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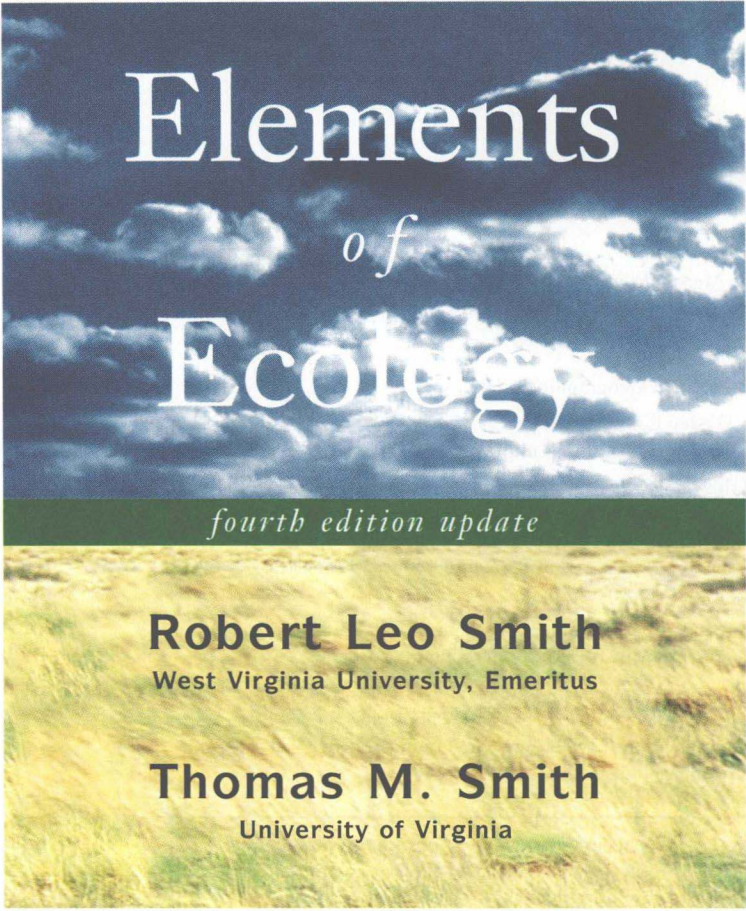
Elements — *of* — Ecology

FOURTH EDITION

ROBERT LEO SMITH

THOMAS M. SMITH

UPDATE



Elements *of* Ecology

fourth edition update

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For Ben and Nate

PREFACE

We believe that ecology should be a part of a liberal education. It is essential that students who major in such diverse fields as economics, sociology, engineering, political science, history, English, and the like have some basic understanding of ecology for the simple reason that it impinges on their lives. They cannot appreciate or arrive at informed opinions on such highly politicized environmental issues as clean air and water, wetland preservation, endangered species, logging, ozone depletion, global warming, flood control, and myriad of issues without a grounding in ecological concepts. *Elements of Ecology* not only presents the principles of ecology but shows their relationship to today's most pressing environmental issues in a way that is meaningful to students.

Fourth Edition Update

Elements of Ecology is a continually evolving textbook. As this textbook is used primarily in nonmajors courses, we realized that the material required a greater infusion of the human element. This updated edition incorporates new content and features that demonstrate the relevance of ecology and includes innovative new web solutions.

UPDATED FEATURES

New Ecological Application essays that appear at the end of each of the text's six parts demonstrate to students the real-world relevance of the ecological concepts they have learned. For instance, the application essay in Part V, "Ecosystems" discusses the ecological problems caused by the American obsession with green lawns.

Chapter 26, Global Environmental Change, has been significantly revised to include research on current issues and new and updated references.

New *Elements of Ecology* Companion Website features all the art as well as some photos from the text. This website also provides resources such as Ecology Web links, on-line quizzing, creation of individualized syllabi, threaded discussions groups, and on-line content. This website can be accessed from <http://www.awlonline.com/bc>.

New *Biology Labs* On-Line

At <http://biologylab.awlonline.com>, this on-line, interactive complement to a traditional lab lets students

conduct simulated experiments. Instructors can tailor the labs to individual courses and different levels of difficulty. Students can explore DemographyLab and EvolutionLab.

New *The Biology Place*[™] at www.biology.com is a web-based learning environment which includes interactive tutorials, investigative learning activities, lab simulations, and quizzes.

Fourth Edition Revisions

The changes in this edition mark a major departure from the organization and style of previous editions and from other ecological textbooks. Our goal in making this dramatic shift is to make ecology more accessible to nonmajors. For this reason we have employed a different pedagogical approach in Parts I through V by discussing a key concept in each section and introducing it with a conceptual statement. These sentence headings become the focal point of each section. The organization of the chapter summaries is now a hierarchy of related topics identified by brief headings. Such groupings enable students to see how the concepts in the chapter fit together.

We have retained the organization of Part VI, "A Guide to Ecosystems," specifically to emphasize in a descriptive way the structure and functions of the various ecosystems and the human effects on them.

We have tightened the text and shifted its emphasis to reflect our major objective of providing an accessible introduction to ecology for nonmajors. Three new opening chapters ground the reader in essentials: the scientific method in ecology; homeostasis and adaptation, which keep the organism in tune with its environment; and the key processes of photosynthesis, assimilation, and decomposition, which are the basis of all ecological processes.

The chapters on natural selection and speciation are at the end of Part III, "Populations," because nonmajors need some background on population forces in order to grasp the natural selection process.

We have incorporated human disturbances, environmental problems such as pollution, and other topics of applied ecology into their appropriate conceptual chapters, rather than treating the material in "afterthought" chapters, and have included a chap-

ter on a topic of particular concern: global climate change.

Because this is a nonmajors textbook, we have deliberately held to a minimum the amount of mathematics, chemistry, and physics. Of course, in ecology you cannot completely escape math and chemistry. Where they are essential to the topic, we have tried to explain them clearly. In a number of places we have placed this material in special boxes entitled **Quantifying Ecology**.

HALLMARK FEATURES

Special features of this edition make learning easy:

- **Unique modular format.** With complete concept statements at the beginning of each module, the text helps students focus on the core concepts by dividing chapter material into manageable amounts of information.
- **Dynamic four-color art** engages and maintains students' interest.
- **The text's clear descriptive approach** helps students appreciate and understand ecology without overwhelming them with excessive amounts of quantitative information.
- **Pedagogy** including chapter opening objectives, chapter summaries, study questions, bold face key terms, and an extensive glossary increases students' retention and understanding of key concepts.
- **"Focus on Ecology" boxes** contain real-world examples of ecological principles.
- **"Quantifying Ecology" boxes** clarify mathematical or quantitative aspects of ecology.

ILLUSTRATION PROGRAM

The fourth edition introduces four-color illustrations. Retained in black and white are the outstanding original pen-and-ink drawings of the late Ned Smith that date back to the first edition, as well as a number of pen-and-ink illustrations by Robert Leo Smith, Jr., that are most effective in their original format.

PRINT SUPPLEMENTS

A set of supplementary materials support the instructor:

- A combined Instructor's Manual by Robert Leo Smith and Test Bank by Edmund E. Bedecarrax and Eugene J. Fenster.

- Computerized Test Banks for Macintosh and Windows.
- A set of 72 four-color Transparency Acetates

MEDIA SUPPLEMENTS

Elements of Ecology Companion Website

<http://www.awlonline.com/bc>

A rich Web site that allows instructors to offer on-line quizzing, create syllabi, conduct threaded discussion groups, and administer on-line content. This website also provides on-line access to all the art and some of the photos in the text.

Biology Labs On-Line

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A web-based learning environment which includes interactive tutorials, investigative learning activities, lab simulations, and quizzing.

ORGANIZATION

We have divided this text into six related parts with numerous cross-references and an ever-broadening focus. Part I sets the stage. Chapter 1 explains what ecology is, how it relates to other sciences, and how ecologists use scientific methods. Chapter 2 introduces the concept of homeostasis and the intimate connection between organism and environment. Chapter 3 introduces the three processes basic to life: the fixation of carbon-based energy in photosynthesis and the use of that energy in assimilation and respiration. These chapters provide a conceptual framework for the chapters to come.

Part II begins with individual organisms. It explores how organisms interact with their physical environment. Chapters 4 through 10 each focus on a significant condition for life.

Part III turns to the biological environment—the other organisms with which an individual shares the environment and interacts. Chapter 11 introduces the population and its major properties—density, distribution, and age structure. Chapter 12 looks at the relationships among individuals reflected in various life history patterns, including mating and reproductive strategies. Much of this chapter falls into the category of behavioral ecology. Chapter 13 explores population growth, tying it to mortality, natality, and survivor-

ship. Regulation of population growth involves intraspecific competition, covered in Chapter 14. Introduced in this chapter are the concepts of density and growth in plants, dispersal, and social behavior. Organisms have to deal not only with individuals of their own species, but with other species as well. These relationships include interspecific competition, predation, parasitism, and mutualism, the topics of Chapter 15 through 17. The impact of humans on natural populations has a chapter of its own. Chapter 18 looks at exploitation, restoration, conservation, and pest control. It introduces the concepts of sustained yield and integrated pest management. Part II culminates in Chapter 19. It introduces natural selection, population genetics, and speciation, concepts crucial to the management of endangered species.

Part IV broadens the focus from the population to the community. A thin line separates population ecology from community ecology. Chapter 20 introduces the concept of community, its vertical structure and horizontal patterns, and the concepts of dominance and diversity. Chapter 21 explores the spatial and temporal dynamics of the community, with the emphasis on the concepts of edge, succession, and island biogeography. Basic processes that affect community structure and that drive community change are explored in Chapter 22.

Part V, broader still, explores ecosystem dynamics. Chapter 23 presents the concept of the ecosystem and primary and secondary production. How energy flows through the ecosystem is the topic of Chapter 24. It discusses trophic levels, food chains, and food webs. Chapter 25 explores major biogeochemical cycles and examines how humans have intruded upon them. A more detailed look at the carbon cycle and human intrusions upon it form the basis for Chapter 26, which deals with the looming problem of global climate change and associated environmental change.

Part VI covers the whole range of the Earth's ecosystems. These chapters provide examples of the physical structure of communities, nutrient cycling, energy flow, and human intrusions. They equip the student to enter many of the ecopolitical debates of today that will affect the ecosystems of tomorrow.

Terrestrial ecosystems are covered in Chapters 27 to 31. The Human Impact Sections in these chapters discuss the effects of overgrazing (Chapter 27), urbanization and increasing desertification (Chapter 28), mining, oil drilling, and timber exploitation (Chapter 29), timber harvest and fragmentation (Chapter 30), and deforestation (Chapter 31). Freshwater ecosystems occupy three chapters, Chapters 32 to 34. Spe-

cial topics of interest are the effects of pollution on lakes and ponds (Chapter 32), the value and demise of wetlands (Chapter 33), and the impact of dams and channelization on flowing water ecosystems (Chapter 34). The last three chapters, Chapters 35 to 37, explore the marine environment and the effects of development, habitat destruction, and oil and toxic pollution on marine ecosystems.

Acknowledgements

My son, Dr. Thomas M. Smith, Associate Professor, Environmental Science Department, University of Virginia, has joined this edition. He brings to this text global experience, fresh ideas, and a familiarity with the needs and problems of nonmajors students in an ecology course.

No textbook is a product of the authors alone. The material it covers represents the work of hundreds of ecological researchers who have spent their lifetimes in the field and the laboratory. Their published works on experimental results, observations, and conceptual thinking provide the raw material out of which a textbook is fashioned.

Revision of a textbook depends heavily on the input of users who point out inaccuracies and inconsistencies and suggest changes. We took these suggestions seriously and incorporated many of them. We are deeply grateful to the following reviewers for their helpful comments and suggestions: Edmund E. Bedecarrax, San Francisco City College; Mike Bell, Richland College; Leslie S. Bowker, California Polytechnic State University; Renee Brooks, University of South Florida; Donald Dahlsten, University of California at Berkeley; Gerald R. Dotson, Front Range Community College; Courtney Hackney, University of North Carolina at Wilmington; Ron Hofstetter, University of Miami; Norman Jensen, Milliken University; Michael Kutilek, San Jose State University; David V. McCalley, University of Northern Iowa; Larry Meisner, Concordia University; Bette H. Nybakken, Hartnell College; David Pimentel, Cornell University; Fred Smeins, Texas A & M University; Jack Stout, University of Central Florida; Robert A. Wright, West Texas A & M University; Richard Wunderlind, University of South Florida.

Of inestimable help in ferreting out errors and inconsistencies in a number of figures were John Walsh, Piedmont Community College; Robert Colwell, University of Connecticut; and Erica Corbett, Southeastern Oklahoma State University.

My first son, Robert Leo, Jr. rendered all the color graphics under considerable time pressure. His familiarity with the text, artistic ability, and skill at computer graphics allowed close collaboration and success.

At Benjamin Cummings/Addison Wesley Longman, Elizabeth Fogarty, Sponsoring Editor, sparked the idea of doing an update, and Project Editor Erika Buck kept it on track. The essays are a collaborative effort among Tom Smith, Todd Dennis, a postdoctoral student in Environmental Sciences, and Elizabeth Zayatz, who played the role of technical editor

for the essays and the global chapter, and also as teacher. She showed us how to write in a style that makes ecology relevant to a nonscience audience.

Through it all our wives, Alice and Nancy, had to endure the time demands imposed on the throes of book production. My wife Alice took care (and still does) of all the problems of living, while I devote full time, including evenings and weekends, working on this book. She has patiently endured book widowhood for years. Adding to time demands for Tom were the arrival of twins, Ben and Nate, to whom this edition is dedicated.

Robert Leo Smith, Sr.
Thomas M. Smith
December, 1999

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