ecology that build on classical models of predator-prey interactions. The early to middle twentieth century was a golden age for theoretical ecology. However, those developments have not stopped. Contemporary ecologists continue to build on that legacy, improving our representation and understanding of ecological systems as they do so. The seventh edition updates the discussion of consumer functional response by introducing alternative models based on the ratio of prey to predator numbers rather than prey density per se. This discussion is coupled with reviews of experimental and field studies that support the ratio-dependent models.

The present edition connects ratio-dependent models of functional response to patterns of consumer abundance and secondary production in ecosystems. Previous editions have provided thorough coverage of the ecology of primary production in terrestrial and aquatic ecosystems, but secondary production has received much less attention. This seventh edition addresses this deficiency by including a section that covers the fundamentals of secondary production. The introduction to secondary production in this edition is presented in the context of consumer responses to variations in primary production.

New supplementary materials are placed online. Materials cut from the sixth edition and those previously cut from the fifth and fourth editions are available online. Suggested readings have been updated and placed online, along with answers to Concept Review and Critiquing the Evidence questions.

Significant Chapter-by-Chapter Changes

In **chapters 1 to 23,** numbered learning outcomes were added to all concept discussions and Evaluating the Evidence and Applications features. The average number of learning outcomes added to each chapter is 20.

In **chapter 10,** a new Applications feature explores evidence that plant and animal ranges have shifted northward to higher latitudes in the Northern Hemisphere during the period of rapid global warming. This is the beginning of the global climate change thread in the seventh edition. However, the presentation builds on earlier content in chapter 1 on physiological responses to climate change, including evolutionary responses, and in chapter 4 on temperature relations of organisms.

In **chapter 12,** a new Applications feature reviews studies that have shown shifts in the timing of flowering in plants and of migration in birds in response to climate warming. This discussion complements the earlier discussion of shifts in species ranges in chapter 10 by demonstrating that climate warming is not just inducing organisms to move in response to global warming but also adjusting their life histories.

In **chapter 13,** the Lotka-Volterra equations have been modified from previous editions to make them more consistent, less cluttered, and easier for students to follow, which is essential, since these equations are the foundation of the mathematical ecology covered in the text.

In **chapter 14,** we revisit predator functional response first introduced in chapter 7 by evaluating alternative models. The Lotka-Volterra models of predator-prey interactions published in the early twentieth century stimulated a century of research. More recently, researchers have offered models that help identify where those classical mathematical models, with their simplifying assumptions, apply and where alternative formulations better account for aspects of predator-prey interactions, particularly at larger spatial and longer temporal scales. The discussion in this chapter reviews how ratio-dependent functional response models better predict

functional responses in experimental and natural settings. The discussion helps to dispel the idea that mathematical ecology ceased to develop in the mid-twentieth century and reinforces the complementary roles of theoretical, experimental, and observational studies.

In **chapter 18,** a new concept connects primary producer diversity to higher levels of primary production. The chapter also includes a new concept featuring the relationship between levels of primary production and secondary production. This discussion provides a basis for introducing the fundamentals of secondary production. This addition also revisits the ratio-dependent functional responses introduced in chapter 14 by extending the implications of those models beyond predator functional response to the trophic structure of ecosystems. The treatment also formally introduces secondary production, filling a conceptual gap in previous editions.

In **chapter 20,** the fields of ecological restoration and restoration ecology are introduced for the first time. Human impact on the environment has altered ecological communities and ecosystems in nearly every corner of the planet. Restoring structure and function to these systems emerges as one of the great contemporary ecological challenges. Increasingly ecologists addressing this challenge are turning to the conceptual framework of ecological succession to guide their work. Examples of such work are included in this chapter to help bridge the historical divide between ecological theory and restoration practice.

In **chapter 23,** the discussion of the Antarctic ozone hole has been updated to 2013, including 35 years of data from NASA on the size of the ozone hole. The pattern shows that the maximum size of the Antarctic ozone hole has stabilized, signaling a basis for ozone recovery predicted by atmospheric scientists over the next 50 years, providing a bit of good planetary news. The growing body of climate change research, published since the earlier editions of *Ecology Concepts and Applications,* has greatly improved understanding of how earth's changing climate will impact ecosystems and human populations, if not stabilized. A discussion of these impacts concludes this edition, underscoring the relevance of ecological knowledge to sustaining natural as well as human-centered systems.