

ESSENTIAL environment

THE SCIENCE BEHIND THE STORIES 6th Edition

Jay Withgott

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About the Authors



Jay Withgott has authored *Essential Environment* as well as its parent volume, *Environment: The Science behind the Stories*, since their inception. In dedicating himself to these books, he works to keep abreast of a diverse and rapidly changing field and continually seeks to develop new and better ways to help today's students learn environmental science.

As a researcher, Jay has published scientific papers in ecology, evolution, animal behavior, and conservation biology in journals ranging from *Evolution* to *Proceedings of the National Academy of Sciences*. As an instructor, he has taught university lab courses in ecology and other disciplines. As a science writer, he has authored articles for numerous journals and magazines including *Science*, *New Scientist*, *BioScience*, *Smithsonian*, and *Natural History*. By combining his scientific training with prior experience as a newspaper reporter and editor, he strives to make science accessible and engaging for general audiences. Jay holds degrees from Yale University, the University of Arkansas, and the University of Arizona.

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He is an active scholar in environmental science education and has received grants from state, federal, and private sources to develop and evaluate innovative curricular materials. His scholarly work has received numerous awards, including the Georgia Board of Regents' highest award for the Scholarship of Teaching and Learning.

Matt resides in suburban Atlanta with his wife, Lisa, and children, Lauren, Cameron, and Saffron.

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Contents



1 Science and Sustainability: An Introduction to Environmental Science

Our Island, Earth	2
The Nature of Environmental Science	3
The Nature of Science	6
THE SCIENCE behind the story What Are the Lessons of Easter Island?	7
Environmental Ethics	8
Sustainability and Our Future	14



2 Environmental Systems: Matter, Energy, and Ecosystems

central CASE STUDY The Vanishing Oysters of the Chesapeake Bay	22
Earth's Environmental Systems	23
THE SCIENCE behind the story Are We “Turning the Tide” for Native Oysters in Chesapeake Bay?	24
Matter, Chemistry, and the Environment	26
Energy: An Introduction	30
Ecosystems	33
Biogeochemical Cycles	36



3 Evolution, Biodiversity, and Population Ecology

central CASE STUDY Saving Hawaii's Native Forest Birds	48
Evolution: The Source of Earth's Biodiversity	49
THE SCIENCE behind the story How Do Species Form in Hawaii's “Natural Laboratory” of Evolution?	50
Ecology and the Organism	56
Population Ecology	59
Conserving Biodiversity	61



4 The Ecology of Communities

central CASE STUDY Leaping Fish, Backwards River: Asian Carp Threaten the Great Lakes	68
Species Interactions	69
Ecological Communities	70
THE SCIENCE behind the story How Do Communities Recover after Disturbance?	73
Earth's Biomes	80



5 Economics, Policy, and Sustainable Development

central CASE STUDY Costa Rica Values Its Ecosystem Services	92
Economics and the Environment	93
Environmental Policy: An Overview	94
THE SCIENCE behind the story Do Payments Help Preserve Forest?	101
U.S. Environmental Law and Policy	102
International Environmental Policy	105
Approaches to Environmental Policy	109
Sustainable Development	111



6 Human Population

central CASE STUDY Will China's New “Two-Child Policy” Defuse Its Population “Time Bomb”?	118
Our World at Seven Billion	119
Demography	121
Population and Society	123
THE SCIENCE behind the story Did Soap Operas Help Reduce Fertility in Brazil?	129



7 Soil, Agriculture, and the Future of Food

central CASE STUDY Farm to Table—And Back Again: The Commons at Kennesaw State University	138
The Race to Feed the World	139

The Changing Face of Agriculture	142	Toxic Substances and Their Effects on Ecosystems	219
Soils	143	THE SCIENCE behind the story Are Endocrine Disruptors Lurking in Your Fast Food?	220
Watering and Fertilizing Crops	146	Studying Effects of Hazards	222
Conserving Agricultural Resources	148	Risk Assessment and Risk Management	225
Controlling Pests, Preserving Pollinators	151		
THE SCIENCE behind the story What Role Do Pesticides Play in the Collapse of Bee Colonies?	154		
Raising Animals for Food	156		
Genetically Modified Food	158		
The Growth of Sustainable Agriculture	162		
 8 Biodiversity and Conservation Biology	166	 11 Geology, Minerals, and Mining	230
central CASE STUDY Will We Slice through the Serengeti?	167	central CASE STUDY Mining for . . . Cell Phones?	231
Life's Diversity on Earth	169	Geology: The Physical Basis for Environmental Science	232
Benefits of Biodiversity	171	Geologic and Natural Hazards	235
Biodiversity Loss and Extinction	174	THE SCIENCE behind the story Are the Earthquakes Rattling Oklahoma Caused by Human Activity?	238
Conservation Biology: The Search for Solutions	181	Earth's Mineral Resources	241
THE SCIENCE behind the story Can Forensic DNA Analysis Help Save Elephants?	186	Mining Methods and Their Impacts	244
		Toward Sustainable Mineral Use	249
 9 Forests, Forest Management, and Protected Areas	190	 12 Fresh Water, Oceans, and Coasts	254
central CASE STUDY Saving the World's Greatest Rainforest	191	central CASE STUDY Starving the Louisiana Coast	255
Forest Ecosystems and Forest Resources	193	Freshwater Systems	257
Forest Loss	195	The Oceans	260
Forest Management	198	Marine and Coastal Ecosystems	263
Parks and Protected Areas	203	THE SCIENCE behind the story Are We Destined for a Future of "Megadroughts" in the United States?	264
THE SCIENCE behind the story Forest Fragmentation in the Amazon	206	Effects of Human Activities on Waterways	268
		Solutions to Depletion of Fresh Water	273
		Water Pollution and Its Control	275
		Emptying the Oceans	281
 10 Environmental Health and Toxicology	210	 13 The Atmosphere, Air Quality, and Pollution Control	286
central CASE STUDY Are We Being Poisoned by Our Food Packaging?	211	central CASE STUDY Clearing the Air in L.A. and in Mexico City	287
Environmental Health	213	The Atmosphere	288
Toxic Substances and Their Effects on Organisms	216		

Outdoor Air Quality	291	Geothermal Energy	387
THE SCIENCE behind the story Does Air Pollution Affect the Brain, as Well as the Lungs and Heart?	298	Ocean Energy Sources	389
Ozone Depletion and Recovery	301	Hydroelectric Power	390
Addressing Acid Deposition	303	Bioenergy	391
Indoor Air Quality	306	Hydrogen and Fuel Cells	395



14 Global Climate Change

central CASE STUDY Rising Seas Threaten South Florida	310
Our Dynamic Climate	311
Studying Climate Change	312
THE SCIENCE behind the story How Do Climate Models Work?	317
Impacts of Climate Change	318
Responding to Climate Change	320
	328



15 Nonrenewable Energy Sources, Their Impacts, and Energy Conservation

central CASE STUDY Fracking the Marcellus Shale	340
Sources of Energy	341
Fossil Fuels: Their Formation, Extraction, and Use	343
Reaching Further for Fossil Fuels . . . and Coping with the Impacts	345
THE SCIENCE behind the story Discovering Impacts of the Gulf Oil Spill	352
Energy Efficiency and Conservation	358
Nuclear Power	363
	366



16 Renewable Energy Alternatives

central CASE STUDY Germany Reaches for the Sun	374
Renewable Energy Sources	375
THE SCIENCE behind the story Can We Power the World with Renewable Energy?	377
Solar Energy	380
Wind Power	382
	385



17 Managing Our Waste

central CASE STUDY A Mania for Recycling on Campus	398
Approaches to Waste Management	399
Municipal Solid Waste	400
THE SCIENCE behind the story Can Campus Research Help Reduce Waste?	401
Industrial Solid Waste	408
Hazardous Waste	410
	412



18 The Urban Environment: Creating Sustainable Cities

central CASE STUDY Managing Growth in Portland, Oregon	418
Our Urbanizing World	419
Sprawl	420
Creating Livable Cities	422
Urban Sustainability	423
THE SCIENCE behind the story Do Baltimore and Phoenix Act as Ecosystems?	429
	430

Epilogue Sustainable Solutions 434

APPENDIX A Answers to Data Analysis Questions	A-1
APPENDIX B How to Interpret Graphs	B-1
APPENDIX C Metric System	C-1
APPENDIX D Periodic Table of the Elements	D-1
APPENDIX E Geologic Time Scale	E-1
Glossary	G-1
Photo Credits	CR-1
Index	I-1

Preface

Dear Student,

You are coming of age at a unique and momentous time in history. Within your lifetime, our global society must chart a promising course for a sustainable future. The stakes could not be higher.

Today we live long lives enriched with astonishing technologies, in societies more free, just, and equal than ever before. We enjoy wealth on a scale our ancestors could hardly have dreamed of. However, we have purchased these wonderful things at a steep price. By exploiting Earth's resources and ecological services, we are depleting our planet's ecological bank account. We are altering our planet's land, air, water, nutrient cycles, biodiversity, and climate at dizzying speeds. More than ever before, the future of our society rests with how we treat the world around us.

Your future is being shaped by the phenomena you will learn about in your environmental science course. Environmental science gives us a big-picture understanding of the world and our place within it. Environmental science also offers hope and solutions, revealing ways to address the problems we confront. Environmental science is more than just a subject you study in college. It provides you basic literacy in the foremost issues of the 21st century, and it relates to everything around you throughout your lifetime.

We have written this book because today's students will shape tomorrow's world. At this unique moment in history, the decisions and actions of your generation are key to achieving a sustainable future for our civilization. The many environmental challenges we face can seem overwhelming, but you should feel encouraged and motivated. Remember that each dilemma is also an opportunity. For every problem that human carelessness has created, human ingenuity can devise a solution. Now is the time for innovation, creativity, and the fresh perspectives that a new generation can offer. Your own ideas and energy can, and *will*, make a difference.

—Jay Withgott and Matthew Laposata

Dear Instructor,

You perform one of our society's most vital functions by educating today's students—the citizens and leaders of tomorrow—on the processes that shape the world around them, the nature of scientific inquiry, and the pressing environmental challenges we face. We have written this book to assist you in this endeavor because we feel that the crucial role of environmental science in today's world makes it imperative to engage, educate, and inspire a broad audience of students.

In *Essential Environment: The Science behind the Stories*, we strive to show students how science informs our efforts to bring about a sustainable society. We aim to encourage critical thinking and to maintain a balanced approach as we flesh out the vibrant social debate that accompanies environmental issues. As we assess the challenges facing our civilization and our planet, we focus on providing realistic, forward-looking solutions, for we truly feel there are many reasons for optimism.

As environmental science has grown, so has the length of textbooks that cover it. With this volume, we aim to meet the needs of instructors who favor a more succinct and affordable book. We have distilled the most essential content from our full-length book, *Environment: The Science behind the Stories*, now in its sixth edition. We have streamlined our material, updated our coverage, and carefully crafted our writing to make *Essential Environment* every bit as readable, informative, and engaging as its parent volume.

New to This Edition

This sixth edition includes an array of revisions that enhance our content and presentation while strengthening our commitment to teach science in an engaging and accessible manner.

- **SUCCESS STORY** This brand-new feature highlights one discrete story per chapter of successful efforts to address environmental problems, ranging from local examples (such as prairie restoration in Chicago) to national and global successes (such as halting ozone depletion by treaty, or removing lead from gasoline). Our book has always focused on positive solutions, but the new emphasis the *Success Story* feature brings should help encourage students by showing them that sustainable solutions are within reach. Students can explore the data behind these solutions with new *Success Story Coaching Activities* in *Mastering Environmental Science*.
- **central CASE STUDY** Three *Central Case Studies* are completely new to this edition, complementing the seven new *Central Case Studies* added in the fifth edition. All other *Central Case Studies* have been updated as needed to reflect recent developments. These updates provide fresh stories and new ways to frame emerging issues in environmental science. In our new *Central Case Studies*, students will learn of the changes that Asian carp and other invasive species are having on North American waterways, wrestle with the challenges of conserving the

Amazon rainforest, and examine how Miami-area residents are coping with sea level rise.

- **Chapter 4:** Leaping Fish, Backwards River: Asian Carp Threaten the Great Lakes
- **Chapter 9:** Saving the World’s Greatest Rainforest
- **Chapter 14:** Rising Seas Threaten South Florida
- **closing THE LOOP** Also new to this edition, each chapter now concludes with a brief section that “closes the loop” by revisiting the *Central Case Study* while reviewing key principles from the chapter. This new *Closing the Loop* section enhances our long-standing and well-received approach of integrating each *Central Case Study* throughout its chapter. A further step in this direction is the new **CASE STUDY CONNECTION** question feature. These questions, in the *Seeking Solutions* section at the end of each chapter, place students in a scenario and empower them to craft solutions to issues raised in the *Central Case Study*.
- **THE SCIENCE behind the story** Nine of our 18 *Science behind the Story* features are new to this edition, giving you a current and exciting selection of scientific studies to highlight. Students will follow along as researchers discover how Hawaiian birds evolved, trace ecological recovery at Mt. St. Helens, sleuth out the mystery of honeybee declines, use DNA fingerprinting to combat poaching, reveal synthetic chemicals in fast food, determine whether fracking is causing earthquakes, predict the future of drought in the American West, ask whether renewable energy alone can power civilization, and seek to enhance recycling efforts on campus.
 - **Chapter 3:** How Do Species Form in Hawaii’s “Natural Laboratory” of Evolution?
 - **Chapter 4:** How Do Communities Recover after Disturbance?
 - **Chapter 7:** What Role Do Pesticides Play in the Collapse of Bee Colonies?
 - **Chapter 8:** Can Forensic DNA Analysis Help Save Elephants?
 - **Chapter 10:** Are Endocrine Disruptors Lurking in Your Fast Food?
 - **Chapter 11:** Are the Earthquakes Rattling Oklahoma Caused by Human Activity?
 - **Chapter 12:** Are We Destined for a Future of “Megadroughts” in the United States?
 - **Chapter 16:** Can We Power the World with Renewable Energy?
 - **Chapter 17:** Can Campus Research Help Reduce Waste?
- **New and revised DATA Q, FAQ, and Weighing the Issues features** Incorporating feedback from instructors across North America, we have examined each example of these three features that boost student engagement, and have revised them and added new examples as appropriate.

- **Currency and coverage of topical issues** To live up to our book’s hard-won reputation for currency, we have incorporated the most recent data possible and have enhanced coverage of emerging issues. As climate change and energy concerns play ever-larger roles in today’s world, our coverage has evolved to keep pace. This edition highlights the tremendous growth and potential of renewable energy, yet also makes clear how we continue reaching further for fossil fuels, using ever more powerful technologies. The text tackles the complex issue of climate change in depth, while connections to this issue proliferate among topics in every chapter. And in a world newly shaken by dynamic political forces amid concerns relating to globalization, trade, immigration, health care, jobs, national security, and wealth inequality, our introduction of ethics, economics, and policy early in the book serves as a framework to help students relate the scientific findings they learn about to the complex cultural aspects of the society around them.
- **Enhanced style and design** We have significantly refreshed and improved the look and clarity of our presentation throughout the text. A more appealing layout, striking visuals, additional depth in the *Central Case Studies*, and an inviting new style all make the book more engaging for students. More than 40% of the photographs, graphs, and illustrations in this edition are new or have been revised to reflect current data or to enhance clarity or pedagogy.

Existing Features

We have also retained the major features that made the first five editions of our book unique and that are proving so successful in classrooms across North America:

- **A focus on science and data analysis** We have maintained and strengthened our commitment to a rigorous presentation of modern scientific research while simultaneously making science clear, accessible, and engaging to students. Explaining and illustrating the *process* of science remains a foundational goal of this endeavor. We also continue to provide an abundance of clearly cited data-rich graphs, with accompanying tools for data analysis. In our text, our figures, and our online features, we aim to challenge students and to assist them with the vital skills of data analysis and interpretation.
- **An emphasis on solutions** For many students, today’s deluge of environmental dilemmas can lead them to feel that there is little hope or that they cannot personally make a difference. We have consistently aimed to counter this impression by highlighting innovative solutions being developed on campuses and around the world—a long-standing approach now enhanced by our new *Success Story* feature. While taking care not to paint too rosy a picture of the challenges that lie ahead, we demonstrate that there is ample reason for optimism, and we encourage action and engagement.

- **central CASE STUDY integrated throughout the chapter** We integrate each chapter's *Central Case Study* into the main text, weaving information and elaboration throughout the chapter. In this way, compelling stories about real people and real places help to teach foundational concepts by giving students a tangible framework with which to incorporate novel ideas. Students can explore the locations featured in each Central Case Study with new Case Study Video Tours in *Mastering Environmental Science*.
- **THE SCIENCE behind the story** Because we strive to engage students in the scientific process of testing and discovery, we feature *The Science behind the Story* in each chapter. By guiding students through key research efforts, this feature shows not merely *what* scientists discovered, but *how* they discovered it.
-  These data analysis questions help students to actively engage with graphs and other data-driven figures, and challenge them to practice quantitative skills of interpretation and analysis. To encourage students to test their understanding as they progress through the material, answers are provided in Appendix A. Students can practice data analysis skills further with *Interpreting Graphs and Data: DataQs* in *Mastering Environmental Science*.
- **FAQ** The *FAQ* feature highlights questions frequently posed by students, thereby helping to address widely held misconceptions and to fill in common conceptual gaps in knowledge. By also including questions students sometimes hesitate to ask, the *FAQs* show students that they are not alone in having these questions, thereby fostering a spirit of open inquiry in the classroom.
- **weighing the ISSUES** These questions aim to help develop the critical-thinking skills students need to navigate multifaceted issues at the juncture of science, policy, and ethics. They serve as stopping points for students to reflect on what they have read, wrestle with complex dilemmas, and engage in spirited classroom discussion.
- **Diverse end-of-chapter features** *Testing Your Comprehension* provides concise study questions on main topics, while *Seeking Solutions* encourages broader creative thinking aimed at finding solutions. “Think It Through” questions place students in a scenario and empower them to make decisions to resolve problems. *Calculating Ecological Footprints* enables students to quantify the impacts of their choices and measure how individual impacts scale up to the societal level.

Mastering Environmental Science

With this edition we continue to offer expanded opportunities through *Mastering Environmental Science*, our powerful yet easy-to-use online learning and assessment platform. We have developed new content and activities specifically to support

features in the textbook, thus strengthening the connection between online and print resources. This approach encourages students to practice their science literacy skills in an interactive environment with a diverse set of automatically graded exercises. Students benefit from self-paced activities that feature immediate wrong-answer feedback, while instructors can gauge student performance with informative diagnostics. By enabling assessment of student learning outside the classroom, *Mastering Environmental Science* helps the instructor to maximize the impact of classroom time. As a result, both educators and learners benefit from an integrated text and online solution.

New to this edition *Mastering Environmental Science* for this edition of *Essential Environment: The Science behind the Stories* offers new resources that are designed to grab student interest and help them develop quantitative reasoning skills.

- **NEW *GraphIt!*** activities help students put data analysis and science reasoning skills into practice in a highly interactive and engaging format. Each of the 10 *GraphIt!* activities prompts students to manipulate a variety of graphs and charts to develop an understanding of how data can be used in decision making about environmental issues. Topics range from agriculture to fresh water to air pollution. These mobile-friendly activities are accompanied by assessment in *Mastering Environmental Science*.
- **NEW *Case Study Video Tours*** use Google Earth to take students on a virtual tour of the locations featured in each *Central Case Study*.
- **NEW *Success Story Coaching Activities*** pair with the new in-text *Success Story* features and give students the opportunity to explore the data behind each solution.
- **NEW *Everyday Environmental Science*** videos highlight current environmental issues in short (5 minutes or less) video clips and are produced in partnership with BBC News. These videos will pique student interest, and can be used in class or assigned as a high-interest out-of-class activity.

Existing features *Mastering Environmental Science* also retains its popular existing features:

- ***Process of Science*** activities help students navigate the scientific method, guiding them through explorations of experimental design using *Science behind the Story* features from the current and former editions. These activities encourage students to think like a scientist and to practice basic skills in experimental design.
- ***Interpreting Graphs and Data: Data Q*** activities pair with the in-text *Data Q* questions, coaching students to further develop skills related to presenting, interpreting, and thinking critically about environmental science data.
- ***First Impressions Pre-Quizzes*** help instructors determine their students' existing knowledge of core content areas in environmental science at the outset of the academic term, providing class-specific data that can then be employed for

powerful teachable moments throughout the term. Assessment items in the Test Bank connect to each quiz item, so instructors can formally assess student understanding.

- *Video Field Trips* enable students to visit real-life sites that bring environmental issues to life. Students can tour a power plant, a wind farm, a wastewater treatment facility, a site combating invasive species, and more—all without leaving campus.

Essential Environment has grown from our experiences in teaching, research, and writing. We have been guided in our efforts by input from hundreds of instructors across North America who have served as reviewers and advisors. The participation of so many learned, thoughtful, and committed experts and educators has improved this volume in countless ways.

We sincerely hope that our efforts are worthy of the immense importance of our subject matter. We invite you to let us know how well we have achieved our goals and where you feel we have fallen short. Please write to us in care of our editor, Cady Owens (cady.owens@pearson.com), at Pearson Education. We value your feedback and are eager to know how we can serve you better.

—Jay Withgott and Matthew Laposata

Instructor Supplements

A robust set of instructor resources and multimedia accompanies the text and can be accessed through *Mastering Environmental Science*. Organized chapter-by-chapter, everything you need to prepare for your course is offered in one convenient set of files. Resources include Video Field Trips, Everyday Environmental Science Videos, PowerPoint Lecture presentations, Instructor's Guide, Active Lecture questions to facilitate class discussions (for use with or without clickers), and an image library that includes all art and tables from the text.

The Test Bank files, offered in both MS Word and Test-Gen formats, include hundreds of multiple-choice questions plus unique graphing and scenario-based questions to test students' critical-thinking abilities.

The *Mastering Environmental Science* platform is the most effective and widely used online tutorial, homework, and assessment system for the sciences.

NEW to this edition, Ready-to-Go Teaching Modules on key environmental issues provide instructors with assignments to use before and after class, as well as in-class activities that use clickers or Learning Catalytics for assessment.

Acknowledgments

This textbook results from the collective labor and dedication of innumerable people. The two of us are fortunate to be supported by a tremendous publishing team.

Sponsoring editor Cady Owens coordinated our team's efforts for this sixth edition of *Essential Environment*. She has been a pleasure to work with, and we are grateful for her guidance, deft touch, and sound judgment. We were also thrilled to welcome back Courseware Sr. analyst Mary Ann Murray, whose past work for our books has stood the test of time. Mary Ann again brought an intense work ethic and a mix of creativity, big-picture smarts, and focus on detail that we truly appreciate. Content producer Margaret Young once more ably steered us through the complex logistical tangles of the textbook process. Executive editor Alison Rodal oversaw the project and lent her steady hand, and we thank director Beth Wilbur for her support of this book through its six editions and for helping to invest the resources that our books continue to enjoy.

Editorial assistant Ali Candlin managed the review process and provided timely assistance, while Courseware director Ginnie Simone-Jutson oversaw our development needs. Bonnie Boehme provided meticulous copy editing, and photo researcher Kristin Piljay helped to acquire quality photos. Eric Schrader managed permissions for our figures. Alicia Elliot of Imagineering Art did a wonderful job executing our art program, and Lisa Buckley designed our engaging new text and cover style. We offer a big thank-you to Norine Strang for her extensive work with our compositor to help guide our book through production.

As always, a select number of top instructors from around North America teamed with us to produce the supplementary materials, and we are grateful for their work. Our thanks go to Danielle DuCharme for updating our Instructor's Guide,

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We give thanks to marketing managers Christa Pesek Pelaez and Mary Salzman. And we admire and appreciate the work and commitment of the many sales representatives who help communicate our vision, deliver our product, and work with instructors to ensure their satisfaction.

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We dedicate this book to today's students, who will shape tomorrow's world.

—Jay Withgott and Matthew Laposata

Reviewers

We wish to express special thanks to the dedicated reviewers who shared their time and expertise to help make this sixth edition the best it could be. Their efforts built on those of the nearly 700 instructors and outside experts who have reviewed material for the previous five editions of this book and the six editions of this book's parent volume, where they are acknowledged in full. Here we thank those who contributed in particular to this sixth edition of *Essential Environment*—in most cases with multiple in-depth chapter reviews despite busy teaching schedules. Our sincere gratitude goes out to all of them. If the thoughtfulness and thoroughness of these reviewers are any indication, we feel confident that the teaching of environmental science is in excellent hands!

Donna Bivans, *Pitt Community College*
Martha Bollinger, *Winthrop University*
Lynn Corliss, *South Puget Sound Community College*
James Daniels, *Huntingdon College*
Eden Effert-Fanta, *Eastern Illinois University*
Jeff Fennell, *Everett Community College*
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Ned Knight, *Linfield College*
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