

Eldon D. Enger Bradley F. Smith Anne Todd Bockarie

Environmental Science

A Study of Interrelationships

(Tenth Edition)

环境科学 ——交叉关系学科 (第10版)



大学环境教育丛书

(影印版)

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清华大学出版社
北 京

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出版前言

在 21 世纪初，面临各种环境问题，人类清醒地认识到要走可持续发展之路。而发展环境教育是解决环境问题和实施可持续发展战略的根本。高等学校的环境教育，是提高新世纪建设者的环境意识，并向社会输送环境保护专门人才的重要途径。为了反映国外环境类教材的最新内容和编写风格，同时也为了提高学生阅读专业文献和获取信息的能力，我们精选了国外一些优秀的环境类教材，加以影印或翻译，组成大学环境教育丛书。所选教材均在国外被广泛采用，多数已再版，书中不仅介绍了有关概念、原理及技术方法，给出了丰富的数据，也反映了作者不同的学术观点。

我们希望这套丛书的出版能对高等院校师生和广大科技人员有所帮助，并为我国的环境教育事业作出贡献。

清华大学出版社

2006 年 10 月



Preface

Ten Respected, Successful Editions

As we produce the tenth edition of this text, it is appropriate to celebrate its success and reflect on how the field has changed over the past two decades. Since *Environmental Science: A Study of Interrelationships* was first published in 1983, it has been translated into Chinese and Korean, and we estimate that nearly a million students have used the text. Over the 10 editions, we have seen the field of environmental science change significantly. Initially, most of the courses were designed to raise awareness about environmental issues. Today, the field of environmental science has become a major discipline at many colleges and universities. Students who enroll in an introductory environmental science course may move in several directions that were not present over 20 years ago. Fields such as environmental law and environmental engineering are new disciplines. In addition, other traditional disciplines such as landscape planning, urban planning, agriculture, and industrial engineering now pay significant attention to environmental concerns.

It has been an interesting intellectual exercise to keep up-to-date in this rapidly changing field. For example, in the early 1980s, air and water pollution by industry was a key issue in the developed countries. Today, however, most industries have made major improvements in controlling pollution and are no longer the main sources of air and water pollution. The actions of individual citizens now have become major sources of pollution. Automobile use is responsible for much of the air pollution that affects cities, and runoff from lawns, city streets, and farms is an important source of water pollution. Many new environmental problems have also arisen. Climate change, the AIDS pandemic, genetically modified crops, and concerns about the loss of biodiversity have become core issues. Over time, as these issues have assumed greater importance, they have been incorporated into the text.

Why “a Study of Interrelationships”?

Environmental science is an interdisciplinary field. Because environmental disharmonies occur as a result of the interaction between humans and the natural world, we must include both when seeking solutions to environmental problems. It is important to have a historical perspective, appreciate economic and political

realities, recognize the role of different social experiences and ethical backgrounds, and integrate these with the science that describes the natural world and how we affect it. *Environmental Science: A Study of Interrelationships* incorporates all of these sources of information when discussing any environmental issue. This text is written for a one-semester, introductory course taken by students with a wide variety of career goals. The central theme of the book is interrelatedness. No text of this nature can cover all issues in depth. Although many facts are presented in charts, graphs, and figures to help illustrate the scope of environmental issues, the text's main focus is on identifying major issues and giving appropriate examples to illustrate the complex interactions that are characteristic of all environmental problems. The facts are provided for the person who wants them, but they do not obscure the general concepts and principles being described. The authors have endeavored to present a balanced view of issues, diligently avoiding personal biases and fashionable philosophies. It is not the purpose of this textbook to tell you what to think. Rather, our goal is to provide access to information and the conceptual framework needed to understand complex issues so that you can comprehend the nature of environmental problems and formulate your own views.

New to this Anniversary Edition!

New Author Brings Expertise and Unique Perspective

A special contributing author, Anne Todd Bockarie, updated chapters 2 and 16 for the tenth edition. She is an Assistant Professor of Biology at Philadelphia University and teaches Ecology, Biodiversity, Environmental Science, Introductory Biology, and Special Topics: Tropical Conservation. She helped develop the Environmental Science program at the university as well as a new major in Environmental and Conservation Biology. She has created new courses in ecological field methods, coral reef assessment in Jamaica, and wildlife management in Yellowstone National Park. She holds a Research Associate position at Yale University and has supervised graduate research on the ecological and social impacts of large-scale park restoration for the past six years. Dr. Bockarie's M.S. and Ph.D. degrees in reforestation and forestry extension are from the University of Florida. She has extensive international consulting and training experience in agriculture, forestry, and parks management in Africa and the Caribbean.

New Biodiversity Chapter

Chapter 12, “Biodiversity Issues,” discusses how population growth and the ability of people to exploit resources led to current concerns about biodiversity. This important topic is examined at the genetic, species, and ecosystem levels, and the value of biodiversity is described from several points of view: ethics, direct economic values, and services provided by organisms in functioning ecosystems. A discussion of the threats to biodiversity looks at habitat loss, overexploitation, introduction of exotic species, and control of pest organisms. The chapter ends with an overview of efforts to protect biodiversity and includes a discussion of legal protection and steps being taken to ensure that sustainable management practices are used to preserve biodiversity.

In-Depth Coverage on Sustainability

Sustainability is a core concept in this text and is covered in several chapters. In chapter 2, sustainability is discussed in the context of ethical considerations. Chapter 3 expands on the idea by looking at the topic from an economic point of view. Sustainability is also discussed in the chapters on energy use, biodiversity, water management, agriculture, and at many other points in the text.

New Feature Examines Environmental Change

When we look at environmental issues in general, we find that the same basic issues exist today as in 1983. Although significant progress has been made toward solving some environmental problems, progress in others has been slow, and new threats or concerns have emerged. To help the reader evaluate progress and recognize how difficult some problems are, we have instituted a new feature with this edition. Each chapter begins with a “Past, Present, Future” feature that shows how specific topics discussed in the chapter have changed over more than 20 years.

New Art Adds Depth and Realism

There are over 40 new figures and tables in this tenth edition, many of which have been drawn in a more realistic, three-dimensional style. Numerous other pieces have been revised to reflect updated data or content.

“Risk and Cost” Chapter Completely Rewritten

Chapter 3, “Risk and Cost: Elements of Decision Making,” has a new introduction to the topics of risk and economics, a new section on how risk is characterized, and a new table on the causes of accidental death. The chapter now describes renewable and nonrenewable resources, and includes a major section on assigning value to natural resources. There are also greatly expanded sections on deferred costs, external costs, and subsidies.

All New “Issues—Analysis” Case Studies

Every chapter in the tenth edition features a new “Issues—Analysis” reading, written to reflect current issues and/or

new data pertaining to the chapter subject matter. In addition, there are 10 other new readings chosen to complement new text content.

New Foldout World Map

This unique, oversized foldout piece features full-color ecological regions and political world maps and allows students to refer to either map while reading, helping them to better understand and appreciate global environmental issues.

Special Introduction to Critical Thinking

In preparation for the critical thinking questions found at the end of every chapter, this important preface to Chapter 1 explains the value of correctly evaluating available information to make informed decisions. Six key characteristics of critical thinking are examined.

Guest Essays Provide Regional Examples

In this tenth edition, each part opens with a new guest author’s essay highlighting an environmental issue close to their home. These articles offer expert insight into problems similar to those in students’ own backyards.

- Part I opens with an essay entitled “**Can We Save Both Blue Crabs and Watermen?**” which describes the regulation of the blue crab fishery in Chesapeake Bay by looking at a specific problem and the ramifications of regulatory action. *Author: Jennifer Rhode, Georgia College and State University*
- The Part II opening composition, “**Imitating Mother Nature in a Florida Lake,**” examines the cleanup of a lake in central Florida and its effects on ecosystems and businesses downstream. This essay is an excellent transition to the chapters in this unit, which provide an understanding of the ecological principles that are basic to organism interactions and the flow of matter and energy in ecosystems. *Authors: Blase Maffia and Lisa Ganser, University of Miami*
- Part III focuses on energy, beginning with its opening article, “**Winds of Change,**” which follows the events that led an electric utility that relies on nuclear power to invest in wind power in Minnesota. *Author: John C. Cronn, St. Cloud State University*
- Part IV begins with the essay, “**Natural Community Conservation Planning,**” which describes a California policy designed to preserve biodiversity. *Author: Morgan Barrows, Saddleback College*
- The Part V essay, “**Lake Champlain: It Isn’t Easy Stayin’ Clean,**” introduces the topic of pollution by tracing the effects of human activities on the Lake Champlain ecosystem and provides a good introduction to the conflict between human impacts on the environment and efforts to reduce damage. *Author: Alan McIntosh, University of Vermont*

Significant Revision

As with previous editions, reviewers' suggestions have been incorporated into the text. Some of these suggestions required small changes in text or figures to improve clarity and accuracy. Others required major revisions in the content of certain chapters. Specific changes include:

- Chapter 1 has two new boxed readings: Environmental Close-Up: "Traditional Resource Use and Conflict Management in Keoladeo National Park, India—Science Versus Policy" and Global Perspective: "Biodiversity, Human Welfare, and Economic Development."
- Chapter 2 has a new table that lists the accomplishments of selected international treaties and a new Environmental Close-Up: "What's in Your Backyard?" that allows students to assess the level of pollution in their neighborhood. The sections dealing with the CERES principles, environmental justice issues and international trade in endangered species have all been expanded.
- Chapter 3 has been completely revised and includes major new sections dealing with renewable and nonrenewable resources, environmental costs and pollution, and subsidies. These changes are supported with new tables and figures.
- Chapter 5 features a new Environmental Close-Up entitled "Human Health and Exotic Species."
- Chapter 6 includes a new Environmental Close-Up on "Non-native Invasive Aquatic Plants."
- Chapter 7 provides new material on lemming cycles in the Arctic and the concept of cultural carrying capacity.
- Chapter 8 has been updated with recent information on human population.
- Chapter 9 features a major new section on the politics and economics of energy use, which incorporates fuel efficiency standards and OPEC, and many new and revised figures.
- Chapter 10 now includes expanded coverage on renewable energy as well as energy efficiency and conservation.
- Chapter 11 has a new section explaining the politics of nuclear power and additional material on world demand for nuclear power.
- Chapter 12 has been completely rewritten to emphasize biodiversity issues. Its new Global Perspective, "Biodiversity 'Hot Spots,'" has an extensive table and a map detailing the characteristics and locations of these important ecosystems. The chapter also includes new material on the genetic, species, and ecosystem diversity aspects of biodiversity; information on the value of biodiversity; a major new section on threats to biodiversity that focuses on habitat loss, over-exploitation, introduction of exotic species, and control of pest organisms; and a new section on legal protection of endangered species.
- Chapter 13 contains a new Environmental Close-Up entitled "Farmland Preservation in Pennsylvania." The chapter also includes additional coverage on urban sprawl and sustainable growth.

- Chapter 14 features two new Environmental Close-Ups: "Desertification and Global Security" and "The Conservation Security Program."
- Chapter 15 has a new example and table showing the development of pesticide resistance by insects and a new figure on the amount of pesticide used on agricultural land.
- Chapter 16 offers updated information on efforts to save the Aral Sea, the long-term impact of the *Exxon Valdez* oil spill, and water use throughout the world.
- Chapter 17 was updated throughout and modified to allow for a better flow of content. The chapter includes new information on the deaths in Europe due to the 2003 heat wave.
- Chapter 18 has a much-expanded section on mining waste and includes an Environmental Close-Up entitled "Mountain Top Removal."
- Chapter 19 has been updated throughout and includes a new pie graph that shows industries responsible for toxic releases.
- Chapter 20 has expanded coverage on the societal benefits of environmental compliance and a new section explaining the difference between *governance* and *government*. There are also two new tables and a new Global Perspective on "ISO Standards for Environmental Management Systems" in this chapter.

Acknowledgements

The creation of a textbook requires a dedicated team of professionals who provide guidance, criticism, and encouragement. It is also important to have open communication and dialog to deal with the many issues that arise during the development and production of a text. Therefore, we would like to thank Publisher Marge Kemp; Developmental Editors Kathy Loewenberg and Kennie Harris; Marketing Managers Lisa Gottschalk and Tami Petsche; Project Manager Mary Powers; Production Supervisor Sandy Ludovissy; Photo Research Coordinator Lori Hancock; and Designer David Hash for their suggestions and kindnesses.

We'd like to express our gratitude to the guest essay authors; their contributions add an interesting regional perspective to each of the five units: Jennifer Rhode, *Georgia College and State University*; Blase Maffia and Lisa Ganser, both of the *University of Miami*; John C. Cronn, *St. Cloud State University*; Morgan Barrows, *Saddleback College*; and Alan McIntosh, *University of Vermont*. Finally, we'd like to thank our many colleagues who have reviewed all or part of *Environmental Science: A Study of Interrelationships*. Their valuable input has continued to shape this text and help it meet the needs of instructors around the world. In particular, we'd like to thank: Saleem H. Ali, *University of Vermont*; Frank Bartell, *Community College of Philadelphia*; Donna Bivans, *Pitt Community College*; Daniel Capuano, *Hudson Valley Community College*; Richard Clements, *Chattanooga State Tech College*; John C. Cronn, *St. Cloud State University*; Peter Konovnitzine, *Chaffey College*; Julie Phillips, *De Anza College*; Lauren Preske, *University of Southern Indiana*; Jennifer

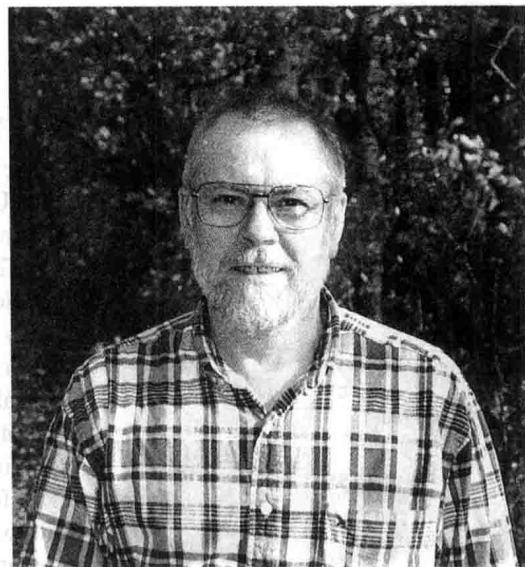
Rhode, *Georgia College and State University*; Daniel Sivek, *University of Wisconsin-Stevens Point*; Kristen Jensen Sullivan, *De Anza College*; Sara Topf, *Parks College*; Mike Toscano, *San*

Joaquin Delta College; Arlene Westhoven, *Ferris State University*; and Jeff White, *Lake Land College*.

Eldon D. Enger
Bradley F. Smith

About the Authors

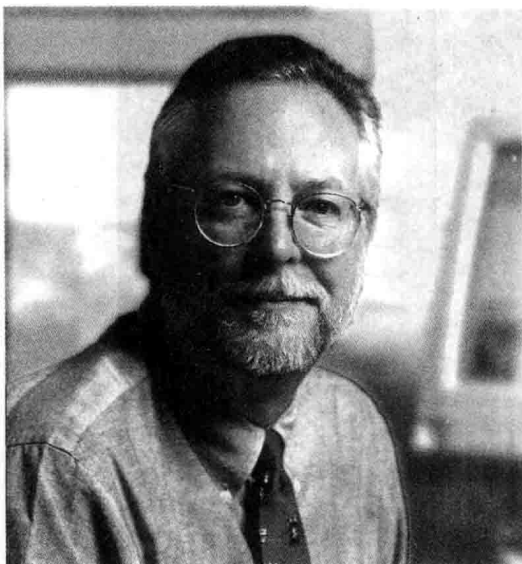
Eldon D. Enger is an emeritus professor of biology at Delta College, a community college near Saginaw, Michigan. He received his B.A. and M.S. degrees from the University of Michigan. Professor Enger has over 30 years of teaching experience, during which he has taught biology, zoology, environmental science, and several other courses. He has been very active in curriculum and course development. A major contribution to the curriculum was the development of an environmental technician curriculum and the courses that support it. He was also involved in the development of learning community courses in stream ecology, winter ecology, and plant identification. Each of these courses involved students in weekend-long experiences in the outdoors that paired environmental education with physical activity—stream ecology and canoeing, winter ecology and cross-country skiing, and plant identification with backpacking.



Professor Enger is an advocate for variety in teaching methodology. He feels that if students are provided with varied experiences, they are more likely to learn. In addition to the standard textbook assignments, lectures, and laboratory activities, his classes included writing assignments, student presentation of lecture material, debates by students on controversial issues, field experiences, individual student projects, and discussions of local examples and relevant current events. Textbooks are very valuable for presenting content, especially if they contain accurate, informative drawings and visual examples. Lectures are best used to help students see themes and make connections, and laboratory activities provide important hands-on activities.

Professor Enger received the Bergstein Award for Teaching Excellence and the Scholarly Achievement Award from Delta College and was selected as a Fulbright Exchange Teacher twice—to Australia and Scotland. He has participated as a volunteer in several Earthwatch Research Programs. These include: studying the behavior of a bird known as the long-tailed manakin in Costa Rica, participating in a study to reintroduce endangered marsupials from islands to mainland Australia, and efforts to protect the leatherback turtle in Costa Rica. He also served as a participant in a People to People program which allowed for an exchange of ideas between U.S. and South African environmental professionals. While traveling he has spent considerable time visiting coral reefs, ocean coasts, mangrove swamps, alpine tundra, prairies, tropical rainforests, cloud forests, deserts, temperate rainforests, coniferous forests, deciduous forests, and many other special ecosystems. This extensive experience provides the background to look at environmental issues from a broad perspective.

Professor Enger is married, has two grown sons, and enjoys a variety of outdoor pursuits such as cross-country skiing, hiking, hunting, fishing, camping and gardening. Other interests include reading a wide variety of periodicals, beekeeping, singing in a church choir, and preserving garden produce.



Bradley F. Smith is the Dean of Huxley College of Environmental Studies at Western Washington University in Bellingham, Washington. Prior to assuming the position as Dean in 1994, he served as the first Director of the Office of Environmental Education for the U.S. Environmental Protection Agency in Washington, D.C. from 1991 to 1994. Dean Smith also served as the Acting President of the National Environmental Education and Training Foundation in Washington, D.C. and as a Special Assistant to the EPA Administrator.

Before moving to Washington, D.C., Dean Smith was a professor of political science and environmental studies for fifteen years, and the executive director of an environmental education center and nature refuge for five years.

Dean Smith has considerable international experience. He was a Fulbright Exchange Teacher to England and worked as a research associate for Environment Canada in New Brunswick, Canada. He is a frequent speaker on environmental issues worldwide and serves on the International Scholars Program for the U.S. Information Agency. He also served as a U.S. representative on the Tri-Lateral Commission on environmental education with Canada and Mexico. In 1995, he was awarded a NATO Fellowship to study the environmental problems associated with the closure of former Soviet military bases in Eastern Europe. Dean Smith is an Adjunct Professor at Far Eastern State University in Vladivostok, Russia and is a member of the Russian Academy of Transport. He also serves as a commissioner for the International Union for the Conservation of Nature (IUCN) and is the President of the World Conservation Learning Network for the IUCN.

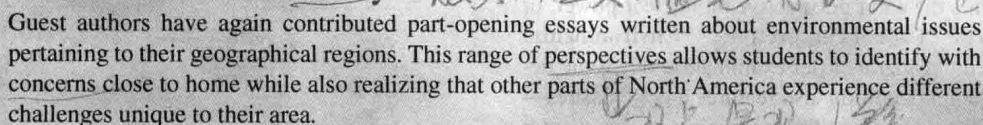
Nationally, Dean Smith serves as a member/advisor for many environmental organizations' boards of directors, advisory councils, and executive committees. He is the co-chair of the Washington State Sustainability Council and President of the Council of Environmental Deans and Directors. He previously served President Clinton's Council for Sustainable Development (Education Task Force).

Dean Smith holds B.A. and M.A. degrees in Political Science and Public Administration and a Ph.D. from the School of Natural Resources and Environment at the University of Michigan.

Dean Smith lives with his wife Daria, daughter Morgan, son Ian, and English setter Skye, along Puget Sound, south of Bellingham. He is an avid outdoor enthusiast.

The organization and principle features of this book were planned with the students' holistic learning and comprehension in mind. The text discussion is supported by unique learning aids that offer assistance in studying, reinforce the understanding of key concepts, and promote critical thinking skills.

Two oversized maps on a dual foldout page allow students to use both a political map, showing countries of the world, and an ecological regions map, indicating various biomes, while studying from any section of the textbook. The maps are accompanied by a guest essay that offers map reading guidelines.



Conceptual Study Aids

A brief list of objectives and an outline open each chapter, giving the reader a broad overview of the interrelated forces involved in the material to be discussed. Students are encouraged to refer to these resources while reading and reviewing the chapter.

New! "Past, Present, Future" Charts

When we look at environmental concerns in general, we find that the same basic issues exist today as in 1983, when this book was first published. Although there has been significant progress in addressing some environmental problems, improvement in others has been slow, and new threats or worries have emerged. To help the reader evaluate progress in solving environmental problems and also to understand the complexity of these issues, a new feature entitled, *Past, Present, Future* appears at the beginning of each chapter. These charts show how specific topics discussed in the pages to come have changed over the past 20-plus years.

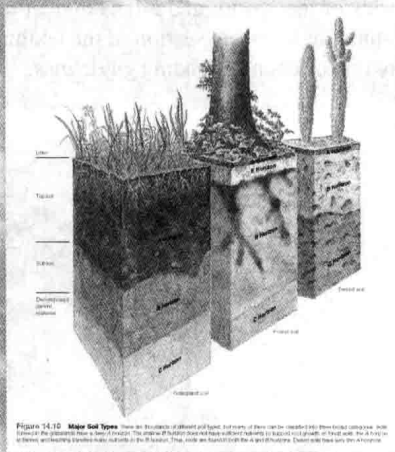


Figure 14.10 Major Soil Types. These are cross-sections of different soil types. Cross-sections of these can be made into three-dimensional models. The models can be used to show the vertical layers of the soil and the plants growing on them. The models can be used to show the vertical layers of the soil and the plants growing on them. The models can be used to show the vertical layers of the soil and the plants growing on them.

New Three-dimensional Art

There are over 40 new figures and tables in this tenth edition, many of which have been drawn in a more realistic, three-dimensional style. Numerous other pieces have been revised to reflect updated data or content.

Relevant Readings

Context is so very important in the world of environmental science. Boxed readings help students understand that variables surrounding an environmental issue can affect both the problem and the solution. Looking beyond our borders helps to gain a different perspective on nuclear power, or water pollution—just two of the topics discussed in the “Global Perspectives.” “Environmental Close-Ups” are case study-like readings that offer the reader a closer examination of a topic described in the surrounding text. Every chapter in the tenth edition also features a new “Issues—Analysis” reading, written to reflect current issues and/or new data pertaining to the chapter subject matter.

Issues—Analysis

The Problem of Insects

When we think of environmental problems, we almost always envision a natural resource being damaged or destroyed. In the case of insects, the damage is often done to crops and forests. Insects are a major pest to agriculture and forestry. They can cause billions of dollars of damage each year. Insects are also a major pest to human health. They can cause allergic reactions and other health problems. Insects are also a major pest to the environment. They can damage ecosystems and cause the extinction of other species.

For the most vulnerable crops, the damage is often done by insects. Insects are a major pest to agriculture and forestry. They can cause billions of dollars of damage each year. Insects are also a major pest to human health. They can cause allergic reactions and other health problems. Insects are also a major pest to the environment. They can damage ecosystems and cause the extinction of other species.



CHAPTER 14 Ecosystems

277

Digital Content Manager (DCM) CD-ROM

This indispensable supplement is a multimedia collection of visual resources that allows instructors to utilize artwork from the text and other sources to create customized course tools.

ALL of the Art from the Book

Over 275 illustrations and 300 photos, already in PowerPoint format, are at your disposal to use in classroom presentations. These include all of the new, realistic drawings that were rendered for this tenth edition, representing some of the most important concepts in environmental science.

Protozoa, nematodes, earthworms, insects, algae, bacteria, and fungi are typical inhabitants of soil. (See figure 14.8.) The role of protozoa in the soil is not firmly established, but they seem to act as parasites and predators on other forms of soil organisms and, therefore, help to regulate the populations of those organisms.

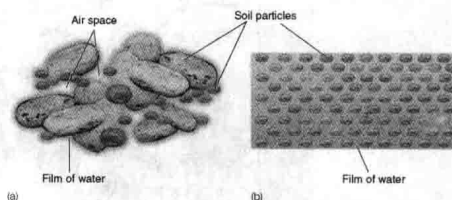
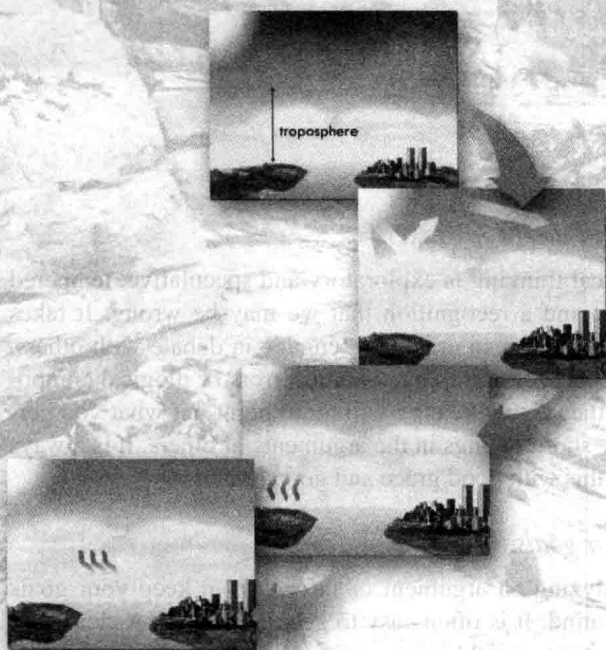


Figure 14.7 Pore Spaces and Particle Size. (a) Soil that is composed of particles of various sizes has spaces for both water and air. The particles have water bound to their surfaces (represented by the colored halo around each particle), but some of the spaces are so large that an air space is present. (b) Soil composed of uniformly small particles has less space for air. Since roots require both air and water, the soil in (a) would be better able to support crops than would the soil in (b).

Digital Content Manager



Animations

One hundred full-color animations illustrating many different concepts covered in the study of environmental science are available for your use in creating classroom lectures, testing materials, or online course communications.

PowerPoint Lecture Outline

Don't have time to create your own classroom presentation? The Digital Content Manager offers a customized presentation combining art from the text with instructor-written lecture notes, covering all 20 chapters.

Additional Photo Library

Over 300 full-color photographs *additional* to those already in the textbook are also included in this CD-ROM. Chosen for their specific contribution to topics in environmental science, these photos are searchable by content and will add interest and contextual support to your lectures.

Active Art

These special art pieces consist of key environmental science illustrations that are converted to a format that allows you to break the art down into core elements, and then group the various pieces and create customized images. This is especially helpful with difficult concepts as they can be explained to students step by step.

Table Library

In addition to hundreds of illustrations and photos, this valuable CD also includes every table in the textbook, available in ready-to-use digital files.

"See It in Motion" Videos

For those of you who want more coverage on oceans in your environmental science course, a special collection of live underwater videos is included in the Digital Content Manager. "See It in Motion" video clips display interesting habitats and behaviors for many animals in the ocean.



Global Base Maps

Frustrated that your students can't identify cities/states/countries beyond their immediate surroundings? In support of the authors' commitment to global environmental concern with the environment, we've developed 22 base maps for all world regions and major sub-regions. These maps are offered in four versions: black-and-white and full-color, both with labels and without labels. All of these choices allow you flexibility in planning class activities, quizzing opportunities, study tools, and PowerPoint enhancements. Help your students understand that what happens in Africa or Europe affects all of us.





Critical Thinking

We live in an age of information. Computers, e-mail, the Internet, CD-ROMs, instant news, and fax machines bring us information more quickly than ever before. A simple search of the Internet will provide huge amounts of information. Some of the information has been subjected to scrutiny and is quite valid, some is well-informed opinion, some is naive misinformation, and some is even designed to mislead. How do we critically evaluate the information we get?

Critical thinking involves a set of skills that helps us to evaluate information, arguments, and opinions in a systematic and thoughtful way. Critical thinking also can help us better understand our own opinions as well as the points of view of others. It can help us evaluate the quality of evidence, recognize bias, characterize the assumptions behind arguments, identify the implications of decisions, and avoid jumping to conclusions.

Characteristics of Critical Thinking

Critical thinking involves skills that allow us to sort information in a meaningful way and discard invalid or useless information while recognizing that which is valuable. Some key components of critical thinking are:

Recognize the importance of context.

All information is based on certain assumptions. It is important to recognize what those assumptions are. Critical thinking involves looking closely at an argument or opinion by identifying the historical, social, political, economic, and scientific context in which the argument is being made. It is also important to understand the kinds of bias contained in the argument and the level of knowledge the presenter has.

Consider alternative views.

A critical thinker must be able to understand and evaluate different points of view. Often these points of view may be quite varied. It is important to keep an open mind and to look at all the information objectively and try to see the value in alternative points of view. Often people miss obvious solutions to problems because they focus on a certain avenue of thinking and unconsciously dismiss valid alternative solutions.

Expect and accept mistakes.

Good critical thinking is exploratory and speculative, tempered by honesty and a recognition that we may be wrong. It takes courage to develop an argument, engage in debate with others, and admit that your thinking contains errors or illogical components. By the same token, be willing to point out what you perceive to be shortcomings in the arguments of others. It is always best to do this with good grace and good humor.

Have clear goals.

When analyzing an argument or information, keep your goals clearly in mind. It is often easy to get sidetracked. A clear goal will allow you to quickly sort information into that which is pertinent and that which may be interesting but not germane to the particular issue you are exploring.

Evaluate the validity of evidence.

Information comes in many forms and has differing degrees of validity. When evaluating information, it is important to understand that not all the information from a source may be of equal quality. Often content about a topic is a mix of solid information interspersed with less certain speculations or assumptions. Apply a strong critical attitude to each separate piece of information. Often what appears to be a minor, insignificant error or misunderstanding can cause an entire argument to unravel.

Critical thinking requires practice.

As with most skills, you become better if you practice. At the end of each chapter in the text, there are a series of questions that allow you to practice critical thinking skills. Some of these questions are straightforward and simply ask you to recall information from the chapter. Others ask you to apply the information from the chapter to other similar contexts. Still others ask you to develop arguments that require you to superimpose the knowledge you have gained from the chapter on quite different social, economic, or political contexts from your own.

Practice, practice, practice.



Brief Contents

PART I Environmental Science in a Social Context 2

- CHAPTER 1 Environmental Interrelationships 4
- CHAPTER 2 Environmental Ethics 19
- CHAPTER 3 Risk and Cost: Elements of Decision Making 38

PART II Ecological Principles and Their Application 60

- CHAPTER 4 Interrelated Scientific Principles: Matter, Energy, and Environment 62
- CHAPTER 5 Interactions: Environments and Organisms 78
- CHAPTER 6 Kinds of Ecosystems and Communities 104
- CHAPTER 7 Population Principles 131
- CHAPTER 8 Human Population Issues 148

PART III Energy 168

- CHAPTER 9 Energy and Civilization: Patterns of Consumption 170
- CHAPTER 10 Energy Sources 186
- CHAPTER 11 Nuclear Energy: Benefits and Risks 220

PART IV Resource Management 244

- CHAPTER 12 Biodiversity Issues 246
- CHAPTER 13 Land-Use Planning 280
- CHAPTER 14 Soil and Its Uses 305
- CHAPTER 15 Agricultural Methods and Pest Management 329
- CHAPTER 16 Water Management 352

PART V Pollution and Policy 386

- CHAPTER 17 Air Quality Issues 388
- CHAPTER 18 Solid Waste Management and Disposal 419
- CHAPTER 19 Regulating Hazardous Materials 435
- CHAPTER 20 Environmental Policy and Decision Making 452

glossary G-1
credits C-1
index I-1

Contents

Preface xiii
About the Authors xvii
Guided Tour xix
Critical Thinking xxiii

PART I

Environmental Science in a Social Context 2

Can We Save Both Blue Crabs and Watermen? 3



CHAPTER 1

Environmental Interrelationships 4

The Field of Environmental Science 5
The Interrelated Nature of Environmental Problems 5

Environmental Close-Up: Traditional Resource Use and Conflict Management in Keoladeo National Park, India—Science Versus Policy 6

An Ecosystem Approach 7

Regional Environmental Concerns 8
The Wilderness North 8
The Agricultural Middle 8

Environmental Close-Up: The Greater Yellowstone Ecosystem 10

The Dry West 10

Global Perspective: Biodiversity, Human Welfare, and Economic Development 11

The Forested West 12
The Great Lakes and Industrial Northeast 12
The Diverse South 14

Global Perspective: Constraints and Risks of a Regional Approach—The Mekong River Delta Example 15

Issues—Analysis: The Fate of the Gray Wolf 17

CHAPTER 2

Environmental Ethics 19

Views of Nature 20
Environmental Ethics 21
Environmental Attitudes 22

Environmental Close-Up: Naturalist Philosophers 23

Societal Environmental Ethics 24
Corporate Environmental Ethics 24

Environmental Close-Up: What's in Your Backyard? 25

Global Perspective: Chico Mendes and Extractive Reserves 27

Environmental Justice 27
Individual Environmental Ethics 29
Do We Consume Too Much? 29

Global Perspective: International Trade in Endangered Species 30

Food 31
Nature 31
Oil 31
Water 31
The Unknown 31

Global Environmental Ethics 32

Global Perspective: The Gray Whales of Neah Bay 34

Issues—Analysis: Environmental Dissent—Is Ecoterrorism Justified? 36

CHAPTER 3

Risk and Cost: Elements of Decision Making 38

Risk and Economics 39
Characterizing Risk 39
Risk Assessment 39
Risk Management 40

Environmental Close-Up: What's in a Number? 41

True and Perceived Risks 42

Economics in an Environmental Context 43

Resources 43
Supply and Demand 43
Assigning Value to Natural Resources 45
Kinds of Environmental Costs 45
Cost-Benefit Analysis 47
Concerns About the Use of Cost-Benefit Analysis 48
Comparing Economic and Ecological Systems 48
Common Property Resource Problems—The Tragedy of the Commons 49

Using Economic Tools to Address Environmental Issues 50

Subsidies 50
Market-Based Instruments 51

Global Perspective: Pollution Prevention Pays! 52

Life Cycle Analysis and Extended Product Responsibility 53

**Environmental Close-Up: Georgia Pacific Corporation:
Recycled Urban Wood—A Case Study in Extended
Product Responsibility 54**

- Economics and Sustainable Development 54
- Economics, Environment, and Developing Nations 56
- Issues—Analysis: The Economics and Risks of Mercury
Contamination 58

PART II

Ecological Principles and Their Application 60

Imitating Mother Nature in a Florida Lake 61



CHAPTER 4

Interrelated Scientific Principles: Matter, Energy, and Environment 62

- Scientific Thinking 63
 - The Scientific Method 63
 - Observation 63
 - Questioning and Exploring 63
 - Constructing Hypotheses 64
 - Testing Hypotheses 64
 - The Development of Theories and Laws 65
- Limitations of Science 65

Environmental Close-Up: Typical Household Chemicals 66

- The Structure of Matter 67
 - Atomic Structure 67
 - The Molecular Nature of Matter 67
 - Acids, Bases, and pH 68
 - Inorganic and Organic Matter 68
 - Chemical Reactions 69
 - Chemical Reactions in Living Things 70

- Energy Principles 70
 - Kinds of Energy 70
 - States of Matter 71
 - First and Second Laws of Thermodynamics 71

Environmental Implications of Energy Flow 72

- Issues—Analysis: Biofuels Technology 75

CHAPTER 5

Interactions: Environments and Organisms 78

- Ecological Concepts 79
 - Environment 79
 - Limiting Factors 80
 - Habitat and Niche 80

- The Role of Natural Selection and Evolution 82
 - Genes, Populations, and Species 82

Environmental Close-Up: Habitat Conservation Plans: Tool or Token? 83

- Natural Selection 83
- Evolutionary Patterns 84
- Kinds of Organism Interactions 86

- Predation 86
- Competition 86
- Symbiotic Relationships 87
- Some Relationships Are Difficult to Categorize 89
- Human Interaction—A Different Look 89

Environmental Close-Up: Human Health and Exotic Species 90

Community and Ecosystem Interactions 90

- Major Roles of Organisms in Ecosystems 91
- Keystone Species 92
- Energy Flow Through Ecosystems 92
- Food Chains and Food Webs 93

Environmental Close-Up: Contaminants in the Food Chain of Fish from the Great Lakes 95

- Nutrient Cycles in Ecosystems—Biogeochemical Cycles 95
- Human Impact on Nutrient Cycles 99
- Issues—Analysis: Phosphate Mining in Nauru 101

CHAPTER 6

Kinds of Ecosystems and Communities 104

Succession 105

- Primary Succession 105
- Secondary Succession 108
- Modern Concepts of Succession and Climax 108

Biomes: Major Types of Terrestrial Climax Communities 110

- The Effect of Elevation on Climate and Vegetation 111
- Desert 111
- Grassland 112

Environmental Close-Up: Grassland Succession 114

- Savanna 114
- Mediterranean Shrublands (Chaparral) 114
- Tropical Dry Forest 116
- Tropical Rainforest 116

Global Perspective: Tropical Rainforests—A Special Case? 117

- Temperate Deciduous Forest 118

Environmental Close-Up: Protecting Old-Growth Temperate Rainforests of the Pacific Northwest 119

- Taiga, Northern Coniferous Forest, or Boreal Forest 120
- Tundra 120

Major Aquatic Ecosystems 121

- Marine Ecosystems 121
- Freshwater Ecosystems 126

Environmental Close-Up: Non-native Invasive Aquatic Plants 126

- Issues—Analysis: Ecosystem Loss in North America 129

CHAPTER 7

Population Principles 131

Population Characteristics 132

- Natality and Mortality 132
- Sex Ratio and Age Distribution 133
- Population Density and Spatial Distribution 135
- Summary of Factors That Influence Population Growth Rates 135

A Population Growth Curve 135

- Carrying Capacity 136