

Environmental Science *Systems & Solutions*

SIXTH EDITION

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To my children, Jeannie, Michael, Holli, and Maddi

–MLM

To my sons, Nicholas Schoch and Edward Schoch

–RMS

To my parents, Liane Salgado and Don Yonavjak

–LY

To my parents, Christine Kolich Tillman and Lloyd Thomas Mincy

–GAM

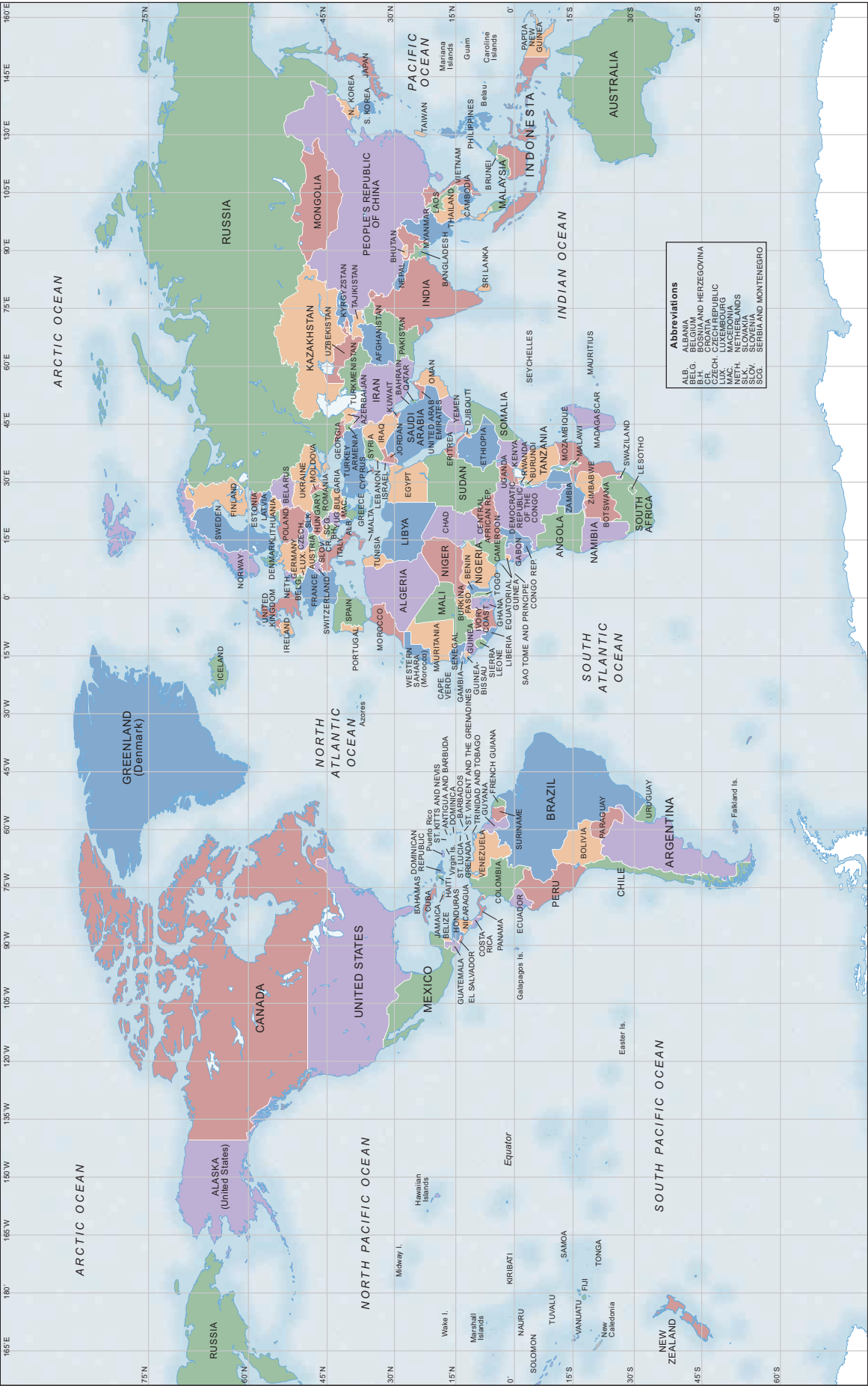
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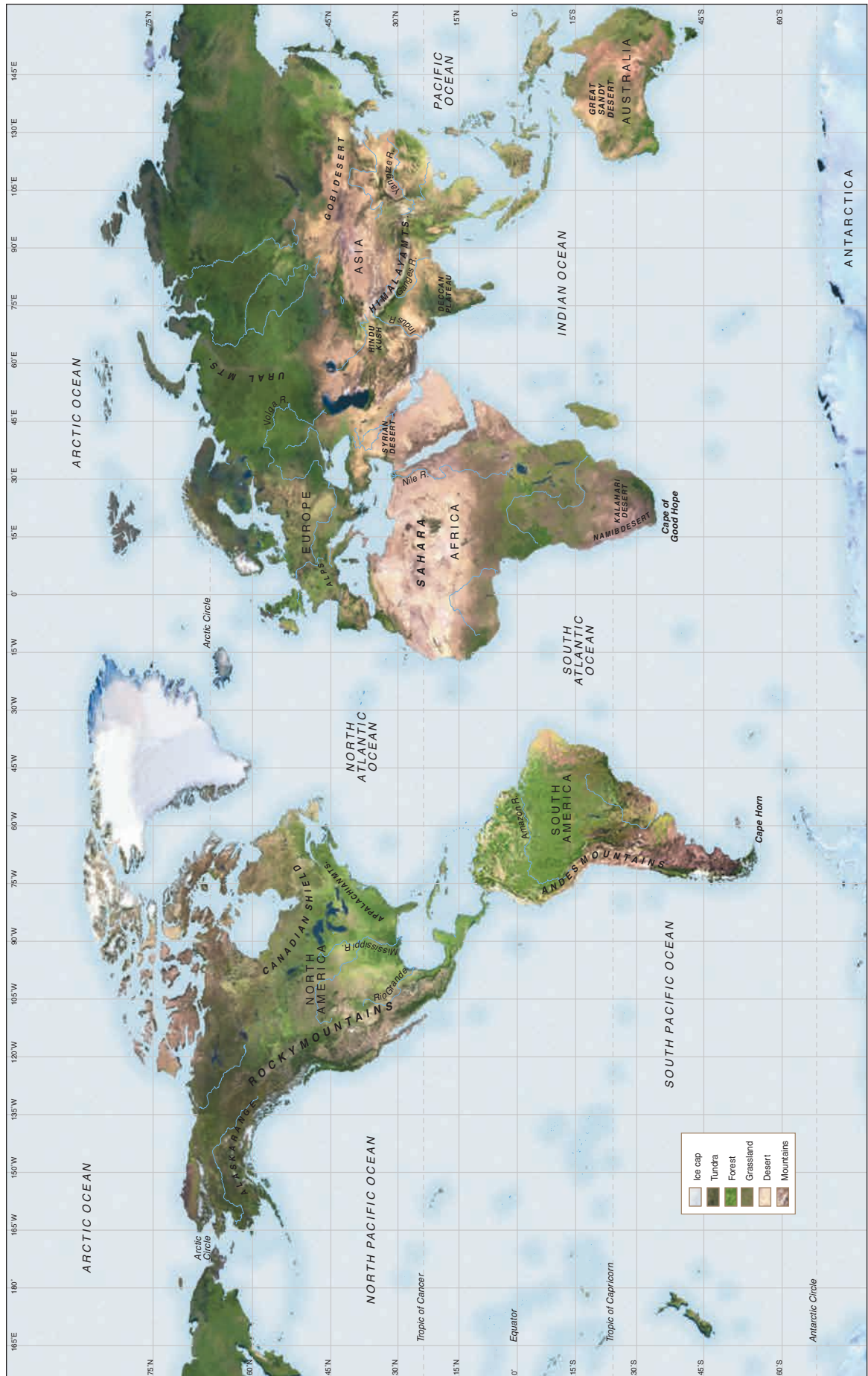
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Political Map of the World



Physical Map of the World





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Preface

The future which we hold in trust for our own children will be shaped by our fairness to other people's children.

—Marian Wright Edelman

Nothing is more honorable to any large mass of people assembled for the purpose of a fair discussion, than that kind and respectful attention that is yielded not only to your political friends, but to those who are opposed to you in politics.

—Stephen Douglas, from the Lincoln–Douglas debates

THE CRITICAL IMPORTANCE of environmental science and environmental studies cannot be disputed as virtually everyone is aware of the issues—be they climate change, the depletion of the ozone layer, the controversy over nuclear power, or the continuing problems of water pollution and solid waste disposal. Issues regarding the environment are in the news every day, and as the world becomes increasingly industrialized we will surely hear more about environmental concerns and advances. *Environmental Science: Systems and Solutions, Sixth Edition*, offers the basic principles necessary to understand and address these multifaceted and often very complex environmental concerns.

We wrote this book to serve as a comprehensive overview and synthesis of environmental science. *Environmental Science: Systems and Solutions* provides the reader with the basic factual data necessary to understand current environmental issues. But to know the raw facts is not enough. A well-informed person must understand how various aspects of the natural environment interconnect with each other and with human society. We thus use a systems approach as a means of organizing complex information in a way that highlights connections for the reader. The systems approach allows the reader to take in the information without feeling overwhelmed, as often happens when large amounts of information are presented in a disorganized fashion. With a subject as diverse as environmental science, it is easy to get lost in the details. We have always kept the “big picture” in mind.

All too often environmental discussions become bogged down in partisan rhetoric or “gloom and doom” tactics. Our intention is not to preach but to inform. Accordingly, in approaching what is often an extremely controversial subject, we have adopted an objective and practical perspective that tries to highlight what is going right in dealing with modern environmental problems. Furthermore, we have consciously aimed at being both fair and balanced (presenting differing opinions and information) in our approach to many controversial issues. In this text, you will read critical analyses of public and private policy with an honest discussion of what has worked and what has failed.

A key concept among modern environmentalists is sustainability. In this book, we have adopted the sustainability paradigm: we focus on sustainable technologies and economic systems and the ways that sustainable development can be implemented around the world. Our emphasis is on specific examples that can give concrete meaning to the concept: Sustainable technological and social solutions to environmental problems are discussed throughout the book. Environmental science is global in scope so it is important for all of us to know that there are regional and local solutions to complex global problems and that individual actions can be a big part of the solution. We hope to inspire the reader to move beyond simple awareness of current environmental problems to become an active promoter of sustainable solutions to these problems.

► Organization and What's New in This Edition

Building on the framework of the five previous editions, we have rewritten the text to improve the discourse. Furthermore, recent disasters and noteworthy updates are reflected in this edition. We have updated case studies that cover topics relevant to the

current environmental situation, including captive breeding, Hurricane Katrina, the Colorado River, sustainable agriculture practices, overpopulation concerns, the Keystone XL pipeline, pollution, the Flint water crisis, global earthquakes, and measuring ecological footprints. Additional changes include updated statistics throughout the text, revised and updated figures and tables, and more coverage of sustainability, climate change, fossil fuels, national parks, and water resources. We believe that all of these changes will make the book both more timely and more accessible to the reader. The five sections of the book are:

Section 1, The Environment and People (Chapters 1 and 2), introduces the systems approach and gives an overview of environmental science in Chapter 1, while Chapter 2 focuses on the increasing impact that the growing human population has had on all natural systems.

Section 2, The Environment of Life on Planet Earth (Chapters 3 through 5), describes how natural systems work, including both biological systems and physical systems. Here we introduce such concepts as populations, communities, ecosystems, the distribution of life on Earth, biogeochemical cycles, weather patterns and climatic zones, the rock cycle and plate tectonics, deep time, and natural hazards.

Section 3, Resource Use and Management (Chapters 6 through 13), deals with issues surrounding the use of natural resources by human society. Chapter 6 introduces the broad principles of resource management, both in urban and wild environments. The following chapters address energy use, water use, mineral use, ecosystem services, and the use of biological resources (including agriculture and soil resources). A major theme is that humans have been rapidly depleting many of these resources and that we must begin using them in a sustainable manner if we are to survive and flourish in the future.

Section 4, Dealing with Environmental Degradation (Chapters 14 through 18), concentrates on various forms of pollution and waste—the results of dumping large amounts of the by-products of human society into the environment. Chapter 14 introduces the

principles of pollution control, toxicology, and risk, while subsequent chapters deal with such subjects as water pollution, air pollution, the destruction of the ozone layer, global climate change, municipal solid waste, and hazardous waste. Every chapter includes discussions of how we can limit or mitigate the effects of excessive pollution, especially by limiting the production of pollutants in the first place, as well as by increased efficiency, reuse, recycling, and substitutions.

Section 5, Social Solutions to Environmental Concerns (Chapters 19 and 20), includes discussions of economic, social, historical, and legal aspects of environmental issues. A major emphasis of the book is on solutions to current environmental concerns. Woven throughout the text are discussions and examples of environmentally friendly technological, legal, and economic solutions. We firmly believe that sustainable and realistic solutions must be implemented and that the root causes of the environmental problems we now face must be addressed. Such problems cannot be solved using science and technology alone; the human aspect must also be taken into account. This section is available online and in eBook formats.

► Using This Book for a Course in Environmental Science or Environmental Studies

We designed this book to be accessible to introductory nonmajor students, but it has enough depth and breadth to be used in a majors' course. It can be adapted to either an environmental science course or an environmental studies course, and it can be used for either one or two semesters. Also, we designed the book so that the chapters need not necessarily be used in the order in which they appear. In particular, depending on the nature and emphasis of a specific course, an instructor may choose to use the chapters of Section 5 (Social Solutions to Environmental Concerns) at either the beginning or end of the course, or these or other chapters may be omitted entirely.

Assuming a standard 15 full weeks for a semester (usually about a week is lost due to holidays, exams,

and the like), the chapters of this text might be assigned according to one of the following schedules:

For a comprehensive environmental science and environmental studies course:

- Week 1:** Chapters 1 & 2, An Overview of Environmental Science and Human Population Growth
- Week 2:** Chapter 3, The Ever-Changing Earth: The Biosphere and Biogeochemical Cycles
- Week 3:** Chapters 4 & 5, The Distribution of Life on Earth and Dynamic Earth and Natural Hazards
- Week 4:** Chapter 6, People and Natural Resources
- Week 5:** Chapter 7, Fundamentals of Energy, Fossil Fuels, and Nuclear Energy
- Week 6:** Chapter 8, Renewable (including Hydropower) and Alternative Energy Sources
- Week 7:** Chapters 9 & 10, Water and Mineral Resources
- Week 8:** Chapter 11, Conserving Biological Resources
- Week 9:** Chapter 12, Land Resources and Management
- Week 10:** Chapter 13, Food and Soil Resources
- Week 11:** Chapters 14 & 15, Principles of Pollution Control and Water Pollution
- Week 12:** Chapter 16, Local and Regional Air Pollution
- Week 13:** Chapter 17, Destruction of the Ozone Layer and Global Climate Change
- Week 14:** Chapter 18, Municipal Solid Waste and Hazardous Waste
- Week 15:** Chapters 19 & 20, Economic, Historical, Social, and Legal Aspects of Current Environmental Concerns

For a basic environmental science course:

- Week 1:** Chapters 1 & 2, An Overview of Environmental Science and Human Population Growth
- Week 2:** Chapter 3, The Ever-Changing Earth: The Biosphere and Biogeochemical Cycles
- Week 3:** Chapter 4, The Distribution of Life on Earth
- Week 4:** Chapter 5, The Dynamic Earth and Natural Hazards
- Week 5:** Chapter 6, People and Natural Resources
- Week 6:** Chapter 7, Fossil Fuels and Nuclear Energy
- Week 7:** Chapter 8, Renewable (including Hydropower) and Alternative Energy Sources
- Week 8:** Chapters 9 & 10, Water and Mineral Resources
- Week 9:** Chapter 11, Conserving Biological Resources
- Week 10:** Chapter 12, Land Resources and Management
- Week 11:** Chapter 13, Food and Soil Resources
- Week 12:** Chapters 14 & 15, Principles of Pollution Control and Water Pollution
- Week 13:** Chapter 16, Local and Regional Air Pollution
- Week 14:** Chapter 17, Destruction of the Ozone Layer and Global Climate Change
- Week 15:** Chapter 18, Municipal Solid Waste and Hazardous Waste

For a general environmental studies course (emphasizing social and historical aspects):

Week 1: Chapter 1, An Overview of Environmental Science

Week 2: Chapter 17, Destruction of the Ozone Layer and Global Climate Change—Examples of the impacts humans are having on the environment

Week 3: Chapter 20, Historical, Cultural, and Legal Aspects of Current Environmental Concerns

Week 4: Chapter 2, Human Population Growth

Week 5: Chapter 6, People and Natural Resources

Week 6: Chapter 7, Fossil Fuels and Nuclear Energy

Week 7: Chapter 8, Renewable (including Hydropower) and Alternative Energy Sources

Week 8: Chapters 9 & 10, Water and Mineral Resources

Week 9: Chapter 11, Conserving Biological Resources

Week 10: Chapter 12, Land Resources and Management

Week 11: Chapter 13, Food and Soil Resources

Week 12: Chapters 14 & 15, Principles of Pollution Control and Water Pollution

Week 13: Chapter 16, Local and Regional Air Pollution

Week 14: Chapter 18, Municipal Solid Waste and Hazardous Waste

Week 15: Chapter 19, Environmental Economics

If this book is used for a two-semester course, some of the chapters should be used over a period longer than 1 week. In particular, we recommend that the following chapters be split as indicated and extended over 2 weeks:

Chapter 3, The Ever-Changing Earth: The Biosphere and Biogeochemical Cycles

Chapter 4, The Distribution of Life on Earth

Chapter 5, The Dynamic Earth and Natural Hazards

Chapter 7, Fundamentals of Energy & Fossil Fuels/Nuclear Energy

Chapter 8, Renewable and Alternative Energy Sources

Chapter 13, Food/Soil Resources

Chapter 14, Pollution Control/Toxicology

Chapter 17, Destruction of the Ozone Layer/Global Climate Change

Chapter 18, Municipal Solid Waste/Hazardous Waste

Chapter 20, Historical and Social Perspectives/Environmental Law and Decision Making

If these chapters are used as suggested, then chapter or subchapter readings from the text will easily fit into a two-semester schedule (approximately 30 full weeks).

► The Student Experience

Each chapter uses the same basic organizational format. Following an opening photograph and learning objectives, the chapter begins with an introduction that offers an overview of the subject matter of the chapter and places it in context.



CHAPTER 14 Principles of Pollution Control, Toxicology, and Risk

CHAPTER OBJECTIVES

After reading this chapter, you should be able to do the following:

- Describe what is meant by "pollution"
- Explain how pollution is produced
- Describe how pollution can be controlled
- Critique testing for toxic chemicals
- Reflect on how society copes with risk
- Weigh the costs and benefits of avoidance

Chapter Opening Image: Nearly all human activities produce waste that will find its way into the air, water, and soil. To mitigate this challenge, scientists and international citizen groups are working in their communities to make a positive impact on the infrastructure and behaviors that will increase societal sustainability. Even if you do not have the time to volunteer or the financial means to contribute to a cause, the most thoughtful actions made daily in our behavior can have significant global consequences. For example, conserving kitchen waste properly in a caddy could reduce annual landfill waste by at least 17 to 20%. Environmental Protection Agency report from 2012 estimates that Americans could keep 140 pounds of waste per person per year out of the landfill by composting. The water report notes that food waste decomposition in landfill accounts for nearly a quarter of the nation's methane emissions—go with 25 times the warming potential of carbon dioxide. Furthermore, recent studies suggest that through a "zero waste" commitment throughout the entire United States, the collection and reuse programs can emissions that would amount to saving 27% of U.S. coal-fired power plants. Additionally, establishing a backyard kitchen for using food or creating a butterfly garden on a balcony all help to conserve space in small ways, especially during emergency times. When it comes to the best way to conserve Earth's resources for future generations, being thoughtful of everyday impacts can truly make a big difference.

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We have written the text to be interesting and accessible to the average reader, and we have illustrated it with numerous diagrams, charts, tables, and photographs demonstrating basic concepts and key ideas. Throughout the text key terms denoting important concepts are in **boldface** type.

Environmental problems often are caused by resource depletion or excess inputs to society due to too many outputs by society. Many of these outputs involve the release of chemicals into the environment. It is important to know which chemicals in our daily lives impose the greatest risks to our health. Despite many problems (both of an ethical sort and questions involving the applicability of animal data to humans), data gathered from laboratory animals provide the most widely used way of making sound decisions about whether chemical products, including pesticides, should be used.

14.1 What Is Pollution?

Pollution generally refers to society's excess inputs into the environment. In this case, "excess" means something produced in amounts high enough to be harmful to us, other life, or valued objects, such as cars and buildings. Almost anything can be harmful if it is concentrated enough in a particular context, so all matter and energy can cause pollution if locally produced in sufficient amounts (e.g., carbon dioxide). Because pollution is such a widespread environmental problem, many aspects of it deserve special consideration.

- **Pollution as matter cycling and energy flow.** All of the environment, including land, sea, air, and life, ultimately consists of matter cycles and energy flows. Pollution represents local concentrations in the matter cycle or energy flow. For instance, the rapid burning of fossil fuels releases into the atmosphere tons of carbon that was stored underground as coal and petroleum. Similarly, concentrations of energy can be a form of pollution. Heat pollution is a serious form of air and water pollution. Automobiles speak of "high pollution" from idling cars that dump their heat into the air.
- **Pollution as an accelerated natural process.** Pollution is often associated with building factories, but many natural processes have been causing "pollution" for billions of years. For example, volcanic release gases that are harmful to life, affect global climate, and cause acid rain. Many organisms produce highly toxic chemicals.

However, people cause pollution at a much greater rate than nature does for two reasons, which are related to both the quantity and the quality of our waste:

1. The quantity of waste produced every day is staggering. For example, the more than 8.795

14.1 What Is Pollution? 379

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A **Study Guide** at the end of each chapter includes a bulleted summary, a list of the chapter's key terms, and several kinds of questions. Answers to the odd-numbered questions are available online.

Study Guide

Summary

- Major components of the Earth's internal structure include the crust, lithosphere, asthenosphere, mantle, and core.
- The lithosphere (crust and upper mantle) is divided into plates that move relative to one another.
- Plate tectonics, the unifying theory of geology, can account for the distribution of major features (such as mountain ranges, earthquake zones, and volcanoes) on the surface of Earth.
- Rocks are formed primarily of minerals, which are, in turn, formed of atoms.

New Terms

anthropogenic	desert pavement
albedo	drainage basin
atmosphere	droughts
atmospheric cycle	earthquakes
atoms	elements
climate	evapotranspiration
compound	flood
continental crust	hydrologic cycle
convection cells	igneous rocks
core	lithosphere
Coriolis effect	mantle
craters	Mercalli scale

Study Questions

1. If you could cut a slit through the Earth, what would you encounter?
2. Describe the modern theory of plate tectonics. What is the elemental composition of matter on Earth?
3. What is the hydrologic cycle?
4. What role do geo-chemical cycles contribute to large-scale atmospheric cycles and climatic belts?
5. What happens when warm, moist air rises and cools?
6. Using sketch diagrams as necessary, describe the major atmospheric circulation patterns on Earth.
7. What is the source of the most powerful natural hazards?
8. What approaches have scientists used in their attempts to predict future earthquake activity?
9. Describe some of the most important weather hazards. What, if anything, can people do to prepare for such disasters?
10. Why did the Americans that flew over the Gulf of Mexico in 1946 not see the nuclear cloud that was being blown to prevent such disasters?

Calculations

- [illegible]

Illustration and Table Review

- E. Study Table 5.3, which shows the Mercalli scale. Have you ever experienced an earthquake? If so, where would you judge that it fell on the Mercalli scale? If you have not experienced an earthquake, either talk to someone firsthand about an earthquake experience and

English to Metric		
	English	Metric
Length:	1 inch (in)	2.54 centimeters (cm) (exactly)
	1 foot (ft)	30.48 cm (exactly) 0.3048 meters (m) (exactly)
1 yard (yd)		91.44 cm (exactly) 0.9144 m (exactly)
	1 mile (5280 ft)	1609.34 m (exactly) 1.60934 kilometers (km) (exactly)
Mass (weight):	1 ounce, avoirdupois	28.3495231 grams (g)
	1 pound (lb), avoirdupois	453.59237 g (exactly) 0.45359237 kilograms (kg) (exactly)
	1 ton, net or short (2000 lb)	907.18474 kg 907.18474 metric ton
	1 square inch (in ²)	6.4516 cm ² (exactly)
Area:	1 square foot (ft ²)	0.092903 m ² (exactly)
	1 square yard (yd ²)	0.836127 m ²
	1 acre (43,560 ft ²)	4046.86 m ² 0.404686 hectares (ha)
	1 square mile	256,000 ha 2,589,975 km ²
Volume:	1 cubic inch (in ³)	16.38706 cm ³
	1 cubic foot (ft ³)	0.028317 m ³
	1 cubic yard (yd ³)	0.764555 m ³
	1 gallon (U.S.)	3.785 liters (l) 0.946 l
	1 liquid quart (U.S.)	0.946 l 0.9463735 liters (l)

Temperature: 1 degree Fahrenheit equals 5/9 (555555) degree Celsius (Celsius). To convert a temperature in degrees Fahrenheit to the equivalent temperature in Celsius, subtract 32 and divide by 1.8; degrees C = (degrees F - 32) x 5/9.

Glossary

[illegible]

Index

Page numbers followed by *f* or *t* indicate material in Sources or tables respectively. Entries with bold page references are from online chapters.

[illegible]

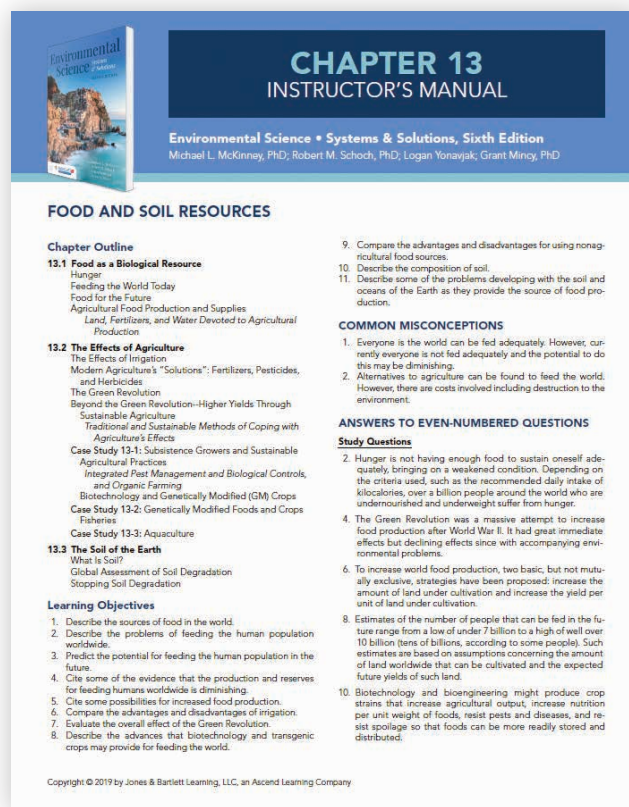
This book includes several special features. On pages iv and v are maps of North America showing the physical geography and political boundaries of all the states and provinces of the United States, Mexico, and Canada. On pages vi and vii are physical and political maps of the world. These maps will serve as handy reference guides for the reader when various states, provinces, and countries are mentioned in the text. It is increasingly important that everyone be familiar with basic global political geography.

— **Appendix:** The book concludes with English/Metric Conversion Tables, a glossary of key terms, and a detailed index.

► Teaching Tools

To assist you in teaching this course and supplying your students with the best in teaching aids, Jones & Bartlett Learning, in conjunction with Stacy K. Zell, PhD of Carroll Community College in Westminster, Maryland, has prepared a complete ancillary package available to all adopters of the text. Additional information and review copies of any of the following items are available through your Jones & Bartlett Learning Sales Representative.

The Instructor's Manual includes complete chapter lecture outlines, learning objectives, discussions of common student misconceptions, and answers to the even-numbered study questions in the text.



FOOD AND SOIL RESOURCES

Chapter Outline

13.1 Food as a Biological Resource

Hunger
Feeding the World Today
Food for the Future
Agricultural Food Production and Supplies
Land, Fertilizers, and Water Devoted to Agricultural Production

13.2 The Effects of Agriculture

The Effects of Irrigation
Modern Agriculture's "Solutions": Fertilizers, Pesticides, and Herbicides
The Green Revolution
Beyond the Green Revolution—Higher Yields Through Sustainable Agriculture
Traditional and Sustainable Methods of Coping with Agriculture's Effects
Case Study 13-1: Subsistence Growers and Sustainable Agricultural Practices
Integrated Pest Management and Biological Controls, and Organic Farming
Biotechnology and Genetically Modified (GM) Crops
Case Study 13-2: Genetically Modified Foods and Crops
Fisheries
Case Study 13-3: Aquaculture

13.3 The Soil of the Earth

What Is Soil?
Global Assessment of Soil Degradation
Stopping Soil Degradation

Learning Objectives

1. Describe the sources of food in the world.
2. Describe the problems of feeding the human population worldwide.
3. Predict the potential for feeding the human population in the future.
4. Cite some of the evidence that the production and reserves for feeding humans worldwide is diminishing.
5. Cite some possibilities for increased food production.
6. Compare the advantages and disadvantages of irrigation.
7. Evaluate the overall effect of the Green Revolution.
8. Describe the advances that biotechnology and transgenic crops may provide for feeding the world.

9. Compare the advantages and disadvantages for using nonagricultural food sources.
10. Describe the composition of soil.
11. Describe some of the problems developing with the soil and oceans of the Earth as they provide the source of food production.

COMMON MISCONCEPTIONS

1. Everyone is the world can be fed adequately. However, currently everyone is not fed adequately and the potential to do this may be diminishing.
2. Alternatives to agriculture can be found to feed the world. However, there are costs involved including destruction to the environment.

ANSWERS TO EVEN-NUMBERED QUESTIONS

Study Questions

2. Hunger is not having enough food to sustain oneself adequately, bringing on a weakened condition. Depending on the criteria used, such as the recommended daily intake of kilocalories, over a billion people around the world who are undernourished and underweight suffer from hunger.
4. The Green Revolution was a massive attempt to increase food production after World War II. It had great immediate effects but declining effects since with accompanying environmental problems.
6. To increase world food production, two basic, but not mutually exclusive, strategies have been proposed: increase the amount of land under cultivation and increase the yield per unit of land under cultivation.
8. Estimates of the number of people that can be fed in the future range from a low of under 7 billion to a high of well over 10 billion (tens of billions, according to some people). Such estimates are based on assumptions concerning the amount of land worldwide that can be cultivated and the expected future yields of such land.
10. Biotechnology and bioengineering might produce crop strains that increase agricultural output, increase nutrition per unit weight of foods, resist pests and diseases, and resist spoilage so that foods can be more readily stored and distributed.

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CHAPTER 13 INSTRUCTOR'S MANUAL

2

12. Integrated Pest Management (IPM) de-emphasizes the use of pesticides and attempts to control, rather than totally eliminate, agricultural pests by using biological predators, rotating fields, interplanting crops, and using other "natural" means.
14. Soil erosion is a major problem. Livestock overgrazing, deforestation, and agriculture account for most of this.
16. No-till sowing of crops, drip irrigation, crop rotation, and leaving the land fallow can prevent soil degradation.

Calculations

2. 5.6 billion acres will be required, or 1.9 billion more acres over the current 3.7 billion acres under cultivation (2.3 billion hectares will be required, or 0.8 billion more hectares over the current 1.5 billion under cultivation).

Illustration and Table Review

2. If present crop yields per land area double and the world population grows according to World Bank estimates, the amount of land that will need to be cultivated in 2050 will be approximately 1.3 billion hectares, which is approximately the amount being cultivated currently.
4. This band of areas that are desert or at risk of desertification is about 7,000 miles long and just to the east of it is another band about 3,000 miles long.

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Evolution of the Biosphere

- In the 1950s, Miller and Urey demonstrated that the complex molecules possessed by all living things are readily produced under laboratory conditions that resemble the early environments of Earth.
- These experiments and other lab work, combined with the fossil record, support the idea that life arose from natural processes.

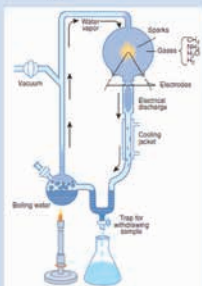


Figure 4.1 Using apparatus similar to this one, Miller and Urey demonstrated that organic molecules can be produced from the chemical components of the Earth's early atmosphere.

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The PowerPoint Lecture Outline presentation package provides lecture notes, graphs, and images for each chapter of *Environmental Science*. Instructors with the Microsoft PowerPoint software can customize the outlines, art, and order of presentation.

Estimating Numbers of Species

- Rain forest insect samples help estimate biodiversity from limited information.
- Ecological ratios use well-studied groups to predict diversity of less-studied groups.
- Species-area curves predict numbers of organisms in unsampled areas.

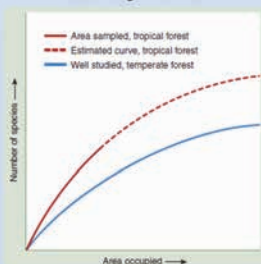


Figure 4.6: A species area curve plots the number of species found in increasingly larger areas. The temperate forests are well-studied compared to tropical forests. Data for tropical forests extrapolated projections (dashed line).

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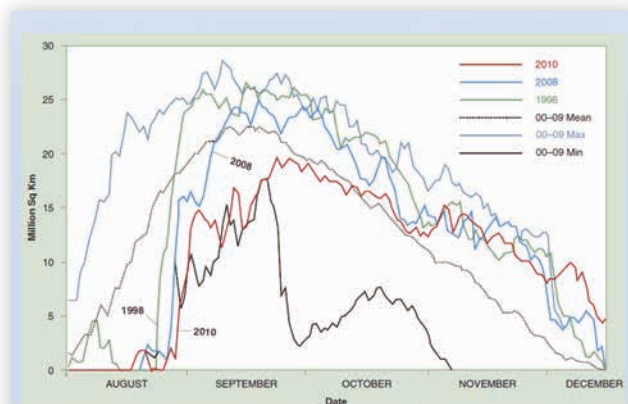


Figure 17.3B. Courtesy of NASA/Goddard Space Flight Center.

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The test bank is available as electronic text files. The test bank contains approximately 2,000 multiple-choice, true/false, fill-in-the-blank, matching, short-answer, analogy, and quantitative questions.

Michael L. McKinney
Robert M. Schoch
Logan Yonavjak
Grant A. Mincy



Figure 11.6. © Frans Lanting/MINT Images/Science Source.

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Acknowledgments

As authors, we are ultimately responsible for the content of this book, but dozens of people have provided help, encouragement, and advice. In particular, we are grateful for the advice of many teachers and practitioners of environmental science. Due to its depth and breadth, environmental science contains far more information than only four people can master, and we drew heavily on the expertise of people who have specialized in its many subfields. We therefore wish to express our deep appreciation to the reviewers of various editions of this book. Reviewers whose input was used for this edition are in bold.

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Michael L. McKinney is Director of the Environmental Studies Program at the University of Tennessee, Knoxville. He is also a Professor in the Geological Science Department and the Ecology & Evolutionary Biology Department. Since 1985, he has taught

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Dr. McKinney has two master's degrees, one from the University of Colorado at Boulder and one from the University of Florida. He received his Ph.D. from Yale University in 1985. Since that time, he has published several books and dozens of technical articles. Most of his recent research has focused on conservation biology. Dr. McKinney has received several teaching awards and a prestigious University award for creative research. He is currently working on a book documenting the harmful impact of urban sprawl on native species.

In addition to his scholarly work, Dr. McKinney is very active in promoting environmental solutions where he lives, the Southern Appalachian bioregion. He is on the Board of Directors of the Foothills Land Conservancy, which is the major private land trust that creates wilderness preserves around the Smoky Mountain National Park. In 2001, Dr. McKinney received the Environmental Achievement award from the city's main newspaper, the *Knoxville News-Sentinel*, given to the individual who has done the most to promote a better environment. Dr. McKinney is also an active member of the Tennessee Citizens for Wilderness Planning, the East Tennessee Sierra Club (Harvey Broome Chapter), the Southern Alliance for Clean Energy, the Tennessee Clean Water Network, and Ijams Nature Center. He writes a bimonthly column called the "Suburban Ecologist" in the *Hellbender*, the environmental newspaper of East Tennessee.

Dr. McKinney lives in Knoxville, Tennessee, where he greatly enjoys hiking and promoting sustainable living.



Robert M. Schoch, a full-time faculty member of the College of General Studies at Boston University, received his Ph.D. in geology and geophysics from Yale University in 1983. Since 1984, he has specialized in teaching undergraduate science, including environmental science, biology, physical

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Dr. Schoch is the author or coauthor of books both technical and popular, including *Phylogeny Reconstruction in Paleontology*; *Stratigraphy: Principles and Methods*; *Horns, Tusks, and Flippers: The Evolution of Hoofed Mammals*; *Voices of the Rocks*; *Voyages of the Pyramid Builders*; *Forgotten Civilization: The Role of Solar Outbursts in Our Past and Future*; and *Origins of the Sphinx*. Keenly interested in how environmental factors have helped shape ancient and modern civilizations, and passionate in his assertion that understanding past environmental changes is important as we face future challenges, Dr. Schoch has undertaken fieldwork in numerous countries, including England, Wales, Scotland, Norway, Malta, Egypt, Turkey, South Africa, Mexico, Peru, Bolivia, Chile (Easter Island), Romania, Bulgaria, Bosnia, India, Japan, and Indonesia.

Besides his academic and scholarly studies, Dr. Schoch is an active environmental advocate who stresses a pragmatic, hands-on approach. In

this connection, he helped found a local community land trust devoted to protecting land from harmful development, for many years serving on its Board of Directors. Furthermore, he takes an active part in “green” politics and for over a decade served as an elected member of the city council of Attleboro, Massachusetts.



Logan Yonavjak is an investment professional who has worked with a variety of organizations on a suite of projects ranging from ESG product development, the development of social and environmental impact metrics

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Grant A. Mincy is an Instructor of Biology at Pellissippi State Community College in Knoxville, Tennessee, where he leads the Concepts of Biology curriculum and teaches courses in general biology and conservation science.

He has also taught physical geology, historical geology, and environmental geology. In the classroom, Grant includes information regarding issues of concern in his town of Knoxville and the Southern Appalachian bioregion. He also likes to discuss local environmental policy and new sustainable initiatives having great success in the area as well.

Grant earned his graduate degree from the University of Tennessee, Knoxville where he studied earth and planetary science with a concentration in conservation biology and environmental science. During his time at the University of Tennessee, Grant was Dr. McKinney’s student and worked on many local and regional environmental research projects with his mentor. Grant is still very active in environmental issues. He serves as the Elinor Ostrom Chair of Environmental Studies and Commons Governance at the Molinari Institute and is also an Energy and Environment Advisory Council Member for the Our America Initiative. He has numerous publications on sites such as *The Ecologist*, *Counter Punch*, and *Resiliency* and has published columns regarding environmental issues in numerous newspapers around the world, including the local *Knoxville News Sentinel* and the *Knoxville Mercury*. In addition, Grant regularly volunteers his time to Ijams Nature Center and encourages service learning in all of his courses.

Grant’s most important role is that of a husband and a father. In his free time he likes to pass the time hiking away the day with his wife and 3-year-old son in the Great Smoky Mountains National Park.

