

# ENVIRONMENT

4/E



# RAVEN & BERG



4/E

# ENVIRONMENT

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# Preface

The challenge of creating and maintaining a sustainable environment is probably the single most pressing issue that will confront students throughout their lives. Today, environmental science is not only relevant to students' personal experiences but also vital to the future of the entire planet. As humans increasingly alter Earth's land, water, and atmosphere on local, regional, and global levels, the resulting environmental problems can seem insurmountable. Armed with the proper tools, however, students need not find these issues overwhelming. *Environment*, fourth edition, equips students with the most essential of these tools: a working knowledge of the ecological concepts that underlie environmental problems.

The overarching concept of **environmental sustainability** has never been more important to the field of environmental science than it is today. We have therefore made sustainability a central theme of *Environment* by integrating it throughout the text. We begin in Chapter 1 with a definition of environmental sustainability, a brief discussion of why experts in environmental science think human society is not operating sustainably, and an introduction to the concept of sustainable development. Sustainability is revisited throughout the text, particularly in the context of sustainable water use (Chapter 13), sustainable soil use (Chapter 14), sustainable manufacturing (Chapter 15), sustainable forest management (Chapter 17), and sustainable agriculture (Chapter 18). In Chapter 24 we conclude with an extended discussion of living sustainably.

From the opening pages, we acquaint students with current environmental issues—issues that have many dimensions and that defy easy solutions. We begin by examining the scientific, historical, ethical, governmental, and economic underpinnings of environmental science. This provides a conceptual foundation for students that they can then bring to bear on the rest of the material in the book. One of our principal goals is to convey to students an appreciation of the remarkable complexity and precise functioning of natural ecosystems. Thus, we next explore the basic ecological principles that govern

the natural world and consider the many ways in which humans affect the environment. Later chapters examine in detail the effects of human activities, including overpopulation, energy production and consumption, depletion of natural resources, and pollution.

Although we avoid unwarranted optimism when presenting these problems—many are very serious indeed—we try to avoid the gloomy predictions of disaster so commonly presented by the media today. Instead, students are encouraged to take active, positive roles, using the practical and conceptual tools presented in this book, to meet the environmental challenges of today and tomorrow.

*Environment*, 4/e, integrates important information from many different fields, such as biology, geography, chemistry, geology, physics, economics, sociology, natural resources management, law, and politics. Because environmental science is an interdisciplinary field, this book is appropriate for use in environmental science courses offered by a variety of departments, including (but not limited to) biology, geology, geography, and agriculture.

All of the chapters have been painstakingly researched, and extraordinary efforts have been made to obtain the most recent data available. Both instructors and students will benefit from the book's **currency** because environmental issues and trends are continually changing.

This book is intended as an introductory text for undergraduate students, both science and nonscience majors. Although relevant to all students, *Environment*, 4/e, is particularly appropriate for those majoring in education, journalism, government and politics, and business, as well as the traditional sciences. We assume our students have very little prior knowledge of how ecosystems work, the dynamics of how matter and energy move through ecosystems, and how populations affect and are affected by ecosystems. These important ecological concepts and processes are presented in a straightforward, unambiguous manner.



## CHARTING A COURSE FOR LEARNING

Learning environmental science is a challenging endeavor. A well-developed pedagogical plan that facilitates student mastery of the material has always been a hallmark of *Environment*.

Pedagogical features in the fourth edition include:

**Learning Objectives** at the beginning of the chapter indicate in behavioral terms what the student must be able to do to demonstrate mastery of the material in the chapter.

**Case In Point** features in the body of the chapter offer a wide variety of in-depth case studies that address important issues in the field of environmental science.

### CASE-IN-POINT The Arctic National Wildlife Refuge

One of the oil industry's biggest obstacles to locating and extracting oil is public resistance based on the perceived threat to environmentally sensitive areas. Consider the proposed opening of the Arctic National Wildlife Refuge.

## MEETING THE CHALLENGE

### Reclamation of Coal-Mined Land

The 1977 Surface Mining Control and Reclamation Act (SMCRA) has been extremely effective in protecting the environment. In the years since this law's passage, thousands of permits regulating the reclamation of active coal mines covering almost 2 million hectares (5 million acres), an area the size of New Jersey, have been issued. In addition, some of the most dangerous (from a health and safety viewpoint) abandoned coal mines have been reclaimed. The Office of Surface Mining of the Department of the Interior gives annual a



## YOU CAN MAKE A DIFFERENCE

### Getting Around Town

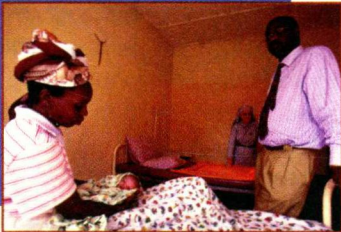
Can you imagine getting around town without a car? How would you get to class, the grocery store, the laundromat? Hopping in your car for every errand seems like the natural thing to do. According to the American Automobile Association, American motorists drive an average of 10,100 miles annually and burn 507 gallons of gasoline in the process.

However, consider this: From the production of gasoline to the disposal of old automobiles, the car has a significant negative impact on the environment. Acid deposition and

3. Carpool to class, to work, to the grocery store, to social events. One car on the road is better than three or four.
4. Buy a good bicycle; it is less expensive than a car to buy and maintain, and it is great for local transportation. It is also good exercise.
5. Walk to class or work if you live within a mile or so. You will need to allow yourself a little extra time, but once you get into the habit, it is easy. Walking is good exercise, too.

**You Can Make a Difference** boxes suggest specific courses of action or lifestyle changes students can make to improve the environment.

8



**AIDS patients.** Both the mother and her child have AIDS (acquired immunodeficiency syndrome), but they do not have access to the medicines that can prolong their lives. The cost of a month's supply of drugs is equal to 1 year's earnings for many African people. Photographed in a hospital in Rwanda.

### Understanding Population Change

**Learning Objectives**  
After you have studied this chapter you should be able to:

1. Describe the extent of the HIV/AIDS epidemic in sub-Saharan Africa.
2. Explain the four factors that produce changes in population size and solve simple problems involving these changes.
3. Define biotic potential (intrinsic rate of increase) and carrying capacity and explain the differences between

Africa has the most rapidly growing population of all the continents. Africa's population in mid-2002 was estimated at 840 million, with most of the population concentrated in sub-Saharan Africa, that part of Africa located south of the Sahara Desert. Experts predict that the sub-Saharan population of 660 million will more than double to 1.4 billion by 2030.  
During the mid- and late-1990s, many population experts lowered their estimates of population growth.

**Chapter Introductions** illustrate certain concepts in the chapter with stories about some of today's most pressing environmental issues.

**Envirobriefs** provide additional topical material about relevant environmental issues.

## ENVIROBRIEF

### Using Goats to Fight Fires

California has about 6,000 wildfires each year, and they are becoming increasingly expensive and dangerous to manage because so many people are building homes and living in fire-vulnerable chaparral. For one thing, the topography is so steep that firefighters often cannot use mechanized equipment but instead must be transported to fires by helicopters. Afraid that prescribed burns will get

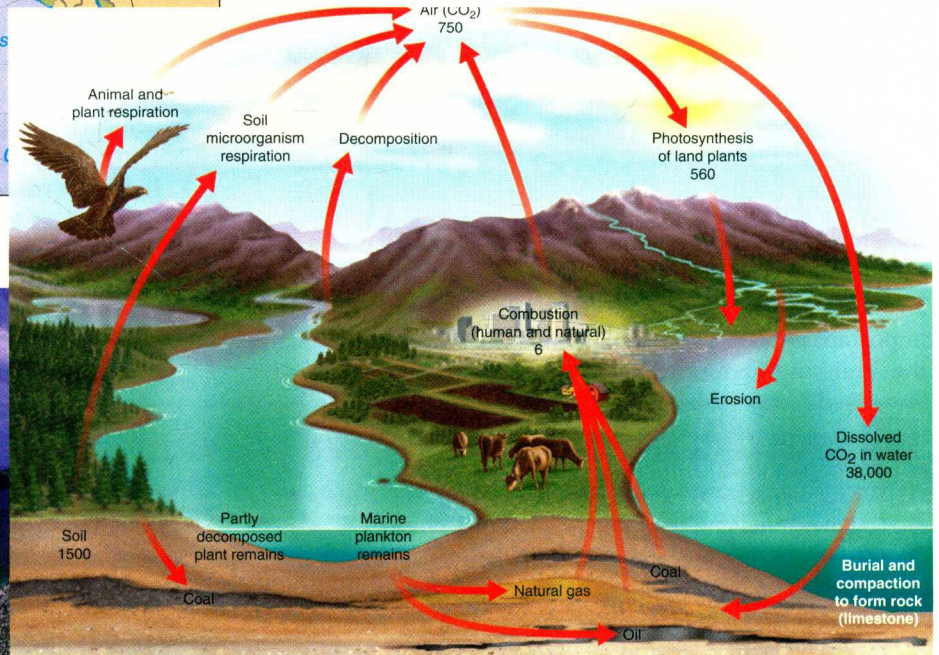
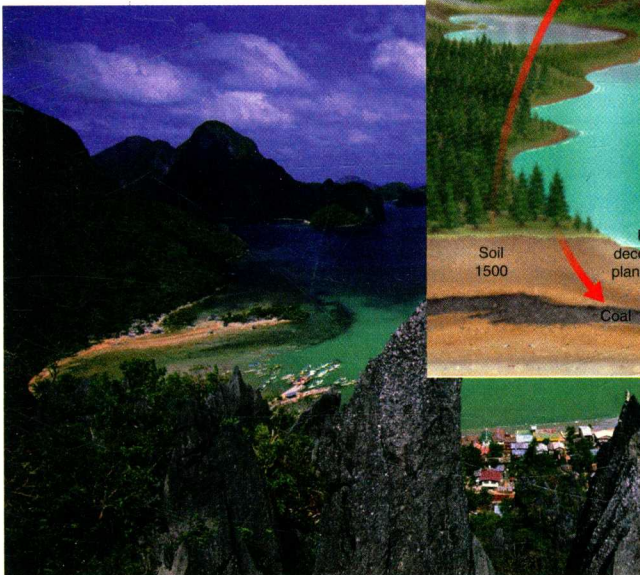
**Meeting the Challenge** boxes profile environmental success stories.





**Area Maps** feature insets of hemispheric locator maps to help students visualize where a particular area is on a continent.

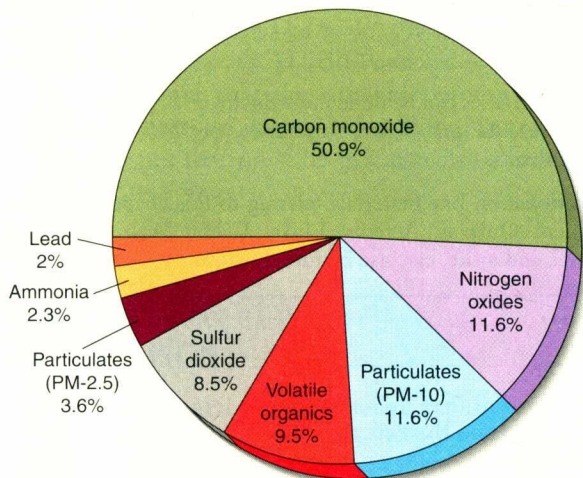
**Illustrations and Photos**, many of them new to this edition, support concepts covered in the text, elaborate relevant issues, and add visual detail. In the fourth edition, a cartographic studio redrew all maps in the text.



**Table 5.1 Ecosystem Services**

Ecosystem	Services Provided by Ecosystem
Forests	Purify air and water; produce and maintain soil; absorb carbon dioxide; provide wildlife habitat; provide humans with wood and recreation
Freshwater systems (rivers and streams, lakes, and groundwater)	Moderate water flow; dilute and remove pollutants; provide wildlife habitat; provide humans with drinking and irrigation water, food, transportation corridors, electricity, and recreation
Grasslands	Purify air and water; produce and maintain soil; absorb carbon dioxide; provide wildlife habitat; provide humans with livestock and recreation
Coasts	Provide a buffer against storms; dilute and remove pollutants; provide wildlife habitat; provide humans with food, harbors and transportation routes, and recreation
Sustainable agricultural ecosystems*	Produce and maintain soil; absorb carbon dioxide; provide wildlife habitat for birds, insect pollinators, and soil organisms; provide humans with food and fiber crops

\* Sustainable agriculture ecosystems are human-made and therefore inherently different from the other ecosystems. Sustainable agriculture is discussed in Chapter 18.



**Tables and graphs**, with data sources cited at the end of the text, summarize and organize important information.



**Mini-Glossaries**, located within many chapters, provide handy definitions and distinctions between closely related terms or potentially confusing new terms.

**Summaries with Selected Key Terms** in outline form at the end of each chapter provide a review of the material presented. Boldfaced selected key terms are integrated within each summary, enabling students to study vocabulary words in the context of related concepts.

## MINI-GLOSSARY

### Köppen's Climate Zones

**humid equatorial climate:** Every month is warm; mean temperature is over 18°C (64°F).

**dry climate:** Evaporation exceeds precipitation in most months.

**humid temperate climate:** Distinct winter and summer seasons; winters are mild; mean temperature in coldest month is above 3°C (27°F).

## SUMMARY WITH SELECTED KEY TERMS

**I. Science** is a systematic process to investigate the natural world. Science seeks to reduce the apparent complexity of our world to general principles that can be used to solve problems or provide new insights.

**A.** The established processes that scientists use to solve problems are collectively called the **scientific method**. There are many variations of the scientific method, which basically

2. Any difference in the outcome between the control group and the experimental group must be the result of the variable.

**C.** Both inductive and deductive reasoning are used in the scientific method.

1. **Inductive reasoning** begins with specific examples and seeks to draw a conclusion or discover a unifying rule on

**Thinking About the Environment** questions, many new to this edition, encourage critical thinking and highlight important concepts and applications. All Learning Objectives presented at the beginning of the chapter are covered in the Thinking About the Environment questions.

## THINKING ABOUT THE ENVIRONMENT

1. What is a biome? What two climate factors are most important in determining an area's characteristic biome?

2. How does vegetation change with increasing elevation and latitude?

3. What climate and soil factors produce each of the major terrestrial biomes?

4. Describe representative organisms of the forest biomes dis-

8. What environmental factors are most important in determining the kinds of organisms found in aquatic environments?

9. Distinguish between freshwater wetlands and estuaries, and between flowing-water and standing-water ecosystems.

10. What would happen to the organisms in a river with a fast

**Take a Stand** features appear at the end of every chapter and ask students to enter into a debate about an issue or controversy from the chapter. Students then visit our Web site to find links for researching the situation and tools for organizing their arguments. Take A Stand can be done individually or in small collaborative groups, and as an oral presentation, a writing assignment, or both.

## TAKE A STAND

Visit our Web site at <http://www.wiley.com/college/raven> (select Chapter 8 from the Table of Contents) for links to more information about the controversies surrounding U.S. immigration policies. Consider the opposing views of supporters and opponents to current immigration policies, and debate the issues with your classmates. You will find tools to help you organize your research, analyze the data, think critically about

Stand activities can be done individually or as part of a team, as oral presentations, written exercises, or Web-based (e-mail) assignments.

Additional on-line materials relating to this chapter, including Student Quizzes, Activity Links, Useful Web Sites, Flash Cards, and more, can also be found on our Web site.

**Suggested Reading** provides current references for further learning.

**2002 World Population Data Sheet**, provided by the Population Reference Bureau, is folded into the text (inside the back cover) and is intended to be pulled out for classroom use. Chapter 8 provides a student assignment of questions about population based on the data sheet.



## ORGANIZATION

Educators present the major topics of an introductory environmental science course in a variety of orders. We make no pretense that we have found the best way to organize the subject of environmental science. However, we have put our best efforts into writing the seven parts and their chapters so that they can be successfully presented in any number of sequences.

**Part 1, Humans in the Environment**, introduces environmental science and current environmental concerns. The three chapters in this section also develop the scientific process and examine how human endeavors such as economics, government policies, and environmental ethics affect the environment.

**Part 2, The World We Live In**, provides a detailed introduction to basic ecological principles. This part, which consists of four chapters, is organized around the ecosystem, which is the fundamental unit of ecology.

**Part 3, A Crowded World**, discusses the principles of population ecology and emphasizes the fact that human populations comply with the same principles of population ecology as other organisms. The two chapters in this part also examine urbanization and other sociological and cultural factors that affect human population growth.

**Part 4, The Search for Energy**, considers the environmental impact of the human quest for energy. This part, which consists of three chapters, discusses key issues associated with the use of fossil fuels, nuclear power, and renewable energy sources.

**Part 5, Our Precious Resources**, examines the overuse and abuse of our natural resources. The six chapters in this section explore resource issues and dilemmas involving water, soil, minerals, biological resources, land, and food production.

The five chapters in **Part 6, Environmental Concerns**, review the effects of local, regional, and global pollution. We discuss the problems associated with air pollution, acid deposition, global climate change, stratospheric ozone destruction, water and soil pollution, pesticide pollution, and solid and hazardous wastes.

**Part 7, Tomorrow's World**, concludes the book with a single chapter that presents the opinions of the authors on social responsibilities, identifying some of the most critical issues that must be grappled with today to assure a better tomorrow.

balance and eliminate bias. A complete list of all changes and updates to the fourth edition is too long to fit in the Preface, but one or two of the more important changes to each chapter follows:

**Chapter 1, Our Changing Environment**, provides a new Chapter Introduction on the Lewis Center of Oberlin College, a new Envirobrief on the invasion of jellyfish in the Gulf of Mexico, and a new Meeting the Challenge box on the 2002 World Summit. **Chapter 2, Using Science to Address Environmental Problems**, contains expanded coverage of toxicology, a new section on the precautionary principle, a new Table on the probability of risk of dying by selected causes, and a new Mini-Glossary of toxicology terms. **Chapter 3, Environmental History, Legislation, and Economics**, offers expanded coverage of both environmental history and environmental economics.

**Chapter 4, Ecosystems and Energy**, presents additional discussion on the concept of ecosystems, updates Vitousek's groundbreaking research on the human appropriation of land-based net primary productivity, and contains a new Envirobrief on unintended changes in food webs. **Chapter 5, Ecosystems and Living Organisms**, increases coverage of evolution, the mechanisms that underlie succession, and the concept of keystone species; it also has a new Table on ecosystem services. **Chapter 6, Ecosystems and the Physical Environment**, contains new sections on the sulfur cycle and on humans and the hydrologic cycle; in addition, much of the artwork in this chapter has been redrawn. **Chapter 7, Major Ecosystems of the World**, has a new Case-in-Point on the Chesapeake Bay, a new Envirobrief on using goats to fight fires, and an updated section on the Florida Everglades.

**Chapter 8, Understanding Population Change**, contains a new section on population boom-bust cycles and density dependence, as well as additional discussion of Malthus' ideas. **Chapter 9, Facing the Problems of Overpopulation**, has new discussions of ecological footprints and sustainable consumption, as well as a new Mini-Glossary of consumption terms.

**Chapter 10, Fossil Fuels**, contains a new Mini-Glossary of synfuel terms and a presentation of Bush's National Energy Policy. **Chapter 11, Nuclear Energy**, has updates on breeder reactors, fixing technical and safety problems in existing nuclear power plants, Chernobyl, and Yucca Mountain. **Chapter 12, Renewable Energy and Conservation**, contains a new Mini-Glossary on direct solar energy terms and a new Table of energy intensities in selected countries.

**Chapter 13, Water: A Fragile Resource**, updates the Case-in-Point on the declining condition of the Missouri River and contains a new Mini-Glossary of water terms. **Chapter 14, Soils and Their Preservation**, has new material on agroforestry, the 2001 soil study by the International Food Policy Research Institute, and sod-busting associated with the Grassland Reserve Program. **Chapter 15, Minerals: A Nonrenewable Resource**,

## MAJOR CHANGES IN THE FOURTH EDITION

Issues in environmental science change rapidly, and the fourth edition of *Environment* is therefore a major revision. Overall, the authors meticulously updated and verified all facts and made a serious attempt to provide more



contains updates on diamonds and gold and on Copper Basin. **Chapter 16, Preserving Earth's Biological Diversity**, has a new section on Earth's 25 biodiversity hotspots, expanded coverage on the concepts that guide conservation biologists, and a new Envirobrief on when one rare species eats another. Coverage of forestry was significantly expanded in **Chapter 17, Land Resources and Conservation**, which also has a new Envirobrief on taking cattle "to the bank." **Chapter 18, Food Resources: A Challenge for Agriculture**, contains improved definitions of the principal types of agriculture in the body of the chapter as well as in a new Mini-Glossary; Chapter 18 also has a new section on food safety and updates on the use of low-dose antibiotics for livestock.

**Chapter 19, Air Pollution**, has a better explanation for how a temperature inversion occurs in the Los Angeles basin, a new Mini-Glossary of Air Pollutants, and significant updates on air pollution and human health, Mexico City, and clean cars. New updates on the IPCC Third Assessment Report, melting of glaciers and icecaps, rising sea levels, the effects of climate change on organisms and on human health, and the status of the Kyoto Protocol are found in **Chapter 20, Regional and Global Atmospheric Changes**. **Chapter 21, Water and Soil Pollution**, has new material on bacterial source testing, a 2002 study of organic pollutants in U.S. waterways, and groundwater pollution in Santa Monica, California. **Chapter 22, The Pesticide Dilemma**, has new paragraphs on resistance management for weeds and on the possible link between pesticides and Parkinson's disease, as well as an updated section on the global ban of persistent organic pollutants. New information on computer waste, the *Khian Sea* saga, and how PCBs bioaccumulate in food webs is found in **Chapter 23, Solid and Hazardous Wastes**.

**Chapter 24, Tomorrow's World**, now has pedagogical material, including new Learning Objectives, a new Summary with Selected Key Terms, new Thinking About the Environment questions, and new Suggested Readings; a new Table shows U.S. participation in selected international environmental treaties.

## SUPPLEMENTS

The package accompanying *Environment*, 4/e includes several items developed specifically to augment students' understanding of environmental issues and concerns. Together, these ancillaries provide instructors and students with interesting and helpful teaching and learning tools and take full advantage of both electronic and print media.

### For the Student and the Instructor

The newly expanded and revised *Environment*, 4/e, **Web site** coauthored by Chris Migliaccio, Miami-Dade

Community College, Wolfson Campus, and Greg Ballinger, Miami-Dade Community College, Kendall Campus is located at [www.wiley.com/college/raven](http://www.wiley.com/college/raven). Some of the Student Resources at this site include Useful Web Sites; Take a Stand (see description above); Activity Links; Quizzes for student self-testing; and Flash Cards. Some of the Instructor Resources include an Image Bank of **all** of the line illustrations in the textbook in jpeg format; and the Instructor's Manual/Test Bank.

### For the Student

**Study Guide** by John Aliff, Georgia Perimeter College. This innovative guide not only helps students learn the details of environmental science but also fosters critical thinking skills and scientific reasoning. Each chapter includes Learning Objectives, Vocabulary Review, Critical thinking Questions, Matching Questions, and Multiple Choice Questions. The Study Guide also includes suggested Web sites and further reading.

### For the Instructor

**Instructor's Manual/Test Bank** by Wendy Ryan, Kutztown University. This resource contains lecture outlines, key terms, and test bank questions. The test bank consists of 40 to 50 challenging multiple-choice questions per chapter, as well as true/false, matching, short answer, and thought questions, with answers provided.

**Computerized Test Bank.** The easy-to-use test-generation program fully supports graphics, print tests, student answer sheets, and answer keys. The software's advanced features allow you to create an exam to your exact specifications.

**Instructor's Resource™ CD-ROM** contains all of the line illustrations from *Environment*, 4/e, in jpeg format so that the images can be used in a variety of ways: to include in PowerPoint™ presentations, to custom-make additional four-color overhead transparencies, to import to a Web site, and more.

**Overhead Transparency Acetates.** The full-color set includes 150 transparencies with figures from the text. Overhead transparencies have been reformatted with large-print labeling for easy viewing in any classroom.

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### The Editorial Environment

We are privileged to work on this edition with our new publisher, John Wiley and Sons, which is unsurpassed in the college textbook industry. Preparing this book has been an enormous undertaking, but working with the outstanding editorial and production staff at John Wiley and Sons has made it an enjoyable task. We thank our Publisher Kaye Pace and Editor Keri Witman for their support, enthusiasm, and ideas. Senior Developmental Editor Ellen Ford expertly guided us through the revision process, coordinated the final stages of development, and provided us with valuable suggestions before the project went into production. We thank Geraldine Osnato for overseeing and coordinating the development of the supplements, and Maureen Powers, for her editorial assistance.

We are grateful to Senior Marketing Manager Clay Stone for his superb marketing and sales efforts.

We thank Teri Stratford for her contribution as photo researcher, helping us find the wonderful photographs that enhance the text. We appreciate the artistic expertise of Maddy Lesure for a striking cover design, Production Editor Norine Pigliucci for her efforts in maintaining a smooth production process, and Sandra Rigby, who coordinated the art development and ensured that a consistent standard of quality was maintained throughout the illustration program. We greatly appreciate our Project Editor, Larry Meyer of Hermitage Publishing Services, for guiding us through the many deadlines of production.

Our colleagues and students have provided us with valuable input and have played an important role in shaping *Environment*, 4/e. We thank them and ask for additional comments and suggestions from instructors and students who use this text. You can reach us through our editors at John Wiley and Sons; they will see that we get your comments. Any errors can be corrected in subsequent printings of the book, and more general suggestions can be incorporated into future editions.

### The Professional Environment

The success of *Environment*, 4/e, is due largely to the quality of the many professors and specialists who have

read the manuscript during various stages of its preparation and provided us with valuable suggestions for improving it. We appreciate the efforts of Alan R. Berg, who was instrumental in researching and analyzing the data used in the fourth edition. Special thanks go to Mas-hood Ahmed Siddiqui, Assistant Director, Environmental Protection Agency, Pakistan, for his invaluable insights into environmental problems outside the United States and Canada. In addition, the reviewers of the first three editions made important contributions that are still part of this book. They are as follows:

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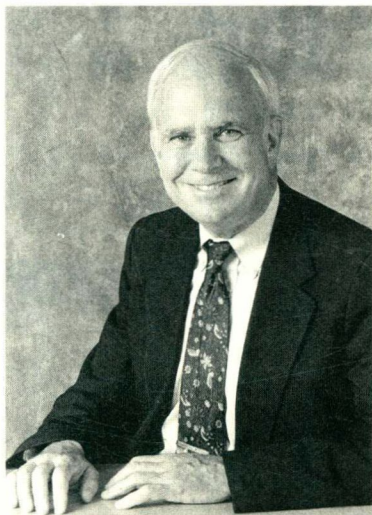
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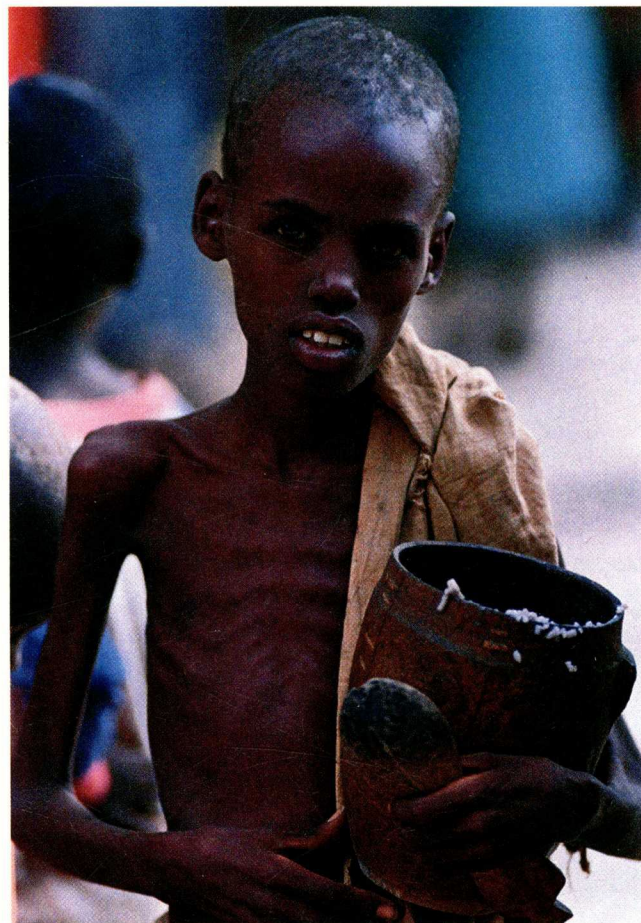
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