

THE ENVIRONMENT AND YOU

THIRD EDITION

Norm Christensen
Lissa Leege
Justin St. Juliana



330 Hudson Street, NY NY 10013

Director, Courseware Portfolio Management: Beth Wilbur
Courseware Portfolio Manager, Specialist: Alison Rodal
Courseware Director, Content Development: Ginnie Simione Jutson
Courseware Senior Analyst: Hilair Chism
Development Editor: Mary Hill
Courseware Editorial Assistant: Alison Candlin
Courseware Managing Producer: Mike Early
Content Producer: Becca Groves, SPi-Global
Senior Content Developer: Sarah Jensen
Rich Media Content Producer: Ziki Dekel

Content Producer, Video Development: Tim Hainley
Full-Service Vendor: Jason Hammond/Kelly Murphy, SPi-Global
Design Manager: Mark Ong, Side By Side Studios
Interior and Cover Designer: Lisa Buckley, Buckley Designs
Art Studio: Kevin Lear, International Mapping
Rights & Permissions Management: Matt Perry, Cenveo Publishing Services
Photo Researcher: Kristin Piljay
Senior Procurement Specialist: Stacey Weinberger
Product Marketing Manager: Christa Pelaez
Field Marketing Manager: Mary Salzman

Cover Photo Credits: WDG Photo/Shutterstock; Hangingpixels/Shutterstock; Michael Potter11/Shutterstock; Fenkieandreas/Shutterstock; Oticki/Shutterstock; Mary Amerman/Moment/Getty Images; Hero Images/Getty Images; Hero Images/Getty Images; Visual Walkthrough: iShift/Shutterstock; Artjazz/Shutterstock; Nik Merkulov/Shutterstock

Copyright ©2019, 2016, 2013 Pearson Education, Inc. All Rights Reserved. Printed in the United States of America. This publication is protected by copyright, and permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise. For information regarding permissions, request forms and the appropriate contacts within the Pearson Education Global Rights & Permissions department, please visit www.pearsoned.com/permissions/.

Acknowledgments of third party content appear on page C-1, which constitutes an extension of this copyright page.

PEARSON, ALWAYS LEARNING and Mastering™ Environmental Science are exclusive trademarks in the U.S. and/or other countries owned by Pearson Education, Inc. or its affiliates.

Unless otherwise indicated herein, any third-party trademarks that may appear in this work are the property of their respective owners and any references to third-party trademarks, logos or other trade dress are for demonstrative or descriptive purposes only. Such references are not intended to imply any sponsorship, endorsement, authorization, or promotion of Pearson's products by the owners of such marks, or any relationship between the owner and Pearson Education, Inc. or its affiliates, authors, licensees or distributors.

Library of Congress Cataloging-in-Publication Data

Names: Christensen, Norman L, 1946- author.
Title: The environment and you / Norm Christensen, Lissa Leege, Justin St. Juliana.
Description: Third edition. | New York : Pearson Education, Inc., [2018]
Identifiers: LCCN 2017042314 | ISBN 9780134646053 (Student edition) | ISBN 0134646053 (Student edition) | ISBN 9780134818764 (A La Carte) | ISBN 0134818768 (A La Carte)
Subjects: LCSH: Environmentalism. | Environmental policy. | Environmental protection.
Classification: LCC GE195 .C575 2018 | DDC 304.2/8--dc23
LC record available at <https://lcn.loc.gov/2017042314>



ISBN 10: 0-13-464605-3; ISBN 13: 978-0-13-464605-3 (Student edition)
ISBN 10: 0-13-481876-8; ISBN 13: 978-0-13-481876-4 (A La Carte)



About the Authors



Norm Christensen is professor emeritus and founding dean of Duke University's Nicholas School of the Environment. A central theme in Norm's career has been ecosystem change from both natural and human causes. Norm has worked on numerous national advisory committees on environmental issues and on the boards of several environmental organizations including Environmental Defense Fund and The Wilderness Society. He is a fellow in the American Association for the Advancement of Science and a fellow and past president of the Ecological Society of America. Norm was the 2017 recipient of the Herbert Stoddard Lifetime Achievement Award from the American Association for Fire Ecology.

This book is very much a product of Norm's passion for connecting students with their environment. Norm was honored twice by the Duke University with awards for distinguished undergraduate teaching. He was instrumental in the development of Duke's undergraduate program in environmental science and policy, and he taught the introductory course for this program for over 15 years.



Lissa Legee is a professor of biology and the founding director of the Center for Sustainability at Georgia Southern University. She earned her undergraduate degree in biology from St. Olaf College and received her Ph.D. in plant ecology at Michigan State University. Her ecological research concerns threats to rare plants, including the effects of fire and invasive species on endangered plant populations and communities. She has also conducted 20 years of research on the impacts of invasive pines on the sand dunes of Lake Michigan and the subsequent recovery of this system following invasive species removal. Lissa was instrumental in the development of an Interdisciplinary Concentration in Environmental Sustainability for undergraduates at Georgia Southern. Under her direction, the Center for Sustainability engages the campus and community with annual sustainability celebrations, a sustainability grant program, and a robust speaker series. Lissa is also involved with the environment on a statewide level as a member of the 2013 Class of the Institute for Georgia Environmental Leadership and a founding member of the Georgia Campus Sustainability Network.

Lissa has taught nonmajors environmental biology for 19 years with an emphasis on how students can contribute to environmental solutions. In 2006, she established an Environmental Service Learning project, through which thousands of environmental biology students have engaged in tens of thousands of hours of environmental service in the local community. Lissa has been honored with both college and university service awards and has served as a faculty fellow in Service-Learning. Her contributions to this book have been inspired by her passion for engaging students in positive solutions to environmental problems.



Justin St. Juliana is a lecturer in the Ecology and Evolutionary Biology Department at Cornell University. He received his bachelor's degree in animal ecology at Iowa State University, his master's degree in evolutionary ecology from Ben Gurion University of the Negev (Israel), and his Ph.D. in biology from Indiana State University. Justin's research lies at the interface of predator prey interactions, optimal foraging, and stress hormones. His study organisms include rodents, foxes, fleas, owls, snakes, and feral cats. Before taking his position at Cornell University, Justin was an associate professor at Ivy Tech Community College (Terre Haute Campus) in Indiana. While at Ivy Tech he taught at multiple biological levels from microbiology to environmental science. Justin also developed and still administers a statewide online nonmajors biology course taken by thousands of Ivy Tech students every year.

Justin teaches the large mixed majors/nonmajors Ecology and the Environment course at Cornell University. He is very interested in the latest teaching innovations and heavily incorporates active and community-based learning into his courses. Justin believes

that scientific concepts can be taught as stories that relate to a student's life. He also extensively utilizes technology to improve student learning outcomes. In addition to being a coauthor, Justin developed the Process of Science, Global Connects, and Focus on Figures activities associated with this book, in **Mastering™ Environmental Science**.

Dedication

To Nicholas, Natalie, Noelle, Nicole, Riley, and all other of Earth's children. May we make decisions today that ensure the future beauty, diversity, and health of the environment on which they will depend.

To Micah and Emory, my constant joy and inspiration. I owe you the beautiful world I inherited, and it is my hope that education will motivate all kinds of students to take leadership and action in bringing about a bright and sustainable future.

To my father, Ronald, who, having spent his formative years as a hunting and fishing guide, enabled me to appreciate the natural world and taught me the value of a strong land ethic. I hope that, in this book, I can pass his valuable lessons along to the readers.



Preface

It has been said that change is the only constant. For billions of years, Earth’s environment and the organisms that inhabit it have been constantly changing. Over tens of millennia we, our species, have constantly changed; each generation’s technologies, values, and understanding of its environment have differed from those that preceded it. As a consequence of those technologies and our growing numbers, we have changed Earth’s environment more than any other species living now or in the past.

You and the world around you are the current manifestation of this process of inexorable change. The health and well-being of most of Earth’s people have markedly improved over the past century but our impacts on Earth’s environment have increased significantly. A century ago, our global population was fewer than 2 billion; today there are well over 7.5 billion of us. What’s more, each of us today uses several times more resources and generates several times more waste than our century-ago ancestors. The effects on our environment are alarming. Resources such as water and petroleum are dwindling. Air pollution and water pollution have become commonplace. Rates of extinction among Earth’s species are more than 100 times higher than in pre-industrial times, and Earth’s climate is warming because of human-caused changes in the chemistry of its atmosphere. Sea level rise, dwindling sea ice in the Arctic, and increased severity of droughts and hurricanes are just a few of the consequences of this global warming.

These changes threaten the health of Earth’s ecosystems and the well-being of many of its people; they directly affect you. These changes are unsustainable, but they are not inevitable. Sustainability and ecosystems are important themes throughout this book. Sustainable action and change require knowledge and understanding of the ecosystems upon which we depend. Yes, they are complex, but the key elements of ecosystem function and sustainability are beautifully simple. In an increasingly urban and technology-driven world, the connections between Earth’s ecosystems and our well-being may seem distant, even irrelevant. But they are at all times immediate and compelling.

We have not downplayed the significant challenges presented by the variety of environmental issues that affect our lives because a balanced view of the challenges is needed. Naïve optimism is not likely to motivate substantial change in our actions and impacts, but neither is pessimism. We can all change the world in directions that are truly sustainable. We are convinced you will be part of that process of change. That confidence and conviction were the motivation for writing this book; hope was the inspiration.

New Innovations and Hallmark Features

A New Author

We welcome Justin St. Juliana to the author team of *The Environment and You*. Justin is a lecturer in the Ecology and Evolutionary Biology Department at Cornell University. Justin believes that scientific concepts can be taught as stories that relate to a student’s life. His ability to relate scientific concepts to a student’s experiences fits perfectly with our goal of bringing environmental science to life. His ability to use technology to improve student learning and engagement has been brought to bear on the various activities in Mastering™, both in this edition and previous ones. Justin’s energy, interests, and teaching philosophy are a welcome addition to the team.

New to this Edition

- **Misconception** New to the third edition, this feature addresses common student misunderstandings related to matters of scientific fact and offers a new take on the Q&A feature from prior editions. Is Earth getting warmer because of the ozone hole? Is bottled water safer to drink than tap water? Do vaccines lead to autism in children?
- **You Decide** New to the third edition, this feature presents you with a real environmental issue and challenges you to take a stand on that issue, using scientific evidence to support your position. Remember Cecil the lion? Are there some situations where it could be permissible to hunt endangered species? How would you react if fracking were to come to your town?

A Focus on You

A hallmark of each edition, now further reinforced in the third edition, is the importance of humans as agents of environmental change. The effects of those changes on human well-being continue to be a central theme in the third edition. *The Environment and You* emphasizes problem solving and solutions that will enable you to make more informed choices on actions to support the well-being of humans and the health of the planet.

- **Where You Live** This feature invites you to use primary data sources to explore environmental principles, issues, and sustainable solutions within the context of your local community. By answering the questions posed, you'll see how concepts and examples from your textbook can be applied to where you live and learn. This will not only satisfy your curiosity but also help you connect local discoveries to central themes of the chapters. Do you know, for example, what biome you live in (Chapter 7) or whether you share your local environment with an endangered species (Chapter 8)? Do you ever think about just how much water you use every day (Chapter 11)? How about the size of your waste footprint (Chapter 17)? These are just a few of the questions you will explore.
- **Seeing Solutions** Problems need solutions and this feature highlights how individuals and groups around the world are using new approaches to solve environmental problems. Topics include a city that is investing in green space to solve problems associated with transportation, the local economy, and the health of its citizens (Chapter 16); a business that lessens its impact while improving profit and employee–community relations with a focus on the triple bottom line (Chapter 1); a group that supports increased educational opportunity for young women as a means to improve the health and well-being of their communities (Chapter 5); and efforts designed to support underdeveloped countries in dealing with the economic pressures of a changing world (Chapter 8).
- **Agents of Change** This feature showcases the efforts of college students and recent graduates who have taken action to produce sustainable environments and improve human well-being. It is intended to provide guidance and encouragement for any student with a similar drive to make the world a better place. The third edition features six new inspiring Agents of Change: Will Amos and Aldrin Lupisan, inventors of a bike-powered plastic recycling system; Erica Davis, contributor to a reform bill that keeps money from natural resource extraction within local communities; Amira Odeh, leader of a campus-wide plastic bottle ban; Dejah Powell, creator of an environmental summer camp targeted at disadvantaged inner city youth; Swarnav Pujari, inventor and founder of TouchLight, a company that captures kinetic energy from human foot traffic; and Destiny Watford, champion of clean air and environmental justice in Baltimore.

Solid Coverage of Environmental Science

Our current understanding of environmental issues is built on a foundation of decades of careful research by generations of scientists. The third edition not only continues to provide many examples to help you understand the role science and scientific data can play in reducing uncertainty surrounding environmental issues but also engages you in the spirit of inquiry scientists use to ask questions and gather evidence to support predictions.

- **Currency** New discoveries are constantly occurring, and our understanding is quickly evolving in all areas of environmental science. Among the many updates to the third edition are recently revised United Nations forecasts for the growth of human populations, the latest information on changes in Earth's climate from the Intergovernmental Panel on Climate Change, and recent innovations in agriculture, energy conservation, and green building practices. This edition provides the most current synthesis of such changes in every environmental field. Graphs and charts use the latest available data, and recent events such as Hurricanes Harvey and Irma; the devastating wildfires in northern California; and the rise and spread of the Zika virus are included.
- **Motivation** Each chapter opens with an essay about humans and their interaction with or understanding of the environment. From the historic collapse of the Newfoundland cod fishery (Chapter 1) to the restoration of breeding populations of the California Condor (Chapter 8) or the spread of the Zika virus into the Americas (Chapter 18), environmental science is full of interesting stories. These stories will help you connect to the scientific concepts introduced in each chapter.
- **Applications and Examples** *The Environment and You* provides numerous explanations of how scientists have found innovative ways to gather the evidence that supports current conclusions and enables informed predictions.
- **Focus on Science** This feature encourages you to think about the process of scientific inquiry and the different methods scientists use to gather evidence by highlighting the work of individual scientists and the contributions they have made. For example, how does a scientist measure the amount of plastic waste in the ocean (Chapter 11)? We emphasize the strategies scientists use to conduct scientific research and include critical thinking questions that will spark class discussion and encourage you to think like a scientist.
- **New Frontiers** This feature highlights interesting areas of environmental research as well as unique approaches to problem solving. New Frontier features emphasize the complex interactions between new scientific discovery, ethics, and policy and ask you to consider the implications of the power science has to change the way we live and interact with the environment.

Organized for Learning

The Environment and You is organized to help students understand environmental science.

- Each lesson begins with a big idea so students always have a way to see the forest as well as the trees.
- Manageable amounts of information are organized by key concepts within modules, giving students complete lessons before moving on to the next topic.
- Important concepts are illustrated with clear, purposeful charts and graphs and supported with photographs that capture the essence of the concept being presented.

Supporting All Levels of Students

Students in introductory environmental science classes have vastly different levels of science background. *The Environment and You* is designed and written to serve that diversity.

- **Self-assessment:** Questions at the end of every module allow students to assess whether they have truly grasped a topic before they move on. Questions at the end of each chapter are designed to encourage synthesis of concepts and application to real situations.
- **Mastering™ Environmental Science:** Used by over a million science students, the Mastering platform is the most effective and widely used online tutorial, homework, and assessment system for the sciences. It motivates students to come to class prepared; provides students with personalized coaching and feedback; quickly monitors and displays student results; easily captures data to demonstrate assessment outcomes; and automatically grades assignments, including concept review activities, 3-D BioFlix® animation activities and quizzes, Graphit! activities, and chapter reading quizzes.

Mastering™ Environmental Science has a suite of activities designed to help your students practice concepts and develop scientific inquiry skills. Assignable activities include:

- *Focus on Figures videos*, new to the third edition, walk students through fifteen of the most critical environmental science figures from *The Environment and You*. Each video, created by Justin St. Juliana, helps students explore and interpret key figures such as the carbon cycle, the Keeling curve, and logistic population growth. The videos are assignable in **Mastering™ Environmental Science** as part of an interactive activity that further reinforces student understanding.
- *Process of Science activities* encourage your students to put scientific inquiry skills into action. These interactive activities guide them through current environmental research and help them understand concepts such as developing a hypothesis, making a prediction, understanding variables and independent variables, and more.
- *Global Connection activities* demonstrate the global relevance of local environmental issues and chapter themes. Your students will be able to draw comparisons between environmental issues in the United States and other countries such as water usage, air pollution, or species habitat loss.
- *Interpreting Graphs and Data* activities allow students to practice quantitative skills related to graph interpretation and analysis.
- *Video Field Trips* bring real environmental issues to life. These fourteen videos are embedded in the eText and assignable in **Mastering™ Environmental Science**. Take a tour of a water desalination plant, explore the sustainability features of a college campus, or visit a coal-fired power plant. These are just a few examples of the issues each video explores.

Acknowledgments

We accept all of the responsibilities of authorship for the third edition of *The Environment and You*, most particularly for any mistakes or flaws. But others deserve much of the credit for its development, organization, presentation, and production. As this project evolved over the course of several years, the Pearson Education publishing team and numerous environmental science colleagues have provided much needed guidance and encouragement.

We are especially grateful to Alison Rodal, our courseware portfolio manager for the second and third editions of *The Environment and You*. She was the catalyst for many of this edition’s new features, and her contagious enthusiasm for this project motivated us at every stage.

Our development editor, Mary Hill, expertly and cheerfully guided us on this third edition journey,

from start to finish, as she did for the second edition. Mary has an exceptional eye for detail on matters ranging from grammar to module organization and layout to connections among chapters. Even more, we are awed by her nuanced understanding of so many facets of environmental science that informed her suggestions on substance and presentation. Her wonderful sense of humor sustained us throughout this process.

We thank Courseware Portfolio Management, Director Beth Wilbur and Courseware Director, Content Development Ginnie Simone Jutson who encouraged and facilitated this project throughout its second and third editions. In addition, we would not have been able to publish this project without the support from SVP Portfolio Management-Science Adam Jaworski and Managing Director, Higher Education Courseware Paul

Corey. Thank you for taking a risk on this project and for your ongoing collective leadership in science education.

Sophie Mitchell and her wonderful team at Dorling Kindersley Education helped craft and execute the original vision for the first edition of this project.

Producing a book where text and art are created, designed, and arranged in tandem requires a highly collaborative approach to publishing. We are grateful to our production colleagues for overseeing and orchestrating this effort. Mike Early and the content production team oversaw the project's many details and milestones. Mark Ong and Lisa Buckley were responsible for the page and cover design of this third edition, Jason Hammond and Kelly Murphy of SPi-Global oversaw the composition of our text files to actual page layouts, along with Becca Groves who managed to keep all members of the team on point. We thank Kevin Lear of International Mapping for his leadership in the production of illustrations, graphs, and maps and Hilair Chism for her graphic talents utilized in creating this edition's cycle diagrams and other complex figures.

We want to thank Editorial Assistant Alison Candlin for coordinating the Agents of Change contributors and elements so masterfully, and for continuing to follow the vision of this great feature. We also appreciate the support she provided to the entire publishing team.

Special thanks to Rich Media Content Producer Ziki Dekel for overseeing all details on the production of media for the new edition and for **Mastering™ Environmental Science**, and to Libby Reiser and Sarah Jensen for bringing their creativity and expertise to the development of our new **Mastering™ Environmental Science** activities. Todd Brown ensured the smooth release of **Mastering™ Environmental Science** for the third edition of the text.

We would also like to thank each contributing supplement author for the edition. Jacquelyn Jordan, Clayton State University, did a wonderful job carefully updating the Instructor's Guide. The Test Bank was written and assembled by David Serrano, Broward State College. David is also the author of the third edition PowerPoint presentations, carefully updating each chapter presentation to help give instructors a headstart in planning each lecture. Reading Questions were crafted by Nilo Marin, Broward State College. We also thank Erica Kipp, Pace University, for her contribution to the updates in **Mastering™ Environmental Science** resources for this edition.

After many years spent creating and crafting this book, there comes a time to pass the torch to marketing and sales. We are grateful to Allison Rona Director of Product Marketing, for her support of this text. Christa Pelaez and Mary Salzman brought endless enthusiasm in promoting *The Environment and You*, communicating our vision to instructors all over the country. We are fortunate to have the support of the many sales representatives who work tirelessly to communicate our vision to faculty and ensure instructors' needs are satisfied. We thank them for their dedication and commitment!

Terrence Bensel, Brian Bovard, Robert Kingsolver, and Lester Rowntree made important contributions in the first edition to chapters on climate change, biodiversity, agriculture, energy, and waste management. Their detailed outlines provided road maps through sometimes unfamiliar territory, and many elements from their drafts of several of these chapters are part of the final product.

We owe much to our students at Duke, Georgia Southern, and Cornell Universities. In many ways, they helped shape the spirit and content of this text. They have been guinea pigs for each of its chapters and volunteered many editorial comments. The book is much the better for their input.

Over the years, each of us has had the benefit of working with wonderful mentors and colleagues, all the while being supported by our families. For each of us, individually, we want to thank those people who are so special to us.

Norm: My undergraduate and master's advisor Bert Tribbey passed along much knowledge and wisdom that appears in these pages, and he has long served as my primary role model for teaching excellence. My Duke colleagues William Chameides, Deborah Gallagher, Prasad Kasibhatla, Emily Klein, Randy Kramer, Susan Lozier, Marie Lynn Miranda, Joel Meyer, Lincoln Pratson, William Schlesinger, and Dean Urban were key sources of information and constructive criticism.

I am grateful to my family for their patience with me over the life of this project. My wife Portia has been a sounding board for new ideas, an editor of essays and features, and the best friend ever.

Lissa: My Ph.D. advisor Peter Murphy was an excellent role model who always encouraged my love of teaching and ultimately inspired my desire to reach a wider audience. I am grateful to Georgia Southern University and the Department of Biology for supporting my pursuit of this project, and to my museum colleagues for opening my eyes to the exhilaration of teaching beyond my classroom.

I thank my parents for believing in my passion for sustainability and supporting my path. I owe much to my children Micah and Emory for the time they allowed me to dedicate to this book. Finally, I extend my deepest gratitude to my remarkably patient and supportive husband Frank D'Arcangelo, who encouraged me to follow this dream, even though it meant that he would take on a greater share of parenting responsibilities.

Justin: I would like to thank my undergraduate advisors Fred Janzen and Brent Danielson, my master's advisor Burt Kotler as well as Berry Pinshow, my Ph.D. advisor William Mitchell as well as Steve Lima, and my former department head Janice Webster. Each of these people taught me valuable lessons about science and education.

I am grateful to my family, Paloma, Tanner, Vincent, and Lourdes. When I was a young child I wanted to be an environmental author. Although, I never thought this would take the form of a textbook, or textbook associated activities, my family afforded me the time to pursue this dream.

Third Edition Reviewers

Shamili Ajoankar <i>College of DuPage</i>	Jeffrey French <i>North Greenville University</i>	Gregory O’Mullan <i>Queens College</i>
Elaine K Alexander Fagner <i>McLennan Community College</i>	Tracy Gartner <i>Carthage College</i>	Hari Pant <i>CUNY - Lehman College</i>
John All <i>Western Kentucky University</i>	Anne Gasc <i>Honolulu Community College</i>	Dan Perlman <i>Brandeis University</i>
Stefan Becker <i>CUNY - Lehman College</i>	Richard Gill <i>Brigham Young University</i>	Juan Carlos Ramirez-Dorronsoro <i>Ball State University</i>
Marguerite Bishop <i>Nash Community College</i>	Richard Groover <i>Reynolds Community College</i>	Keith Summerville <i>Drake University</i>
Judy Bluemer <i>Morton College</i>	Jennifer Harper <i>Bainbridge State College</i>	Daniel Wagner <i>Eastern Florida State College</i>
Randi Brazeau <i>Metropolitan State University of Denver</i>	Meshagae Hunte-Brown <i>Drexel University</i>	Albert Walls <i>Cape Fear Community College</i>
Robert Bruck <i>North Carolina State University</i>	Douglas Kane <i>Defiance College</i>	Jennifer Welch <i>Madison Community College,</i>
Susan Burgoon <i>Amarillo College</i>	Jennifer Latimer <i>Indiana State University</i>	<i>Kentucky Community and Technical College</i>
Kelly Cartwright <i>College of Lake County</i>	Nilo Marin <i>Broward College</i>	<i>System</i>
LuAnne Clark <i>Lansing Community College</i>	Terri Matiella <i>The University of Texas at San Antonio</i>	Justin Williams <i>Sam Houston State University</i>
Scott Connelly <i>University of Georgia</i>	John McClain <i>Temple College</i>	Brian Wolff <i>Normandale Community College</i>
JodyLee Estrada Duek <i>Pima Community College</i>	Eric Myers <i>South Suburban College</i>	John Zahina-Ramos <i>Loyola University Chicago</i>

Second Edition Reviewers

Mark Basinger <i>Barton College</i>	Anthony D. Curtis <i>Radford University</i>	Katherine LaCommare <i>Lansing Community College</i>
Terrence Bensel <i>Allegheny College</i>	Andy Dyer <i>University of South Carolina</i>	Nilo Marin <i>Broward College</i>
Leonard Bernstein <i>Temple University</i>	Gregory S. Farley <i>Chesapeake College</i>	Carolyn Martsberger <i>Loyola University Chicago</i>
Judy Bluemer <i>Morton College</i>	Eric G. Haenni <i>Franciscan University of Steubenville</i>	John McClain <i>Temple College</i>
Scott Brame <i>Clemson University</i>	Jennifer Harper <i>Bainbridge College</i>	Charles McClaugherty <i>University of Mount Union</i>
James R. Brandle <i>College of Agriculture and Natural Resources</i>	Stephanie Hart <i>Lansing Community College</i>	Greg O’Mullan <i>Queens College CUNY</i>
Meshagae Hunte-Brown <i>Drexel University</i>	Alyssa Haygood <i>Arizona Western College</i>	Raymond S. Pacovsky <i>Palm Beach State College</i>
Robert Bruck <i>North Caroline State University</i>	Tara Holmberg <i>Northwestern Connecticut Community College</i>	Barry Perlmutter <i>Community College of Southern Nevada</i>
Kelly Cartwright <i>College of Lake County</i>	Barbara Ikalainen <i>North Shore Community College</i>	Tim Rhoads <i>Central Virginia Community College</i>
David Charlet <i>College of Southern Nevada</i>	Jacqueline Jordan <i>Clayton State University</i>	James Salazar <i>Galveston College</i>
Peter G. Chege <i>Black Hawk College</i>	Natalie Kee <i>University of Mount Union</i>	David Serrano <i>Broward College</i>
Lu Anne Clark <i>Lansing Community College</i>	Reuben Keller <i>Loyola University</i>	Rich Sheibley <i>Edmonds Community College</i>
Jacqueline Courteau <i>University of Michigan</i>	Erica Kipp <i>Pace University</i>	Lynnda Skidmore <i>Wayne County Community College</i>

Justin R St. Juliana
Ivy Tech Community College
Keith Summerville
Drake University
Claire Todd
Pacific Lutheran University
Brad Turner
McLennan Community College

Daniel Wagner
Eastern Florida State College
Albert Walls
Cape Fear Community College
Jennifer Welch
Madison Community College
Kentucky Community & Technical College
System

Jennifer Wiatrowski
Pasco-Hernando State College
Porter Campus
James R Yount
Eastern Florida State College

First Edition Reviewers

David A. Aborn
University of Tennessee,
Chattanooga
Isoken Aighewi
University of Maryland
Saleem Ali
University of Vermont
John All
Western Kentucky University
Mary Allen
Hartwick College
Mark W. Anderson
University of Maine
Joe Arruda
Pittsburg State University
Daphne Babcock
Collin County Community
College
Narinder S. Bansal
Ohlone College
Jon Barbour
University of Colorado,
Denver
Morgan Barrows
Saddleback College
Christy Bazan
Illinois State University
Hans Beck
Aurora University
Peter Beck
St. Edwards University
Diane B. Beechinor
Northeast Lakeview College
Terry Bensel
Allegheny College
Leonard Bernstein
Temple University
William Berry
University of California,
Berkeley
Lisa K Bonnaeu
Metropolitan Community College
Brian Bovard
Florida Golf Coast University
Peter Busher
Boston University
Kelly Cartwright
College of Lake County
Paul Chandler
Ball State University

David Charlet
College of Southern Nevada
Marina Chiarappa-Zucca
De Anza College
Van Christman
Brigham Young University, Idaho
Donna Cohen
Massachusetts Bay Community
College
John Conoley
East Carolina University
Jessica Crowe
Valdosta State University
Jean DeSaix
University of North Carolina
Chapel Hill
Doreen Dewell
Whatcom Community College
Dr. Darren Divine
Community College of Southern
Nevada
Rebecca Dodge
Midwestern State University
James English
Gardner-Webb University
JodyLee Estrada Duek
Pima Community College
Douglas Flournoy
Indian Hills Community College
Steven Frankel
Northeastern University
Jonathan Frye
McPherson College
Karen Gaines
Eastern Illinois University
Kurt Haberyan
Northwest Missouri State
Anne Hall
Emory University
Stephanie Hart
Lansing Community College
Harlan Hendricks
Columbus State University
Carol Hoban
Kennesaw State University
Kelley Hodges
Gulf Coast Community College
Tara Holmberg
Northwestern Connecticut
Community College

Kathryn Hopkins
McLennan Community College
Meshagae Hunte-Brown
Drexel University
Emmanuel Iyiegbuniwe
Western Kentucky University
Tom Jurik
Iowa State University
Richard Jurin
University of Northern Colorado
Susan W. Karr
Carson-Newman College
David K Kern
Whatcom Community College
Kevin King
Clinton Community College
Jack Kinworthy
Concordia University
Rob Kingsolver
Bellarmino University
Cindy Klevickis
James Madison University
Steven A. Kolmes
University of Portland
Ned Knight
Linfield College
Erica Kosal
North Carolina Wesleyan College
Janet Kotash
Moraine Valley Community
College
Robert Kremer
University of Missouri
Diana Kropf-Gomez
Richland College
James David Kubicki
The Pennsylvania State
University
Kody Kuehnl
Franklin University
Frank Kuserk
Moravian College
Troy A. Ladine
East Texas Baptist University
Elizabeth Larson-Keagy
Arizona State University
Jejung Lee
University of Missouri
Lissa M. Leege
Georgia Southern University

Kurt Leuschner
College of the Dessert
Honqi Li
Frostburg State University
Satish Mahajan
Lane College
Kenneth Mantai
State University of New York,
Fredonia
Anthony Marcattilio
St. Cloud State University
Heidi Marcum
Baylor University
Allan Matthias
University of Arizona
Kamau Mbuthia
Bowling Green State University
John McClain
Temple College
Joseph McCulloch
Normandale Community
College
Robert McKay
Bowling Green State University
Bram Middeldorp
Minneapolis Community and
Technical College
Chris Migliaccio
Miami Dade College
Kiran Misra
Edinboro University of
Pennsylvania
James Morris
University of South Carolina,
Columbia
Sherri Morris
Bradley University
Eric Myers
South Suburban College
Jason Neff
University of Colorado,
Boulder
Emily Nekl
High Point University
John Olson
Villanova University
Bruce Olszewski
San Jose State University
Gregory O’Mullan
Queens College

Stephen Overmann	Carleton Lee Rockett	David Serrano	Bradley Turner
<i>Southeast Missouri State University</i>	<i>Bowling Green State University</i>	<i>Broward College</i>	<i>McLennan Community College</i>
William J. Pegg	Susan Rolke	Garey Simpson	Lina Urquidi
<i>Frostburg State University</i>	<i>Franklin Pierce University</i>	<i>Kennesaw State University</i>	<i>New Mexico State University</i>
Barry Perlmutter	Deanne Roquet	Debra Socci	Sean Watts
<i>Community College of Southern Nevada</i>	<i>Lake Superior College</i>	<i>Seminole Community College</i>	<i>Santa Clara University</i>
Shana Petermann	Steven Rudnick	Ravi Srinivas	John Weishampel
<i>Minnesota State Community and Technical College</i>	<i>University of Massachusetts, Boston</i>	<i>University of St. Thomas</i>	<i>University of Central Florida</i>
Julie Phillips	Dork Sahagian	Craig W. Steele	Timothy Welling
<i>De Anza College</i>	<i>Lehigh University</i>	<i>Edinboro University</i>	<i>Dutchess Community College</i>
Frank Phillips	Milton Saier	Michelle Stevens	Kelly Wessell
<i>McNeese State University</i>	<i>University of California, San Diego</i>	<i>California State University, Sacramento</i>	<i>Tompkins Cortland Community College</i>
John Pleasants	James Salazar	Robert Strikwerda	James Winebrake
<i>Iowa State University</i>	<i>Galveston College</i>	<i>Indiana University, Kokomo</i>	<i>Rochester Institute of Technology</i>
Brad Reynolds	Kimberly Schulte	Keith Summerville	Chris Winslow
<i>University of Tennessee, Chattanooga</i>	<i>Georgia Perimeter College</i>	<i>Drake University</i>	<i>Bowling Green State University</i>
Kayla Rihani	Michele Schutzenhofer	Jamey Thompson	Danielle M. Wirth
<i>Northeastern Illinois University</i>	<i>McKendree University</i>	<i>Hudson Valley Community College</i>	<i>Des Moines Area Community College</i>
	Rebecca Sears	Ruthanne Thompson	Todd Yetter
	<i>Western State College of Colorado</i>	<i>University of North Texas</i>	<i>University of the Cumberlands</i>

Class Test and Interview Participants

Ginny Adams, *University of Central Arkansas*; John All, *Western Kentucky University*; Jeff Anglen, *California State University, Fresno*; Dave Armstrong, *University of Colorado*; Berk Ayranci, *Temple University*; Roy Barnes, *Scottsdale Community College*; Christy Bazan, *Illinois State University*; Sandy Bejarano, *Pima College East Campus*; Leonard Bernstein, *Temple University*; William Berry, *University of California, Berkeley*; Neil Blackstone, *Northern Illinois University*; Christopher Bloch, *Texas Tech University*; Gary M. Booth, *Brigham Young University*; James Brandle, *University of Nebraska, Lincoln*; Robert Bruck, *North Carolina State College*; George Byrns, *Illinois State University*; John Calloway, *University of San Francisco*; Frank Carver, *Forsyth College*; Ken Charters, *Cochise Community College*; Dave Charlet, *Community College of Southern Nevada*; LuAnn Clark, *Lansing Community College*; Jaimee Corbet, *Paradise Valley Community College*; Robert Cromer, *Augusta State University*; Wynn Cudmore, *Chemeketa Community College*; Jane Cundiff, *Radford University*; Lynnette Danzl-Tauer, *Rock Valley College*; James Diana, *University of Michigan, Ann Arbor*; Darren Divine, *Community College of Southern Nevada*; Rebecca Dodge, *Midwestern State University*; David Dolan, *University of Wisconsin, Green Bay*; Michael Draney, *University of Wisconsin, Green Bay*; Renee Dutreaux-Hai, *California State University, Los Angeles*; Johannes Feddema, *University of Kansas*; Richard S. Feldman, *Marist College*; Kevin Fermanich, *University of Wisconsin, Green Bay*; Linda Fitzhugh, *Gulf Coast College*; Laurie Fladd, *Trident Technical University*; Chris Fox, *Catonsville Community College*; Katie Gerber, *Santa Rosa Junior College*; Thaddeus Godish, *Ball State University*; James Goetz, *Kingsborough Community College*; Robert Goodman, *Citrus College*; Larry Gray, *Utah Valley University*; Peggy Green, *Broward Community College, North*; Joshua Grover, *Ball State University*; Kurt Haberyan, *Northwest Missouri State*; George Hagen, *Palo Alto College*; Nigel Hancock, *Long Beach City College*; Wendy Hartman, *Palm Beach Community College*; Kim Hatch, *Long Beach City College*; James Haynes, *State University of New York, Brockport*; Kathi Hopkins, *McClennan Community College*; James J. Horwitz, *Palm Beach Community College*; Joseph Hull, *Seattle Central Community College*; Carolyn Jensen, *Pennsylvania State University, University Park*; David Jones, *North Eastern Illinois University*; Susan

Karr, *Carson-Newman College*; Leslie Kanat, *Johnson State College*; Julie Klejeski, *Mesabi Range Community College*; Janet Kotash, *Moraine Valley Community College*; Katherine LaCommare, *Lansing Community College*; John Lendvay, *University of San Francisco*; Paul Lorah, *University of St. Thomas*; Deborah Marr, *Indiana University, South Bend*; Allan Matthias, *University of Arizona*; Shelly Maxfield, *Pima Community College*; John McClain, *Temple Junior College*; Joesph McCulloch, *Normandale Community College*; Rachel McShane, *St. Charles Community College*; Steven J. Meyer, *University of Wisconsin, Green Bay*; Alex Mintzer, *Cypress College*; Jane Moore, *Tarrant County Community College*; James Morris, *University of South Carolina, Columbia*; William Muller, *Temple University*; Hari Pant, *City University of New York, Lehman*; Robert Patterson, *North Carolina State University*; Dan Pavuk, *Bowling Green State University*; Christopher Pennuto, *Buffalo State University*; Barry Perlmutter, *Community College of Southern Nevada*; Julie Phillips, *De Anza College*; Mai Phillips, *University of Wisconsin, Milwaukee*; John Pleasants, *Iowa State University*; Ron Pohala, *Luzerne County Community College*; Juan Carlos Ramirez-Darronsoro, *Ball State University*; Marco Restani, *St. Cloud University*; Brad Reynolds, *University of Tennessee, Chattanooga*; Howard Riessen, *Buffalo State University*; Shamili A. Sandiford, *College of Dupage*; Jodi Shann, *University of Cincinnati*; Loris Sherman, *Somerset Community College*; Brent Sipes, *University of Hawaii, Manoa*; Shobha Sriharan, *Virginia State University*; Edward Standora, *Buffalo State University*; Philip Stevens, *Indiana University, Fort Wayne*; John Suen, *California State University, Fresno*; Jamey Thompson, *Hudson Valley Community College*; Claire Todd, *Pacific Lutheran University*; William Trayler, *California State University, Fresno*; Carl N. Von Endem, *Northern Illinois University*; Zhi Wang, *California State University, Fresno*; Sharon Ward, *Montgomery College*; Jeff Watanabe, *Ohlone College*; Paul W. Webb, *University of Michigan, Ann Arbor*; James W.C. White, *University of Colorado*; Deb Williams, *Johnson County Community College*; Christopher J. Winslow, *Bowling Green State University*; Don Wujek, *Oakland Community College, Auburn Hills*; Lori Zaikowski, *Dowling College*; Carol Zellmer, *California State University, Fresno*; Joseph Zurovchak, *Statue University of New York, Orange Community College*.

Contents

1 Environment, Sustainability, and Science

It Takes a Community

- 1.1 Environment and Sustainability
 - The Environment and You
 - Defining Sustainable Actions
 - Planet, People, and Profit: The Triple Bottom Line

Seeing Solutions DIRT

- 1.2 Ecosystems
 - Ecosystem Function and Integrity
 - Ecosystem Services
- 1.3 Principles of Ecosystem Function
 - Conservation of Matter and Energy
 - Ecosystems Are Open
 - Ecosystem Stability
 - Ecosystem Change
- 1.4 Acting Sustainably
 - Managing Resources
 - Understanding Boundaries
 - Maintaining Balance and Integration
 - Embracing Change
- 1.5 Uncertainty, Science, and Systems Thinking
 - Uncertainty
 - Reducing Uncertainty with Science
 - Systems Thinking

Focus on Science Ways of Knowing

- 1.6 Sustainable Development, The Environment, and You
 - Sustainable Development Goals
 - Challenges to Sustainable Development

Agents of Change Earth Rebirth

SYNTHESIS AND KEY CONCEPTS

2 Environmental Ethics, Economics, and Policy

Dam-nation!

- 2.1 Changing Views of Humans and Nature
 - Pre-Industrial Views
 - The Enlightenment and Industrial Revolution
 - Living in the Modern World: Conservation vs. Preservation

2.2 Environmental Ethics

- Doing the Right Thing
- Who or What Matters?
- Ecofeminism and Environmental Justice

2.3 The Environment and the Marketplace

- Economic Systems
- Supply and Demand
- Economic Value
- Market Complications

2.4 Valuing Ecosystems

- Economic Valuation of Ecosystem Services
- Ecological Valuation

Focus on Science Calculating Ecological Value

- Measuring the Wealth of Nations

2.5 Environmental Policy: Deciding and Acting

- The Policy Cycle
- Policy Decision Framework

2.6 U.S. Environmental Law and Policy

- Governmental Functions
- The Constitution and Environmental Policy

2.7 International Environmental Law and Policy

- Environmental Laws
- International Institutions

Seeing Solutions The Global Environmental Facility and the Mesoamerican Biological Corridor

Agents of Change Reducing Plastic Waste at the University of Puerto Rico

SYNTHESIS AND KEY CONCEPTS

About the Authors	iii
Preface	iv
Acknowledgments	vi
Contents	xi

3

The Physical
Science of the
Environment

64

Searching for Life Elsewhere

66

3.1 Chemistry of the Environment

68

Atoms and Isotopes

68

Molecules and Ionic Compounds

69

The Water Molecule

70

3.2 The Organic Chemistry of Life

71

Biological Chemicals

71

3.3 Energy and the Environment

74

Energy

74

Laws of Thermodynamics

75

Forms of Energy

76

Energy Units

79

3.4 Earth's Structure

80

The Core, Mantle, and Crust

80

Building and Moving Continents

81

The Rock Cycle

83

3.5 Element Cycles in Earth's Ecosystems

85

Biogeochemical Cycles

85

Nutrients

86

3.6 Earth's Atmosphere

87

Composition of Gases

87

Layers of the Atmosphere

88

Water in the Atmosphere

89

3.7 Earth's Energy Budget, Weather, and Climate

90

Earth's Energy Budget

90

Weather and Climate

91

Wind Cells

92

Ocean Currents

93

The Seasons

94

Depicting Earth's Climate

95

SYNTHESIS AND KEY CONCEPTS

96

4

Organism and
Population Ecology
and Evolution

98

Genetic Change and Population
Growth—Fact and Fiction

100

4.1 The Cell—The Fundamental Unit of Life

102

Cell Structure

102

Energy Transformations and the Cell

102

4.2 DNA Is the Key to the Diversity of Life

104

Reproduction

104

Mutations

104

Phenotypes

105

4.3 The Growth of Populations

106

Birth, Death, and Migration

106

Exponential Population Growth: A Case Study

107

Survivorship and Fertility

108

4.4 Limits on Population Growth

109

Environmental Resistance Limits Growth

109

Alternative Patterns of Population Growth

110

Focus on Science The Myth of Lemming Suicide

111

Other Limits on Population Growth

112

Habitat and Ecological Niche

113

4.5 Evolution and Natural Selection

114

Darwin's Finches

114

Finch Studies Continue

115

Natural Selection Works on Inherited Variations

116

Evolution Is Genetic Change

117

4.6 The Evolution of Species

118

Reproductive Isolating Mechanisms

118

4.7 The Hierarchy of Life

120

Evolutionary Map

120

SYNTHESIS AND KEY CONCEPTS

122

5

Human
Population
Growth

124

Human Population Growth—By the Numbers 126

- 5.1 The History of Human Population Growth 128
 - Three Periods of Growth 129

- Seeing Solutions Demography Is Not Destiny 130
 - Demographic Transition Model 131
 - A Tale of Two Countries 132

- 5.2 Global Variation in Human Population Growth 134
 - Birth Rate 134
 - Death Rate 136
 - Age Structure 138
 - Migration 139

- 5.3 Predicting Human Population Growth 140
 - Population Growth Forecasts 140

- Focus on Science Forecasting Future Population Trends and Their Uncertainties 141

- 5.4 Managing Population Growth 142
 - Family Planning 142
 - Development and Population 143
 - Aging Populations 143
 - Two Approaches to Population Growth 144

- Seeing Solutions Women Deliver 145

- 5.5 Resource Use and Population Sustainability 146
 - Sustainability vs. Carrying Capacity 146
 - Human Resource Use 146
 - Affluence and Technology 148

SYNTHESIS AND KEY CONCEPTS 150

6

Communities
and
Ecosystems

152

The Straight Poop on Dung Beetles 154

- 6.1 Competition for Shared Resources 156
 - Interspecific Competition 156
 - How Competitors Coexist 157
 - Exploitation and Interference 159

- 6.2 Herbivory, Predation, and Parasitism 160
 - Herbivores 160
 - Predators 161
 - Parasites 162

- 6.3 Mutualism and Commensalism 164
 - Mutualisms and Commensalisms 164

- 6.4 The Flow of Energy in Ecological Communities 166
 - Food Chains 166
 - Energy and Biomass Pyramids 167
 - Food Web and Species Diversity 168
 - Keystone Species 169

- Focus on Science The Little Things Do Matter 171

- 6.5 The Carbon Cycle and Ecosystem Productivity 172
 - The Carbon Cycle 172
 - Terrestrial Carbon 173
 - Aquatic and Marine Carbon 174
 - Human Impacts 175

- 6.6 Disturbance and Community Change 176
 - Primary Succession 176
 - Secondary Succession 178
 - Cyclic Succession 180
 - The Importance of Place and Time 181

- Agents of Change Vermicomposting at Michigan State University 182

SYNTHESIS AND KEY CONCEPTS 184



7

The
Geography
of Life

Exploring Life's Diversity and Geography

7.1	The Geography of Terrestrial Biomes	190
	Characteristics of Terrestrial Biomes	190
7.2	Tropical Biomes	194
	Tropical Rain Forest	194
	Tropical Seasonal Forest	196
	Tropical Savanna	197
7.3	Temperate Biomes	198
	Temperate Deciduous Forest	198
	Temperate Evergreen Forest	200
	Chaparral	201
	Temperate Grassland	202
7.4	Polar Biomes	204
	Boreal Forest	204
	Tundra	205
7.5	Deserts	206
	Defining Deserts	206
7.6	Mountains and Coastlines	208
	Mountains	208
Focus on Science	Shifting Biomes	210
	Coastlines	211
7.7	Aquatic Biomes	212
	Streams	212
	Lakes and Ponds	214
	Wetlands	216
7.8	Marine Biomes	218
	Estuaries	218
	Oceans	220

SYNTHESIS AND KEY CONCEPTS

186

188

190

190

194

194

196

197

198

198

200

201

202

204

204

205

206

206

208

208

210

211

212

212

214

216

218

218

220

224

8

Biodiversity
Conservation

226

Back from the Brink?

228

8.1 What Is Biodiversity?

230

Landscape Biodiversity

230

Community Biodiversity

232

Genetic Biodiversity

234

8.2 Why Biodiversity Matters

235

Existence Value

235

Ecosystem Functions and Services

235

Ecosystem Stability

236

Economic Value

237

8.3 Global Patterns of Biodiversity

238

Mapping Species Richness

238

Biodiversity Hotspots

240

8.4 Differences in Biodiversity Among

Communities

241

Habitat Diversity

241

Species Interactions

242

Disturbance

243

Local Immigration and Extinction Rates

243

8.5 Threats to Biodiversity

245

Habitat Loss and Degradation

245

Habitat Fragmentation

246

Overharvesting

247

Non-Native Invasive Species

248

Pollution

249

Altered Patterns of Disturbance

249

Climate Change

250

8.6 Strategies for Conserving Biodiversity

251

Preserves and Protected Areas

251

Focus on Science Conservation Corridors

254

Managing Populations of Individual Species

255

8.7 U.S. Policies for Conserving Biodiversity

256

National Parks and Wilderness Areas

256

Legislation to Protect Species

258

Conservation on Private Land

259

8.8 International Policies for Conserving

Biodiversity

260

Endangered Species Trade and Harvest

260

Economic Incentives for Conservation

261

Seeing Solutions Keeping Things Connected

263

SYNTHESIS AND KEY CONCEPTS

264

9

Climate Change and Global Warming

A World of Change

9.1	Long-Term Climate Patterns	266
	The Pleistocene—The Last 2 Million Years	270
	Holocene—The Last 10,000 Years	272
9.2	Measuring Global Temperature	274
	Measuring Recent Climate Change	274
	Causes of Natural Climate Variation	275
9.3	Causes of Global Warming	278
	The Greenhouse Effect	278
	Human Impacts	279
	Sources of Greenhouse Gas Emissions	282
9.4	Consequences of Global Warming	283
	Drier and Wetter	283
	Melting Glaciers and Ice Sheets	283
	Rising Sea Level	285
	Changing Populations and Ecosystems	286
9.5	Forecasting Global Warming	287
	Computer Simulation of Global Warming	287
	Forecasting Scenarios	287
	Forecast Consequences	289
9.6	Mitigating Global Warming	290
	Defining the Challenge	290
	Efficiency and Conservation	291
	Fossil Fuel Use	292
	Renewable Energy	292
	Nuclear Energy	293
	Biostorage	293
9.7	Adapting to Global Warming	294
	Committed Warming, Inevitable Change	294
Focus on Science	Adapting to Rising Seas	296
9.8	Mitigation and Adaptation Policies	297
	What Is the Cost?	297
	Policy Alternatives	297
	Agreeing on the Facts	298
	International Global Change Policy	299
Seeing Solutions	A State of Change	301
Agents of Change	Human Power Brings Energy to the Power Pad	302
	SYNTHESIS AND KEY CONCEPTS	304

10

Air Quality

The Killer Smog

10.1	Air Quality and Air Pollution	306
	Gases and Particles	310
	Sources of Air Pollution	311
	Dispersion and Deposition of Air Pollution	312
10.2	Pollution in the Stratosphere	314
	Aerosols and Climate	314
	Stratospheric Ozone Destruction	315
Focus on Science	Laboratory Science Predicts Global Effects	316
10.3	Pollution in the Troposphere	317
	Acid Deposition	317
	Heavy Metals	318
	Smog	320
	Air Quality Index	321
10.4	Indoor Air Pollution	322
	Combustion By-Products	322
Seeing Solutions	Taking the Fire out of Cooking	324
	Building Materials	325
	Radon	325
	Pesticides	326
	Biological Contaminants	326
10.5	Air Pollution Policy and Law	327
	U.S. Air Pollution Policy	327
	International Air Pollution Policy	328
	Co-Benefits	329
Agents of Change	Resisting a Waste Incinerator in Baltimore	330
	SYNTHESIS AND KEY CONCEPTS	332

11	Water	334	12	Agriculture and the Ecology of Food	374
	A Disappearing Resource	336		Farming for the Future: Contrasting Approaches	376
11.1	Water World	338	12.1	Origins and History of Agriculture	378
	The Hydrologic Cycle and Earth's Water Budget	338		Why Did Agriculture Begin?	378
	The Geography of the Hydrologic Cycle	340		How Did Agriculture Begin?	379
	Watersheds	340		And Then What? Agricultural History	381
	Providing Essential Ecosystem Services	342	12.2	Agroecosystems	382
	Where Is Earth's Fresh Water?	343		Energetics of Agroecosystems	382
11.2	Groundwater	344		Cycling of Nitrogen and Phosphorus	383
	Characteristics of Groundwater	344		Dynamic Homeostasis	386
	Human Uses and Impacts	345	12.3	The Growth of Crop Plants	387
11.3	Water Distribution	346		Plant Growth and Reproduction	387
	Too Much Water	346		What Grows Where and Why?	388
	Too Little Water	348		The Role of Other Organisms	389
	Subsidence and Intrusion	350	12.4	Managing Soil Resources	390
11.4	Water Quality	352		Soil Origins and Structure	390
	Water Pollution	352		Soil Fertility	391
	Effects of Water Pollution on Ecosystems	354		Soil Conservation	392
	Focus on Science Measuring an Ocean of Plastic	356	12.5	Water and Agriculture	393
11.5	Water Management and Conservation	357		Water in Soil	393
	Regulating the Flow	357		Irrigation	394
	Seeing Solutions The Chesapeake Bay Foundation—50 Years of a Private-Public Partnership	360		Conserving Water in Agroecosystems	395
	Managing and Conserving Water Used in Agriculture	361	12.6	Livestock in Agroecosystems	396
	Water Reuse	362		Trophic Level Efficiency	396
	Desalination	363		Environmental Impacts	397
	Getting the Price Right	363	12.7	Managing Genetic Resources	399
11.6	Wastewater Treatment	364		Genetic Diversity and the Stability of Agroecosystems	399
	Municipal Wastewater Treatment	364		Genetically Modified Organisms	401
	On-Site Wastewater Treatment	365	12.8	Managing Competitors and Pests	403
11.7	Water and You	366		Chemical Pest Control	403
	Municipal Water Use	366		Biological Pest Control	405
	Water Efficiency and Conservation	366		Agroecosystem Management of Pests	406
11.8	Water Conservation Policy and Law	368	12.9	The Ecology of Eating	407
	Water Use in the United States	368		The Food Footprint	407
	Water Quality in the United States	369		Ecological Eating	409
	International Water Law	369		Seeing Solutions Urban Farming	411
	Agents of Change Water Conservation Competition	370	12.10	Food for the Future	412
	SYNTHESIS AND KEY CONCEPTS	372		Sustainable Agriculture	412
				Feeding a Hungry World	413
				Agents of Change STOGROW: A Student-Run Campus Farm at St. Olaf College	416
				SYNTHESIS AND KEY CONCEPTS	418

13

Forest Resources

420

The Tragedy of Forest Loss in Haiti

422

13.1 The Values of Forests

424

Ecosystem Services

424

Wood Products

425

Non-Wood Forest Products

428

13.2 Forest Growth

429

The Life History of a Tree

429

The Life History of a Forest Stand

430

The Life History of a Forested Landscape

431

Focus on Science CO₂ and the Growth of Forest Stands

432

13.3 Deforestation

433

Historical Change

433

Causes of Deforestation

434

How Can Deforestation Be Halted?

436

Seeing Solutions Restoring Forests and Community Well-Being in Haiti

437

13.4 Forest Degradation

438

Forest Health in Peril

438

13.5 Defining Sustainable Forest Management

440

Allocation

440

Harvest

441

Rationing

442

Investment

442

Criteria for Sustainable Forest Management

443

SYNTHESIS AND KEY CONCEPTS

444

14

Nonrenewable Energy and Electricity

446

The History of an Oil Field

448

14.1 Energy Production

450

Energy Sources

450

The Economics of Energy Resources

452

14.2 Coal

453

Sources and Production

453

Coal and the Environment

455

14.3 Oil and Natural Gas

457

Sources

457

Oil Production

459

Natural Gas Production

460

Oil, Natural Gas, and the Environment

461

Focus on Science Let It Snow

463

14.4 Nuclear Power

464

Sources and Production

464

Nuclear Power and the Environment

466

14.5 Electric Power—Generation, Distribution, and Use

468

Generating Electricity

468

Batteries and Fuel Cells

469

Transmission of Electricity

469

Seeing Solutions A Smart Grid

470

Environmental Impacts

471

Agents of Change An Advocate for Appalachia

472

SYNTHESIS AND KEY CONCEPTS

474

15	Renewable Energy and Energy Conservation	476
	Human Energy Consumption Through the Ages	478
15.1	Renewable Energy Overview	480
	The Transition to Renewable Energy	480
	Challenges	481
15.2	Solar Energy	483
	Sources and Production	483
	Advantages and Disadvantages	485
15.3	Biomass Energy	486
	Sources and Production	486
	Advantages and Disadvantages	487
	Future Development	489
15.4	Wind Power	490
	Sources and Production	490
	Advantages and Disadvantages	492
	Future Development	492
15.5	Hydropower	493
	Sources and Production	493
	Advantages and Disadvantages	494
	Future Development	496
15.6	Ocean Energy	497
	Sources and Production	497
	Advantages and Disadvantages	498
15.7	Geothermal Energy	499
	Sources and Supplies	499
	Advantages and Disadvantages	500
	Future Geothermal Energy Use	500
15.8	Energy Conservation and Efficiency	501
	Defining Energy Conservation	501
	More Efficient Lighting and Appliances	502
	Automobile Efficiency	502
	Focus on Science Are Electric Vehicles Really Better?	504
15.9	Sustainable Energy Policy	505
	Renewable vs. Nonrenewable Energy	505
	Policy Options	506
	Seeing Solutions Leapfrogging to Renewables	507
	Agents of Change Biodiesel Project at Loyola University Chicago	508
	SYNTHESIS AND KEY CONCEPTS	510

16	Urban Ecosystems	512
	Portland, Oregon: Sustainable by Choice	514
16.1	Urbanization	516
	Ancient Cities	516
	Development of Modern Cities	517
	Current Trends	517
16.2	Urban Ecosystems	519
	Defining Urban Ecosystems	519
	Urban Climate	522
	Urban Hydrology	523
16.3	Urban Land Use	524
	Urban Population Distribution	524
	Causes of Urban Sprawl	526
	Consequences of Sprawl	526
	Urban Slums: Informal Settlements	527
16.4	Urban Planning	528
	Urban Plans and Planning	528
	Bounding Growth	529
	Sustainable Urban Growth	530
	Seeing Solutions Atlanta's Beltline: Abandoned Railway to Transformative Park Network	532
16.5	The Built Environment: Sustainable Building	533
	Green Building	533
	Rating Systems for Sustainable Building	535
	Seeing Solutions Greening the Empire State Building	536
16.6	Urban Transportation	537
	The Challenges of Urban Transportation	537
	Balancing Transportation Options	538
	Urban Transportation Economics	539
16.7	Urban Biodiversity	540
	Urban Wildlife	540
	Green Infrastructure	541
	City Parks, Greenways, and Waterways	542
	Focus on Science Green Walls and Bird Abundance	544
16.8	The City as a Sustainability Strategy	545
	Efficient Capture and Use of Energy and Matter	545
	Ecosystem Characteristics	546
	Agents of Change Get them to the Green	548
	SYNTHESIS AND KEY CONCEPTS	550

17

Waste Management

The Cost of a Can	554
17.1 Solid Waste	556
Municipal Solid Waste	556
Sanitary Landfills	557
Waste to Energy	558
Industrial Solid Waste	559
17.2 Hazardous, Biomedical, Electronic, and Radioactive Waste	560
Hazardous Waste	560
Biomedical Waste	561
Electronic Waste	562
Radioactive Waste	563
17.3 Sustainable Waste Management	564
Diminishing the Waste Stream	564
Challenges to Municipal Recycling	566
Focus on Science To Recycle or Not to Recycle	567
17.4 Managing Product Life Cycles	568
Life-Cycle Assessment	568
Reimagining Product Life Cycles	570
17.5 Waste Management Policy and Law	571
Municipal Solid Waste	571
Hazardous, Biomedical, Electronic, and Radioactive Waste	572
Seeing Solutions Managing E-Waste	573
Agents of Change Trash 2 Treasure: Post-Landfill Action Network	574
SYNTHESIS AND KEY CONCEPTS	576

18

The Environment and Human Health

Out of Africa	580
18.1 Introduction to Public Health	582
Measuring Public Health	582
Hazards and Risk	583
Risk Perception and Reality	584
18.2 Physical Hazards in the Environment	585
Geologic Hazards	585
Weather Hazards	588
Fire in the Environment	590
18.3 Chemical Hazards in the Environment	591
What Is a Toxin?	591
Human Vulnerability to Toxins	592
Toxin Transport and Fate	593
Kinds of Toxins	594
Toxin Testing and Regulation	595
Focus on Science Citizen Science and the Flint Water Crisis	597
18.4 Biological Hazards in the Environment	598
Infectious Disease and the Environment	598
Respiratory Disease	600
Diarrheal Diseases	601
Blood-Borne Diseases	602
Evolutionary Change and the War against Pathogens	603
Seeing Solutions Ebola and the World Health Organization	605
18.5 Environmental Change and Human Health	606
Human Population Size	606
Air and Water Pollution	607
Landscape Change	608
Climate Change	609
Agents of Change The Making of Swine Country: A Film about Public Health and Environmental Justice	610
SYNTHESIS AND KEY CONCEPTS	612

Appendices

Appendix A: Graph Appendix	A1
Appendix B: Metric System	A4
Bibliography	B1
Glossary	G1
Credits	C1
Index	I1

19 The Environment and You

19.1	Hope for the Environment
	Warmer Climates
	Scarcer Resources
	Less Biodiversity
	More People and Bigger Footprints
19.2	And You?
	Continue to Learn and Improve Your Understanding
	Reduce Your Shoe Size
	Give What You Can
	Think and Act for the Future
19.3	Be an Agent of Change
	Articulate a Vision Based on Your Values and Be Willing to Act on It
	Cultivate Diversity
	Focus on Outcomes
	Be Humble and Adaptable
	Be Confident, Committed, and Hopeful

Agents of Change Closing the Loop with Plastics

SYNTHESIS AND KEY CONCEPTS

New Frontiers

Resurrecting Species	162
Counting Species	239
Revving Up Severe Weather?	283
The Highs and Lows of Sharing Water	351
Patenting Life	402
Spying on Forests	436
Cleaning Up Coal	456
A Future for Fusion?	465
Glowing Green	482
Running on Sunshine	503
Building a Truly Sustainable Landfill	559
Proving a Chemical Disrupts Endocrine Function	595

Where You Live

What resources does your national forest provide?	7
What important environmental issues are facing you?	52
What do the numbers tell you?	137
How does the U.S. ecological footprint compare with that of other nations?	146
How do different bird species coexist where you live?	158
What is your climate like?	192
What endangered species live near you?	249
Is your climate changing?	277
Where is the coal plant located nearest to you?	318
What is your AQI?	321
Where does your water come from?	352
How much water do you use?	367
What's growing in your neighborhood?	388
How can you reduce the food footprint of your campus?	409
What can you eat for \$4 a day?	414
What is your national forest worth?	428
Where does your electricity come from?	470
What are your state's renewable portfolio standards?	506
How do you get around on campus?	539
How does your campus compare to an urban ecosystem?	547
Is there a landfill near you?	558
Are you living with hazardous waste?	560
What can you do to reduce your waste footprint?	566
Is there a superfund site located near you?	572
How healthy is your state's population?	582

You Decide

Should "big game" hunting be banned in African wildlife preserves?	41
Should Nigeria enforce a one-child policy to curtail its population growth?	144
Should trade in elephant ivory be banned within countries?	261
Should we attempt to slow global warming by using engineering techniques?	293
Should e-cigarettes be regulated like smoking tobacco?	323
When do water issues transcend homeowners' rights?	349
Should you have to consider the global consequences of your food-buying decisions?	399
Do you believe that converting natural forest to plantations could actually be a conservation strategy?	441
Would you protest the use of hydraulic fracturing in your community?	462
Would you support the installation of new hydropower projects on rivers in the southern Andes of Chile?	496
How would you respond if confronted with the gentrification paradox?	530
Should you bury or burn your garbage?	558
Zika vs. Pesticides: Would you support the use of pesticides to fight mosquitoes carrying the Zika virus?	599