



Environmental Science

Working with the Earth

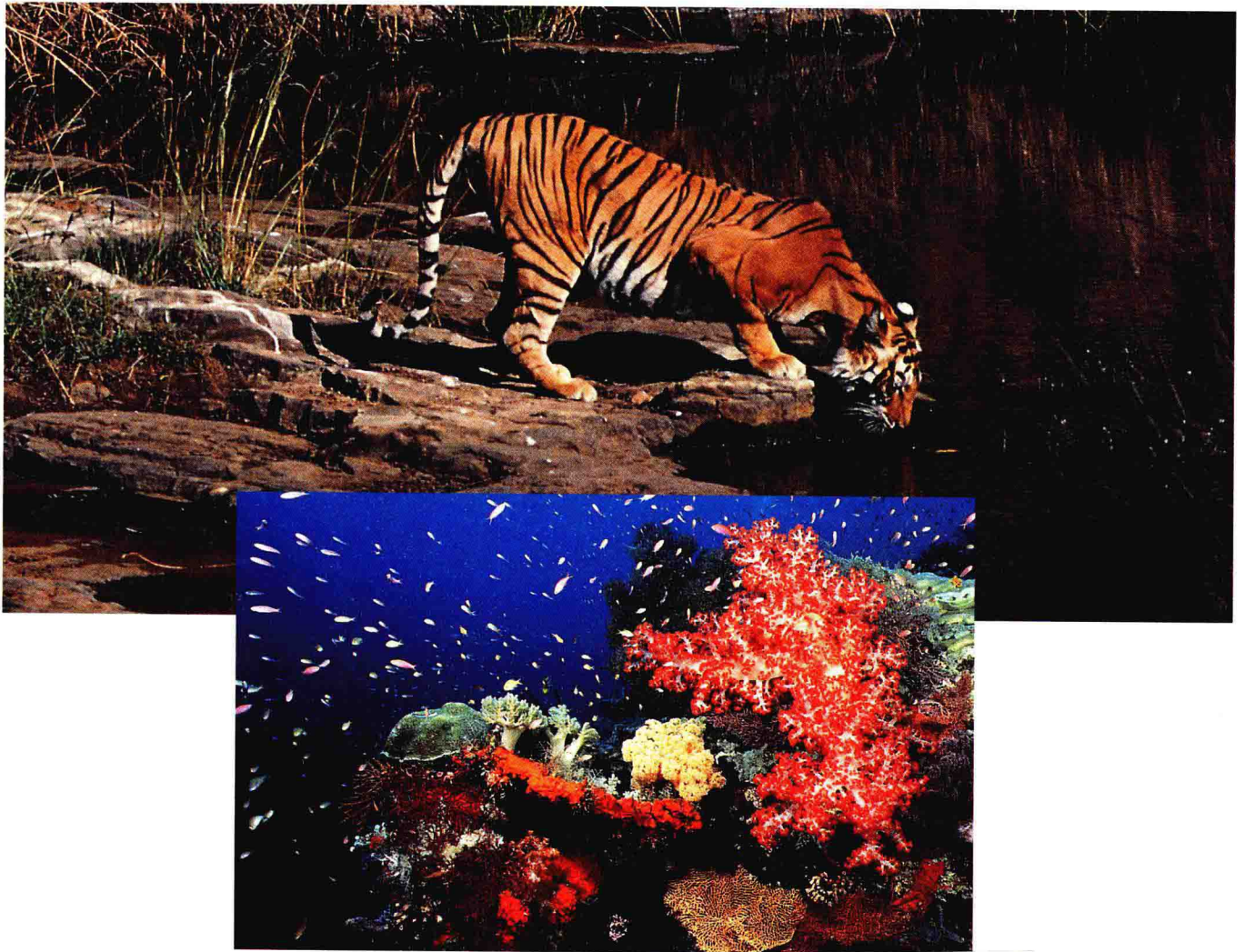
EIGHTH EDITION

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For Instructors and Students

How Did I Become Involved with Environmental Problems?

In 1966 I heard a scientist give a lecture on the problems of overpopulation and environmental abuse. Afterward I went to him and said, "If even a fraction of what you have said is true, I will feel ethically obligated to give up my research on the corrosion of metals and devote the rest of my life to research and education on environmental problems and solutions. Frankly, I don't want to believe a word you have said, and I'm going into the literature to try to prove that your statements are either untrue or grossly distorted."

After 6 months of study I was convinced of the seriousness of these problems. Since then, I have been studying, teaching, and writing about them. This book summarizes what I have learned in over three decades of trying to understand environmental principles, problems, connections, and solutions.

What Is My Philosophy of Education? In our lifelong pursuit of knowledge, I believe we should do three things. The first is to question everything and everybody, as any good scientist does.

Second, each of us should develop a list of principles, concepts, and rules to serve as guidelines in making decisions, and continually evaluate and modify this list on the basis of experience. This is based on my belief that the key goal of education is to learn how to sift through mountains of facts and ideas to find the few that are most useful and worth knowing. We need to be *wisdom seekers*, not information vessels. This requires a firm commitment to learning how to think logically and critically. This book is full of facts and numbers, but they are useful only to the extent that they lead to an understanding of key ideas, scientific laws, concepts, principles, and connections.

Third, I believe in interacting with what I read as a way to sharpen my critical thinking skills. I do this by marking key sentences and paragraphs with a highlighter or pen. I put an asterisk in the margin next to something I think is important and double asterisks next to something that I think is especially important. I write comments in the margins, such as *Beautiful*, *Confusing*, *Misleading*, or *Wrong*. I fold down the top corner of pages with highlighted passages and the top and bottom corners of especially important pages. This way, I can flip through a book and quickly review the

key passages. I urge you to interact in such ways with this book.

Why Is There a Need for More Scientific Content?

This book is designed for introductory courses on environmental science. It treats environmental science as an *interdisciplinary* study, combining ideas and information from *natural sciences* (such as biology, chemistry, and geology) and *social sciences* (such as economics, politics, and ethics) to present a general idea of how nature works and how things are interconnected. It is a study of *connections in nature*.

Since its first edition in 1975 this book has led the way in using scientific laws, principles, models, and concepts to help us (1) understand environmental and resource problems and possible solutions, and (2) how these concepts, problems, and solutions are connected. I have introduced only the concepts and principles necessary for understanding the material in the book, and I have tried to present them simply but accurately.

A number of people have criticized environmental science teachers and textbooks for (1) not having enough basic science content, (2) treating key environmental issues (such as global warming, ozone depletion, and biodiversity loss) superficially, (3) giving an unbalanced, biased view of environmental issues, and (4) focusing mostly on bad environmental news without giving the good environmental news.

I generally agree with these criticisms and believe that *there is a need to expand the fundamental scientific content of environmental science courses*. In each new edition of this book I have done this. This latest edition further expands the treatment of the scientific content by adding an additional chapter on basic ecology (see changes in this edition listed on p. v).

Since the first edition of this book I have also *emphasized in-depth treatment of key environmental issues*. Many instructors have written me thanking me for giving students an in-depth, balanced, up-to-date, and easy-to-understand analysis of major environmental problems such as global warming and ozone depletion (Chapter 11) and loss of biodiversity (a major integrating theme of this book).

To help ensure that the material is accurate and up to date, I have consulted more than 10,000 research sources in the professional literature and about the

same number of Internet sites. I have also benefited from the more than 200 experts and teachers (see list on pp. vii–viii) who have provided detailed reviews of this and my other three books in this field.

How Have I Attempted to Eliminate Bias?

There are at least two sides to all controversial issues. The challenge for an author is to give a fair and balanced view of opposing viewpoints without injecting personal bias. This allows students to make up their own minds about important issues. Studying a subject as important as environmental science and ending up with no conclusions, opinions, and beliefs means that both the teacher and student have failed. But such conclusions should be based on using critical thinking to evaluate opposing ideas.

In this edition I continue to scour every sentence for possible bias. A few examples of my efforts to give a balanced presentation of opposing viewpoints are (1) the pros and cons of reducing birth rates (pp. 213–15), (2) the Pro/Con boxes on genetic engineering (pp. 196–97), and Genetically Modified Food, (pp. 396–97), (3) Section 11-3 on global warming, (4) Section 11-6 on ozone depletion, (5) discussion of acid deposition (pp. 242–46), (6) the asbestos problem (pp. 248–49), (7) problems with the Superfund law (pp. 379), and (8) pros and cons of pesticides (Sections 16-2 and 16-3).

Bias is subtle, however, and there is still room for improvement. I invite instructors and students to write me and point out any remaining bias.

How Do I Deal with the Bad News/Good News Dilemma?

Critics have charged environmentalists with wallowing in doom and gloom and not reporting or rejoicing in the many improvements in environmental quality that have taken place over the past several decades. I generally agree with this criticism and in this book I emphasize the good environmental news along with the bad environmental news in Chapter 1 (Table 1-1, pp. 24-5) and throughout the book.

Rosy optimism and gloom-and-doom pessimism are traps that usually lead to denial, indifference, and inaction. I have tried to avoid these two extremes and give a realistic yet hopeful view of the future. This book is filled with technological and scientific advances that have led to environmental improvements (for example, see the Individuals Matter boxes on pp. 281, 311, 351, 532, and 541) and the openings to Chapters 15 and 20. It also has stories of people who have acted to help sustain the earth's life-support systems for us and for all life (for example, see the Individuals Matter boxes on pp. 43, 177, 306, 446, 447, and 452, the openings to Chapters 3 and 17, and the Guest Essay on p. 406). It's an exciting and challenging time to be alive as we struggle to enter into a new, more cooperative relationship with the planet that is our only home.

What Are Some Key Features of This Book?

This book is *concept oriented* and *solutions oriented*. The book is divided into five major parts (see Brief Contents, p. x). After Chapter 1 and the scientific principles and concepts in Part II have been covered, the rest of the book can be used in almost any order. In addition, most chapters and many sections within these chapters can be moved around or omitted to accommodate courses with different lengths and emphases. I also present a range of solutions to environmental problems proposed by a variety of analysts.

Since its first edition this book has consistently used simple systems analysis to categorize proposed solutions to environmental problems as either (1) *input* (prevention) solutions such as pollution prevention and waste reduction or (2) *output* (cleanup) solutions such as pollution control and waste management. Both approaches are needed, but so far most emphasis has been on output or management solutions. There is a growing awareness of the need to put more emphasis on input or prevention approaches—another major theme of this book.

Each chapter begins with a brief *Earth Story*, a case study designed to capture interest and set the stage for the material that follows. In addition to these 20 case studies, 53 other case studies are found throughout the book (some in special boxes and others within the text); they provide a more in-depth look at specific environmental problems and their possible solutions. Thirteen *Guest Essays* present an individual researcher's or activist's point of view, which is then evaluated through Critical Thinking questions.

Other special boxes found in the text include (1) *Pro/Con boxes* that present both sides of controversial environmental issues, (2) *Connections boxes* that show connections in nature and among environmental concepts, problems, and solutions, (3) *Solutions boxes* that summarize a variety of solutions (some of them controversial) to environmental problems proposed by various analysts, (4) *Spotlight boxes* that highlight and give insights into key environmental problems and concepts, and (5) *Individuals Matter boxes* that describe what people have done to help solve environmental problems. To encourage critical thinking and integrate it throughout the book, all boxes (except Individuals Matter) end with Critical Thinking questions.

This book is an integrated study of environmental problems, connections, and solutions. The eight integrating themes in this book are (1) *biodiversity and natural capital*, (2) *sustainability*, (3) *connections in nature*, (4) *pollution prevention and waste reduction*, (5) *population and exponential growth*, (6) *energy and energy efficiency*, (7) *solutions to environmental problems*, and (8) *the importance of individual action*.

I hope you will start by looking at the brief table of contents (p. x) to get an overview of this book. Then I

suggest that you look at the Concepts and Connections diagram inside the back cover, which shows the major components and relationships found in environmental science. In effect, it is a map of the book.

The book's 422 illustrations are designed to present complex ideas in understandable ways and to relate learning to the real world. They include 322 full-color diagrams (48 of them new to this edition, and 40 of them maps) and 100 carefully selected color photographs.

I have not cited specific sources of information. This is rarely done for an introductory-level text in any field and it would interrupt the flow of the material. Instead, the readings listed at the end of the book for each chapter provide backup for almost all the information in this book and serve as springboards to further information and ideas. This edition also has a greatly expanded and improved interactive World Wide Web site (www.brookscole.com/biology) that can be used as a source of further information and ideas.

Students and teachers also have access to InfoTrac, a fully searchable online database with access to complete environmental articles from over 700 periodicals. I have put two practice exercises at the bottom of two pages in each chapter to help users learn how to navigate this valuable source of information.

Instructors wanting a longer or a shorter book covering this material with a different emphasis and organization can use one of my two other books written for various types of environmental science courses: *Living in the Environment*, 11th edition (815 pages, Brooks/Cole, 2000) or *Sustaining the Earth: An Integrated Approach*, 4th edition (356 pages, Brooks/Cole, 2000, a shorter book with a different integrated approach).

What Are the Major Changes in the Eighth Edition? Major changes include the following:

- Updated and revised material throughout the book.
- Increased coverage of basic ecological concepts. The number of chapters on ecological principles has been increased from three to four and the order of topics in some of these chapters has been changed to improve scientific content and flow.
- Greatly increased *scientific content*, with the addition or expansion of material on principles of ecological sustainability, overloading of the nitrogen cycle, island biogeography, population ecology, ecological restoration, infectious disease, survival ability of cockroaches, and conservation biology.
- Addition or expansion of many topics, including the information revolution, green taxes, failure of Biosphere 2, food supply and demand, sustainable fishery management, possible signs of global warming, organic farming and global warming, solar village in Columbia (Gaviotas), the spread of genetic

resistance of bacteria to antibiotics, controversy over reducing air pollution emissions of ultrafine particles, using honeybees to detect toxic pollutants, our ecological footprints, the termite from hell, genetically modified food, and solutions to the excessive snow goose population.

- Consolidation of environmental economics, politics, and ethics into one chapter (Chapter 2) instead of two chapters.
- Addition of 40 new figures and 8 new photos.
- Addition of comprehensive Review Questions at the end of each chapter.
- Revision and updating of *EnviroLink*, an instructor presentation tool.
- *WebTutor in Web CT*, an online study tool.
- *Online Regional Articles* (www.upcloser.com).
- *Thomson Learning Course software*.
- *CNN Videos for Environmental Science*.
- Booklet on *Essential Study Skills for Science Students*.
- Revision and updating of the *Instructor's Manual and Test Items* booklet.

Welcome to Controversy and Challenge Despite considerable research, we still know little about how nature works at a time when we are altering nature at an accelerating pace. This uncertainty, as well as the complexity and importance of these issues to current and future generations of humans and other species, makes many of these issues highly controversial.

Another source of disagreement is that science advances through controversy and careful scrutiny about its results until there is a general consensus about their validity. What is important is not what the experts disagree on (the frontiers of scientific knowledge that are still being developed, tested, and argued about), but what they generally agree on—the *scientific consensus*—about concepts, problems, and possible solutions.


Controversy also arises because environmental science is an interdisciplinary blend of natural and social sciences that sometimes questions the ways we view and act in the world around us.

Study Aids Each chapter begins with a few general questions to reveal how it is organized and what students will be learning. When a new term is introduced and defined, it is printed in boldface type. A glossary of all key terms is located at the end of the book.

Each chapter and box (except Individuals Matter boxes) ends with (1) a set of Review Questions covering all of the material in the chapter as a study guide for students and (2) a set of questions to encourage students to think critically and apply what they have learned to

their lives. The Critical Thinking questions are followed by several projects that individuals or groups can carry out. Many additional projects are given in the *Instructor's Manual* available with this book.

Readers who become especially interested in a particular topic can consult the further readings for each chapter, given in the back of the book. Appendix 1 contains a list of important publications and some key environmental organizations and government and international agencies.

Students can also access World Wide Web for material in the book marked with the icon . Access to the Brooks/Cole Biology Resource Center is at www.brookscole.com/biology. Users can click on a chapter in the Hypercontents listed and find resources that couldn't be listed in the book. These resources are updated constantly. In the Web site for this text, you will also find Cool Events, Critical Thinking Questions, Tips on Surfing, Interactive Quizzes for each chapter, and much more. Happy surfing.

Help Me Improve This Book Let me know how you think this book can be improved; if you find any errors, bias, or confusing explanations please send them to Jack Carey, Biology Publisher, Brooks/Cole Publishing Company, 10 Davis Drive, Belmont, CA 94002. He will forward them to me. Most errors can be corrected in subsequent printings of this edition, rather than waiting for a new edition.

Annenberg/CPB Television Course This textbook is being offered as part of the Annenberg/CPB Project television series *Race to Save the Planet*, a 10-part public broadcasting series and a college-level telecourse examining the major environmental questions facing the world today. The series takes into account the wide spectrum of opinion about what constitutes an environmental problem and discusses the controversies about appropriate remedial measures. It analyzes problems and emphasizes the successful search for solutions. The course develops a number of key themes that cut across a broad range of environmental issues, including sustainability, the interconnections of the economy and the ecosystem, short-term versus long-term gains, and the

trade-offs involved in balancing problems and solutions. A study guide and a faculty guide, both available from Brooks/Cole Publishing Company, integrate the telecourse and this text.

For further information about available television course licenses and duplication licenses, contact PBS Adult Learning Service, 1320 Braddock Place, Alexandria, VA 22314-1698 (1-800-ALS-AL5-8).

For information about purchasing videocassettes and print material, contact the Annenberg/CPB Collection, P.O. Box 2284, South Burlington, VT 05407-2284 (1-800-LEARNER).

Acknowledgments I wish to thank the many students and teachers who responded so favorably to the 7 previous editions of *Environmental Science*, the 11 editions of *Living in the Environment*, and the 4 editions of *Sustaining the Earth* and who corrected errors and offered many helpful suggestions for improvement. I am also deeply indebted to the reviewers, who pointed out errors and suggested many important improvements in this book. Any errors and deficiencies left are mine.

The members of the talented production team, listed on the copyright page, have made vital contributions as well. My thanks also go to (1) copyeditor Carol Anne Peschke, (2) production editors Brooks Ellis and Tessa Avila, (3) Brooks/Cole's hard-working sales staff, and (4) Kristin Milotich and Daniel Lombardino for their help and efficiency.

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G. Tyler Miller, Jr.

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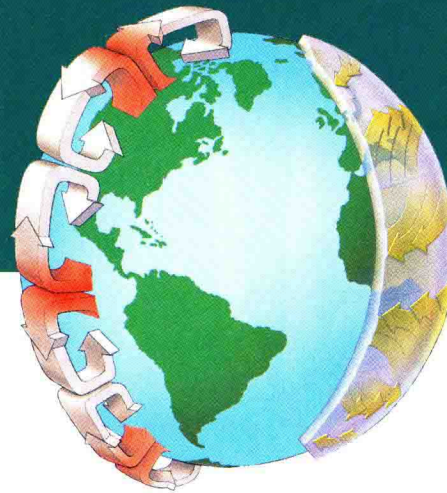
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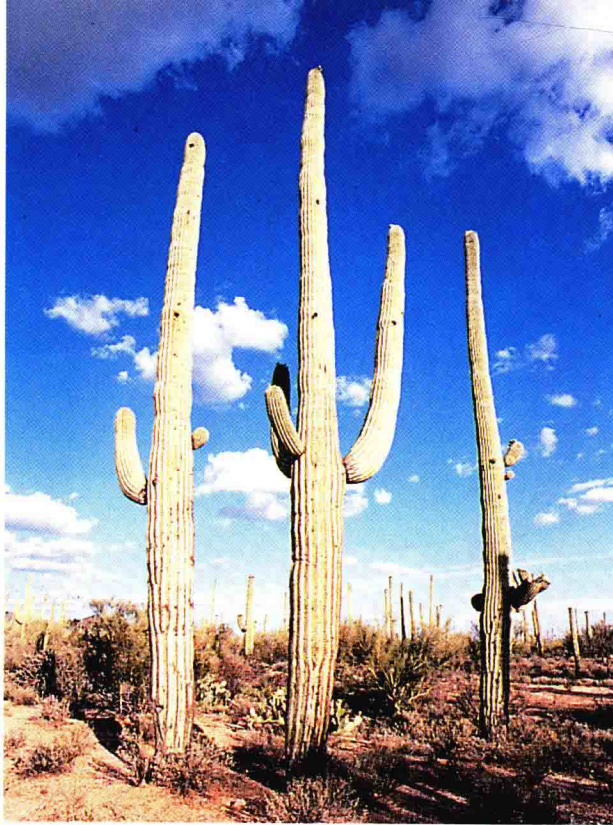
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François Gohier/Ardea London

Saguaro cacti, Arizona

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Paul W. Johnson/Biological Photo Service

Temperate deciduous forest, fall, Rhode Island

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Temperate deciduous forest, winter, Rhode Island



Gene Alexander/USDA

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National Archives/EPA Documentica

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Jack Carey

Crater Lake, Oregon



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Sulfur dioxide emissions from coal-burning power plant

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Heather Angel/BioFotos

Water hyacinth, Florida



Gary Milburn/Tom Stack & Associates

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