Environmental Science
Systems & Solutions

SIXTH EDITION

Michael L. McKinney
University of Tennessee, Knoxville

Robert M. Schoch
Boston University

Logan Yonavjak

Grant A. Mincy

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World Headquarters
Jones & Bartlett Learning
5 Wall Street
Burlington, MA 01803
978-443-5000
info@jblearning.com
www.jblearning.com

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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

Satellite Image of North America

Map of North America

Political Map of the World

Physical Map of the World

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Brief Contents

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Contents

SECTION 2 The Environment and History of Life on Planet Earth 57

SECTION 3 Resource Use and Management 157

Chapters 19 and 20 are available online with access code.

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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

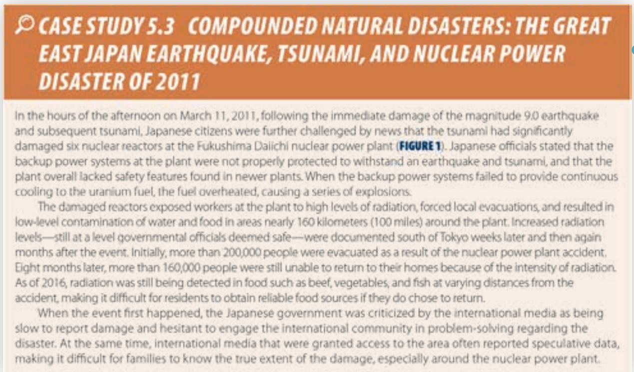
If this book is used for a two-semester course, some of the chapters should be used over a period longer than 1 week. In particular, we recommend that the following chapters be split as indicated and extended over 2 weeks:
Chapter 3, The Ever-Changing Earth: The Biosphere and Biogeochemical Cycles
Chapter 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.

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.

Case Studies: Thought-provoking case studies provide detailed examples of interesting environmental applications, experimental work, and controversies. All of the Case Studies provide follow-up questions that ask the reader to examine the facts, the arguments, and the conclusions.



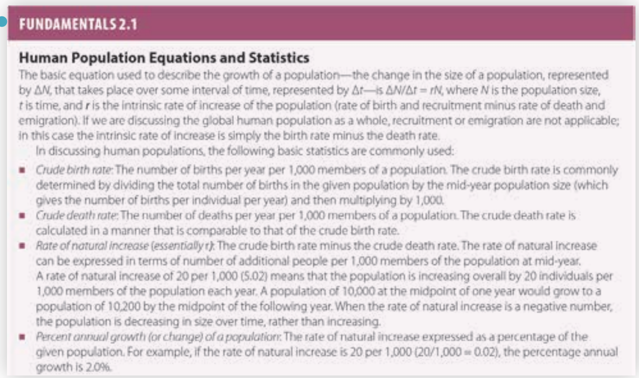
CASE STUDY 5.3 COMPOUNDED NATURAL DISASTERS: THE GREAT EAST JAPAN EARTHQUAKE, TSUNAMI, AND NUCLEAR POWER DISASTER OF 2011

In the hours of the afternoon on March 11, 2011, following the immediate damage of the magnitude 9.0 earthquake and subsequent tsunami, Japanese citizens were further challenged by news that the tsunami had significantly damaged six nuclear reactors at the Fukushima Daiichi nuclear power plant (FIGURE 1). Japanese officials stated that the backup power systems at the plant were not properly protected to withstand an earthquake and tsunami, and that the plant overall lacked safety features found in newer plants. When the backup power systems failed to provide continuous cooling to the uranium fuel, the fuel overheated, causing a series of explosions.

The damaged reactors exposed workers at the plant to high levels of radiation, forced local evacuations, and resulted in low-level contamination of water and food in areas nearly 160 kilometers (100 miles) around the plant. Increased radiation levels—still at a level governmental officials deemed safe—were documented south of Tokyo weeks later and then again months after the event. Initially, more than 200,000 people were evacuated as a result of the nuclear power plant accident. Eight months later, more than 160,000 people were still unable to return to their homes because of the intensity of radiation. As of 2016, radiation was still being detected in food such as beef, vegetables, and fish at varying distances from the accident, making it difficult for residents to obtain reliable food sources if they do chose to return.

When the event first happened, the Japanese government was criticized by the international media as being slow to report damage and hesitant to engage the international community in problem-solving regarding the disaster. At the same time, international media that were granted access to the area often reported speculative data, making it difficult for families to know the true extent of the damage, especially around the nuclear power plant.

Fundamentals boxes: This set of boxes reviews quantitative information covering human population equations and statistics, energy and thermodynamics, and common measures of energy and power.



FUNDAMENTALS 2.1

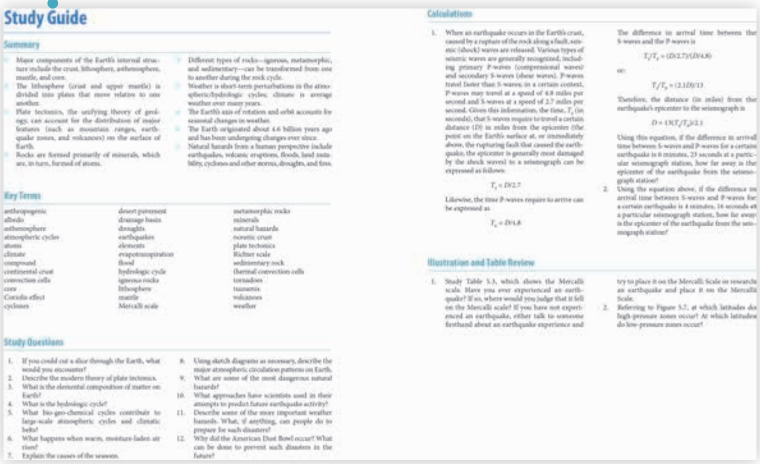
Human Population Equations and Statistics

The basic equation used to describe the growth of a population—the change in the size of a population, represented by ΔN, that takes place over some interval of time, represented by Δt—is $\Delta N/\Delta t = rN$, where N is the population size, t is time, and r is the intrinsic rate of increase of the population (rate of birth and recruitment minus rate of death and emigration). If we are discussing the global human population as a whole, recruitment or emigration are not applicable; in this case the intrinsic rate of increase is simply the birth rate minus the death rate.

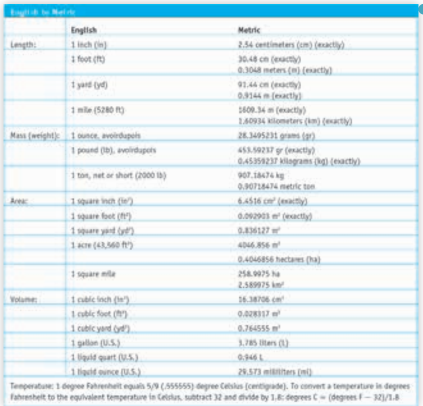
In discussing human populations, the following basic statistics are commonly used:

- *Crude birth rate*: The number of births per year per 1,000 members of a population. The crude birth rate is commonly determined by dividing the total number of births in the given population by the mid-year population size (which gives the number of births per individual per year) and then multiplying by 1,000.
- *Crude death rate*: The number of deaths per year per 1,000 members of a population. The crude death rate is calculated in a manner that is comparable to that of the crude birth rate.
- *Rate of natural increase (essentially r)*: The crude birth rate minus the crude death rate. The rate of natural increase can be expressed in terms of number of additional people per 1,000 members of the population at mid-year. A rate of natural increase of 20 per 1,000 (5.02) means that the population is increasing overall by 20 individuals per 1,000 members of the population each year. A population of 10,000 at the midpoint of one year would grow to a population of 10,200 by the midpoint of the following year. When the rate of natural increase is a negative number, the population is decreasing in size over time, rather than increasing.
- *Percent annual growth (or change) of a population*: The rate of natural increase expressed as a percentage of the given population. For example, if the rate of natural increase is 20 per 1,000 (20/1,000 = 0.02), the percentage annual growth is 2.0%.

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 Questions**: These review questions generally test objective knowledge and require fairly short answers. Some require more analytical and critical-thinking skills.
- **What's the Evidence?** Unique to this book, these innovative questions ask the reader to review the authors' arguments and decide whether the authors have successfully supported their conclusions. The questions then challenge the reader to support their own position if they disagree.
- **Calculations**: Calculation questions, written at a precalculus level or lower, are provided for courses that have a quantitative component.
- **Illustration and Table Review**: These questions are designed to help readers strengthen their data interpretation skills.



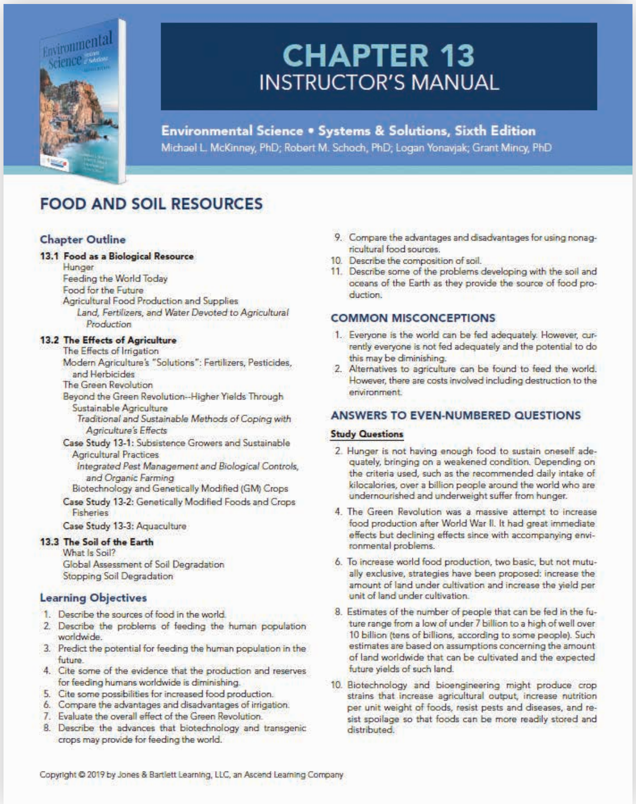
This book includes several special features. On pages iv and v are maps of North America showing the physical geography and political boundaries of all the states and provinces of the United States, Mexico, and Canada. On pages vi and vii are physical and political maps of the world. These maps will 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.



CHAPTER 13
INSTRUCTOR'S MANUAL

Environmental Science • Systems & Solutions, Sixth Edition
Michael L. McKinney, PhD; Robert M. Schoch, PhD; Logan Yonavjak; Grant Mincy, PhD

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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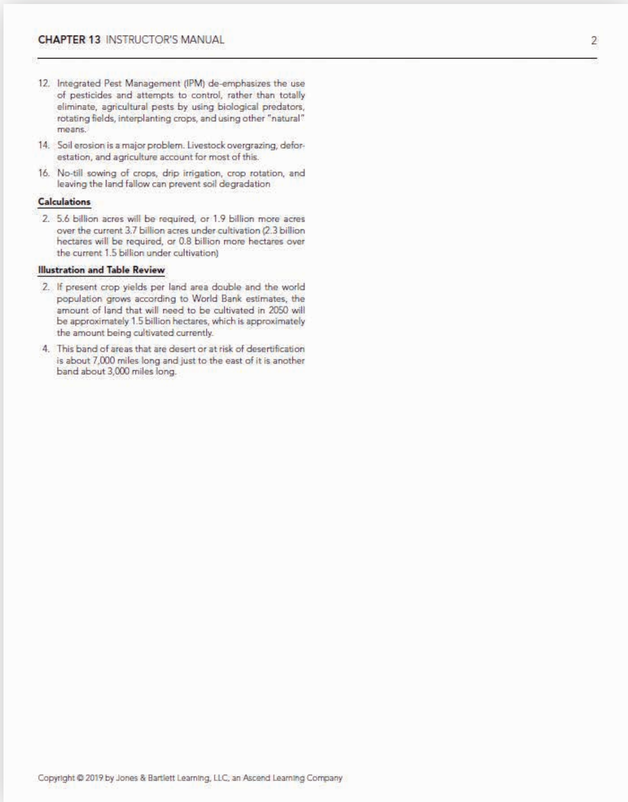

CHAPTER 13 INSTRUCTOR'S MANUAL 2

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 1.5 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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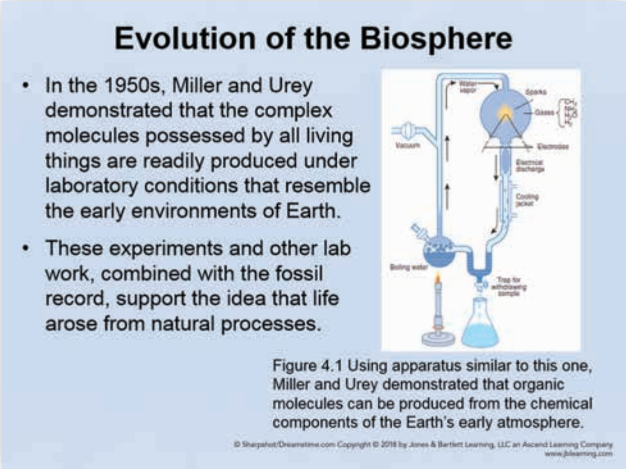
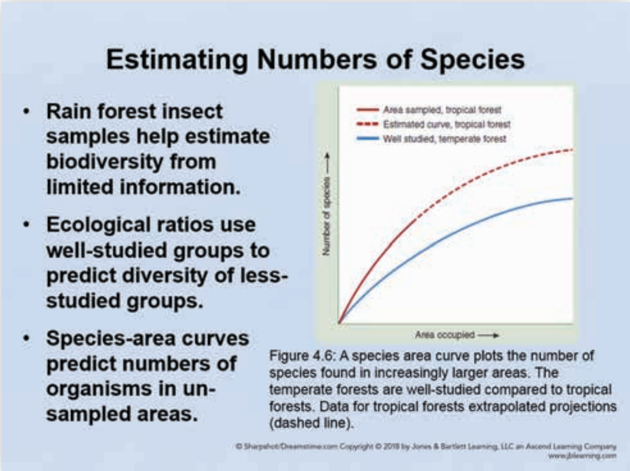
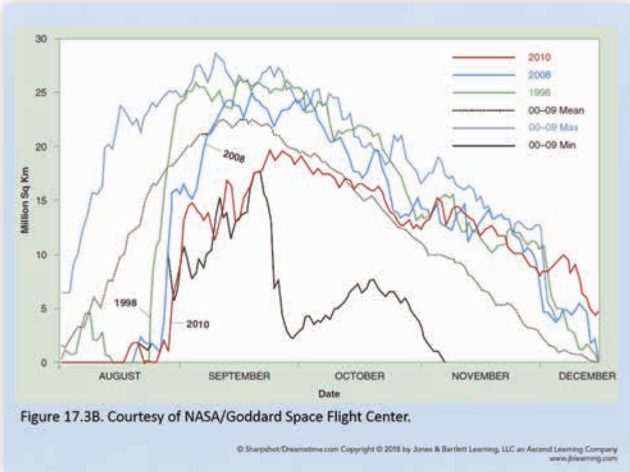




The PowerPoint Lecture Outline presentation package provides lecture notes, graphs, and images for each chapter of *Environmental Science*. Instructors with the Microsoft PowerPoint software can customize the outlines, art, and order of presentation.



The PowerPoint Image Bank provides a library of all of the art, tables, and photographs in the text to which Jones & Bartlett Learning holds the copyright or has permission to reproduce.

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.

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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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C. Lee Rockett	Bowling Green State University
Paul Rowland	Northern Arizona University
Robert Sanford	University of Southern Maine
David B. Scott	Dalhousie University
Terri Jordan Sellers	**Jacksonville University**
Joseph Shostell	Pennsylvania State University, Fayette
Jon Stanley	Metropolitan State College of Denver
Ray Sumner	Los Angeles Valley College
R. Bruce Sundrud	Harrisburg Area Community College
Peter G. Sutterlin	Wichita State University
Jody A. C. Terrell	**Texas Woman's University**
Christopher Thoms	Knox College
S. Carl Tobin	Utah Valley State College
Jerry Towle	California State University, Fresno
Lee B. Waian	Saddleback College
Linda Wallace	University of Oklahoma
Zhi "Luke" Wang	**California State University, Fresco**
Joel Weintraub	California State University, Fullerton
Frank Williams	Langara College
Richard J. Wright	Valencia Community College
Bruce Wyman	McNeese State University
Todd Yetter	University of the Cumberlands
Craig ZumBrunnen	University of Washington

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MLM
RMS
LY
GAM

About the Authors

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 a variety of courses, focusing on environmental science and biodiversity issues at the undergraduate level.

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 science, geology, geography, and courses in science and public policy—with a strong environmental component in all courses he teaches. He is a recipient of his college's Peyton Richter Award for interdisciplinary teaching, and serves as director of its Institute for the Study of the Origins of Civilization.

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 methodologies, and a variety of renewable energy and conservation finance deals. She is currently the Manager of Research and Analysis at CREO Syndicate, a network of family offices focused on driving more private capital to solve global environmental challenges. More recently she worked at Morgan Stanley's Institute for Sustainable Investing, Align Impact, and the Yale Investments Office. Logan received her B.A. with Distinction from the University of North Carolina at Chapel Hill. Logan is a Startingbloc Fellow, a Property and Environment Research (PERC) Fellow, and a Kinship Fellow. She has also been a freelance writer for Ashoka Changemakers, *Forbes*, ImpactAlpha, and NextBillion, and is also the author of several books. Logan received her master's in Forestry and MBA (with a concentration in Asset Management) from Yale in 2016. Logan currently sits on the Board of Slow Money NYC, which connects investors with local food entrepreneurs in New York City. She is also an Advisor to the Yale Initiative on Sustainable Investing (YISF).

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.