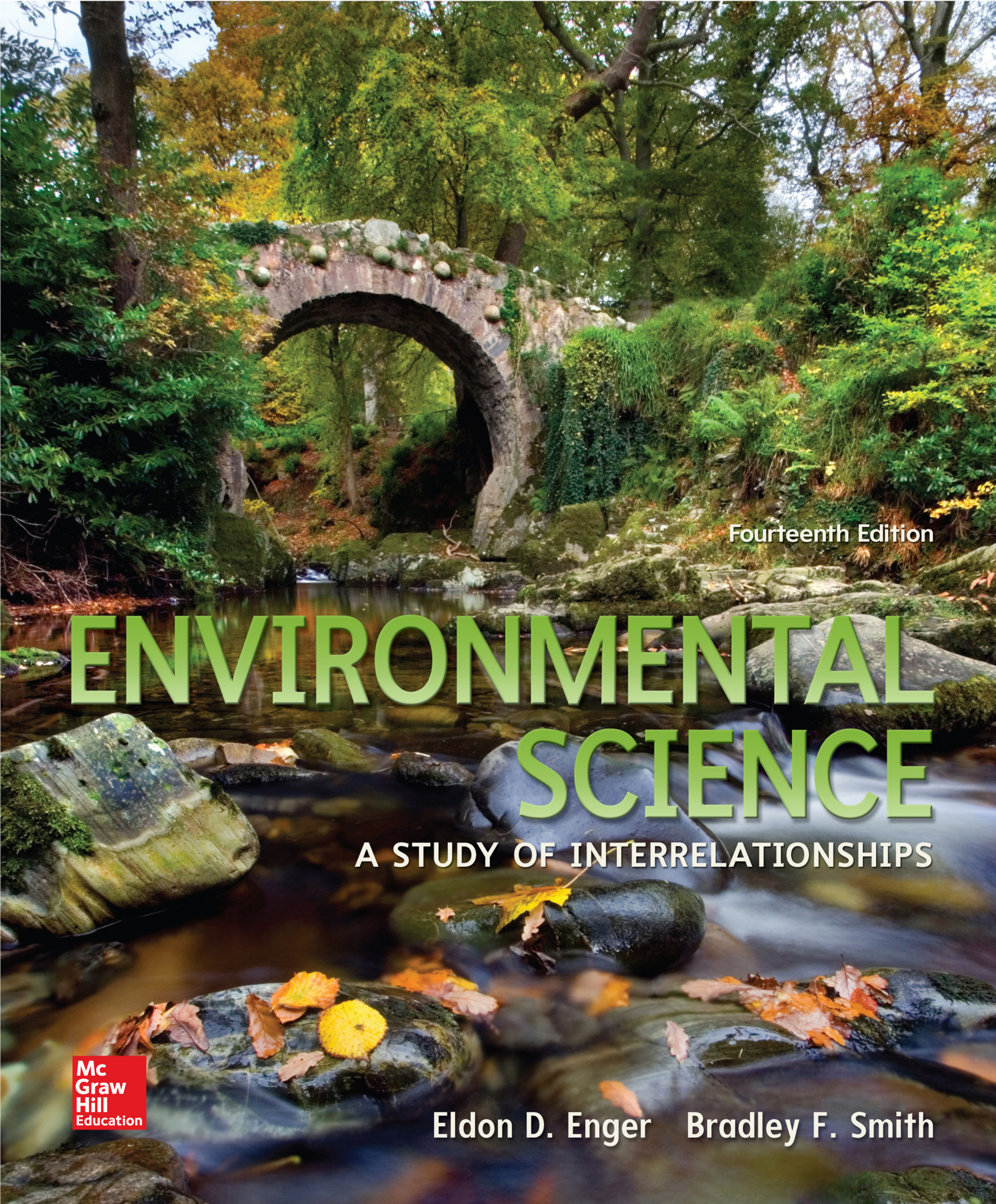
Fourteenth Edition
ENVIRONMENTAL SCIENCE
A STUDY OF INTERRELATIONSHIPS
Mc Graw Hill Education
Eldon D. Enger
Bradley F. Smith

Environmental Science

A Study of Interrelationships

FOURTEENTH EDITION

ELDON D. ENGER
Delta College

BRADLEY F. SMITH
Western Washington University

Mc Graw Hill Education

ENVIRONMENTAL SCIENCE: A STUDY OF INTERRELATIONSHIPS, FOURTEENTH EDITION

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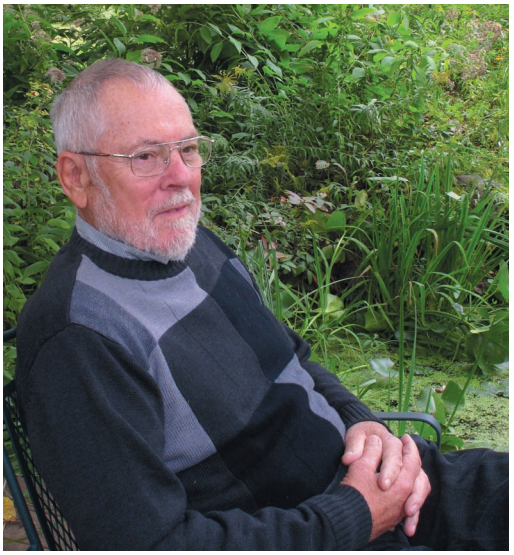
To Judy, my wife and friend,
for sharing life's adventures

ELDON ENGER

For Josh Fox, whose kind and steady nature
makes me proud to have you as a member of our
family and excited at the prospect of watching and
being part of your family as it grows

BRAD SMITH

About the Authors



Eldon D. Enger is an emeritus professor of biology at Delta College, a community college near Saginaw, Michigan. He received his B.A. and M.S. degrees from the University of Michigan. Professor Enger has over 30 years of teaching experience, during which he has taught biology, zoology, environmental science, and several other courses. He has been very active in curriculum and course development. A major curriculum contribution was the development of an environmental technician curriculum and the courses that support it. He was also involved in the development of learning community courses in stream ecology, winter ecology, and plant identification. Each of these courses involved students in weekend-long experiences in the outdoors that paired environmental education with physical activity—stream ecology and canoeing, winter ecology and cross-country skiing, and plant identification with backpacking.

Professor Enger is an advocate for variety in teaching methodology. He feels that if students are provided with varied experiences, they are more likely to learn. In addition to the standard textbook assignments, lectures, and laboratory activities, his classes included writing assignments, student presentation of lecture material, debates by students on controversial issues, field experiences, individual student projects, and discussions of local examples and relevant current events. Textbooks are very valuable for presenting content, especially if they contain accurate, informative drawings and visual examples. Lectures are best used to help students see themes and make connections, and laboratory activities provide important hands-on activities.

Professor Enger received the Bergstein Award for Teaching Excellence and the Scholarly Achievement Award from Delta College and was selected as a Fulbright Exchange Teacher twice—to Australia and Scotland. He has participated as a volunteer in several Earthwatch Research Programs. These include: studying the behavior of a bird known as the long-tailed manakin in Costa Rica, participating in a study to assess the possibility of reintroducing endangered marsupials from off-shore islands to mainland Australia, and helping with efforts to protect the nesting beaches of the leatherback turtle in Costa Rica, and assisting with on-going research on the sustainable use of fish, wildlife, and forest resources in the Amazon Basin in Peru. He also participated in a People to People program, which involved an exchange of ideas between U.S. and South African environmental professionals.

He has traveled extensively, which has allowed him first-hand experience with coral reefs, ocean coasts, savannas, mangrove swamps, tundra, prairies, tropical rainforests, cloud forests, deserts, temperate rainforests, coniferous forests, deciduous forests, and many other special ecosystems. These experiences have provided opportunities to observe the causes and consequences of many environmental problems from a broad social and scientific perspective.

He volunteers at a local nature center, land conservancy, and Habitat for Humanity affiliate. Since 2005, he and his wife have spent a month each year with other volunteers from their church repairing houses damaged by tornados, floods, and hurricanes throughout the United States.

Professor Enger and his wife Judy have two married sons and three grandchildren. He enjoys a variety of outdoor pursuits such as cross-country skiing, snowshoeing, hiking, kayaking, hunting, fishing, camping, and gardening. Other interests include reading a wide variety of periodicals, beekeeping, singing in a church choir, picking wild berries, and preserving garden produce.

Bradley F. Smith is the Dean Emeritus of Western Washington University in Bellingham, Washington, having served as Dean from 1994 to 2012. Prior to assuming the position as Dean in 1994, he served as the first Director of the Office of Environmental Education for the U.S. Environmental Protection Agency in Washington, D.C., from 1991 to 1994. Dean Smith also served as the Acting President of the National Environmental Education and Training Foundation in Washington, D.C., and as a Special Assistant to the EPA Administrator.

Before moving to Washington, D.C., Dean Smith was a professor of political science and environmental studies for 15 years, and the executive director of an environmental education center and nature refuge for five years.

Dean Smith has considerable international experience. He was a Fulbright Exchange Teacher to England and worked as a research associate for Environment Canada in New Brunswick. He is a frequent speaker on environmental issues worldwide and serves on the International Scholars Program for the U.S. Information Agency. He also served as a U.S. representative on the Tri-Lateral Commission on environmental education with Canada and Mexico. He was awarded a NATO Fellowship to study the environmental problems associated with the closure of former Soviet military bases in Eastern Europe. He is a Fellow of the Royal Institute of Environmental Science in the U.K.

He also served on the Steering Committee of the Commission for Education and Communication for the International Union for the Conservation of Nature (IUCN) from 2004 to 2013.

Dean Smith is a trustee of the National Environmental Education Foundation, a member of the North Pacific Research Board, and is Vice-Chair of the Washington State Fish and Wildlife Commission. He also serves on the board of Washington Sea Grant. Previously, he served as the chair of the Washington Sustainability Council, as President of the Council of Environmental Deans and Directors, and as a member of the National Advisory Council for Environmental Policy and Technology for the EPA. He also served on President Clinton's Council for Sustainable Development (Education Task Force).

Dean Smith holds B.A. and M.A. degrees in Political Science/International Relations and Public Administration and a Ph.D. from the School of Natural Resources and the Environment at the University of Michigan.

Dean Smith and his wife, Daria, live along the shores of Puget Sound in Bellingham, Washington, and spend part of the summer at their summer home on the shores of Lake Huron in the Upper Peninsula of Michigan. He has two grown children and is an avid outdoor enthusiast.

Brief Contents

Contents

Preface

The Role of Environmental Science In Society

We live in a time of great change and challenge. Our species has profoundly altered the Earth. Our use of fossil fuels to provide energy is altering climate, our use of Earth's soil resources to feed ourselves results in extinctions, overexploitation of fish populations has resulted in the population declines of many marine species, and freshwater resources are becoming scarce. At the same time we see significant improvement in other indicators. Energy-efficient and alternative energy technologies are becoming mainstream, population growth is beginning to slow, air and water pollution problems are being addressed in many parts of the world, and issues of biodiversity loss, climate change, and human health are beginning to be addressed on a worldwide basis.

However, there are still major challenges and there are additional opportunities to lighten our impact on Earth. Understanding the fundamental principles that describe how the Earth's systems work is necessary knowledge for everyone, not just scientists who study these systems. It is particularly important for political, industrial, and business leaders because the political, technical, and economic decisions they make affect the Earth.

Why "A Study of Interrelationships"?

Environmental science is an interdisciplinary field. Because environmental problems occur as a result of the interaction between humans and the natural world, we must include both scientific and social aspects when we seek solutions to environmental problems. Therefore, the central theme of this book is interrelatedness. It is important to have a historical perspective, to appreciate economic and political realities, to recognize the role of different social experiences and ethical backgrounds, and to integrate these with the science that describes the natural world and how we affect it. *Environmental Science: A Study of Interrelationships* incorporates all of these sources of information when discussing any environmental issue.

Environmental science is also a global science. While some environmental problems may be local in nature—pollution of a river, cutting down a forest, or changing the flow of a river for irrigation—other problems are truly global—climate change, overfishing of the oceans, or loss of biodiversity. In addition, individual local events often add together to cause a worldwide problem—the actions of farmers in China or Africa can result in dust storms that affect the entire world, or the individual consumption of energy from fossil fuels increases carbon dioxide concentrations in the Earth's atmosphere. Therefore, another aspect of the interrelationships theme of this text is to purposely include features that highlight problems, issues, and solutions involving a variety of cultures.

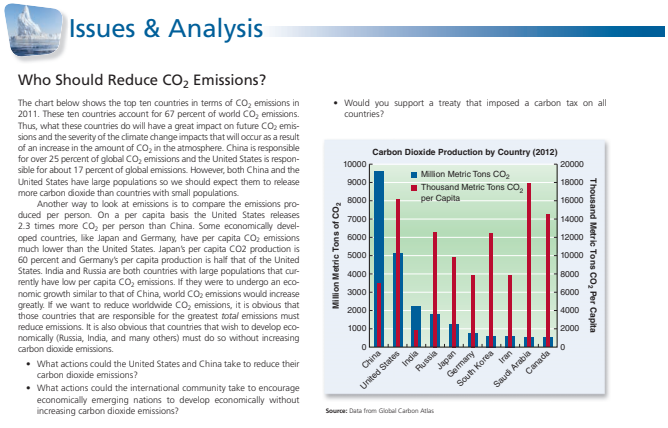
This text has been translated and published in Spanish, Chinese, and Korean. Therefore, students in Santiago, Shanghai, Seoul, or Seattle are learning the "hows and whys" involved in thinking and acting sustainably. At the end of the day we all share the same air, water, and one not-so-big planet. It's important for all of us to make it last.

What Makes This Text Unique?

We present a balanced view of issues, diligently avoiding personal biases and fashionable philosophies.

It is not the purpose of this textbook to tell readers what to think. Rather, our goal is to provide access to information and the conceptual framework needed to understand complex issues so that readers can comprehend the nature of environmental problems and formulate their own views. Two features of the text encourage readers to think about issues and formulate their own thoughts:

- The **Issues & Analysis** feature at the end of each chapter presents real-world, current issues and provides questions that prompt students to think about the complex social, political, and scientific interactions involved.



Issues & Analysis

Who Should Reduce CO_2 Emissions?

The chart below shows the top ten countries in terms of CO_2 emissions in 2011. These ten countries account for 67 percent of world CO_2 emissions. Thus, what these countries do will have a great impact on future CO_2 emissions and the severity of the climate change impacts that will occur as a result of an increase in the amount of CO_2 in the atmosphere. China is responsible for over 25 percent of global CO_2 emissions and the United States is responsible for about 17 percent of global emissions. However, both China and the United States have large populations so we should expect them to release more carbon dioxide than countries with small populations.

Another way to look at emissions is to compare the emissions produced per person. On a per capita basis the United States releases 2.3 times more CO_2 per person than China. Some economically developed countries, like Japan and Germany, have per capita CO_2 emissions much lower than the United States. Japan's per capita CO2 production is 60 percent and Germany's per capita production is half that of the United States. India and Russia are both countries with large populations that currently have low per capita CO_2 emissions. If they were to undergo an economic growth similar to that of China, world CO_2 emissions would increase greatly. If we want to reduce worldwide CO_2 emissions, it is obvious that those countries that are responsible for the greatest *total* emissions must reduce emissions. It is also obvious that countries that wish to develop economically (Russia, India, and many others) must do so without increasing carbon dioxide emissions.

- What actions could the United States and China take to reduce their carbon dioxide emissions?
- What actions could the international community take to encourage economically emerging nations to develop economically without increasing carbon dioxide emissions?
- Would you support a treaty that imposed a carbon tax on all countries?

Source: Data from Global Carbon Atlas

- The **What's Your Take?** feature found in each chapter asks students to take a stand on a particular issue and develop arguments to support their position, helping students develop and enhance their critical thinking skills.

What's Your Take?

Climate change will increase the incidence of flooding in several ways. Rising sea levels will threaten low-lying coastal areas. Intense storms will cause coastal storm surges that can affect areas not normally considered to be in a flood plain. Heavy rain storm events will cause streams and rivers to rise and flood areas adjacent to water courses. Most insurance policies do not cover flood damage. The federal government has made flood insurance available for those in areas at risk of floods; however, many people do not purchase the flood insurance because it is expensive. When flooding occurs victims seek help from government sources and charitable organizations. One way to reduce the cost of flooding is to prevent people from building in areas that are likely to flood. This could be done by federal or state laws or local ordinances. Draw up a law or ordinance that would reduce flood damage to homes and businesses. List at least three criteria that would be used to prevent building in flood-prone areas and justify your selection of each criterion.

We recognize that environmental problems are global in nature.

Three features of the text support this concern:

- Throughout the text, the authors have made a point to use **examples** from around the world as well as those from North America.
- Many of the boxed readings—**Focus On; Going Green; Science, Politics, & Policy;** and **Issues & Analysis**—are selected to provide a global flavor to the basic discussion in the text.

Focus On

Biomass Fuels and the Developing World

Although most of the world uses fossil fuels as energy sources, much of the developing world relies on *biomass* as its source of energy. The biomass can be wood, grass, agricultural waste, or dung. According to the United Nations, 2 billion people (30 percent of the world's population) use biomass as fuel for cooking and heating dwellings. In developing countries, nearly 40 percent of energy used comes from biomass. In some regions, however, the percentage is much higher. For example, in sub-Saharan Africa, fuelwood provides about 80 percent of energy consumed. Worldwide, about 60 percent of wood removed from the world's forests is used for fuel.

This dependence on biomass has several major impacts:

- Often women and children must walk long distances and spend long hours collecting firewood and transporting it to their homes.
- Because the fuel is burned in open fires or inefficient stoves, smoke contaminates homes and affects the health of the people. The World Health Organization estimates that in the developing world, 40 percent of acute respiratory infections are associated with poor indoor air quality related to burning biomass. A majority of those who become ill are women and children because the children are in homes with their mothers who spend time cooking food for their families.
- Often the fuel is harvested unsustainably. Thus, the need for an inexpensive source of energy is a cause of deforestation. Furthermore, deforested areas are prone to soil erosion.
- When dung or agricultural waste is used for fuel, it cannot be used as an additive to improve the fertility or organic content of the soil. Thus, the use of these materials for fuel negatively affects agricultural productivity.

Nepali woman carrying brushwood.

- The presence of easily accessible **Foldout World Maps** at the back of the text allows students to quickly locate a country or region geographically.

We recognize that many environmental issues involve complex social, economic, and cultural aspects.

- The first three chapters focus on the underlying social, economic, health, and ethical aspects involved in understanding how people view environmental issues.
- The **Science, Politics, & Policy feature** shows how the scientific understanding of environmental problems is filtered through the lens of social and political goals to determine policy.

Science, Politics, & Policy

Disposal of Waste from Nuclear Power Plants

The disposal of spent fuel rods from nuclear power plants has been a continuing issue since the first commercial power reactor went on line in 1957. In the more than 50 years since then, it has been clear that there are only two methods of dealing with the nuclear waste from spent nuclear fuel: reprocessing the fuel to reduce the amount of waste or storing the waste at a safe site. U.S. policy has been to store rather than reprocess nuclear waste. Federal law requires the U.S. government to provide a solution to the storage of spent nuclear fuel. All nuclear power plants in the United States have been operating with the assumption that eventually their waste would be stored in a secure federal facility. The National Academy of Sciences recommended underground storage as the best way to deal with waste from nuclear power plants.

The history of U.S. efforts to establish a repository for high-level radioactive waste is long and complicated. The following provides a brief chronology of major steps in the process:

- 1982—The U.S. Congress passed legislation that gave the responsibility for finding, building, and operating a nuclear waste site to the Department of Energy with completion by 1998.
- 1987—Initially several sites were considered and Yucca Mountain was selected to receive further study.
- 1994–1997—A five-mile-long, U-shaped tunnel (the Exploratory Studies Facility) was constructed to study the suitability of the Yucca Mountain site.
- 2002—President George W. Bush signed a joint resolution of Congress designating Yucca Mountain as the site for the nuclear repository.
- 2008—The Department of Energy filed a license application with the Nuclear Regulatory Commission to construct a repository for spent nuclear fuel and high-level radioactive waste at Yucca Mountain. The citizens and political leaders of Nevada opposed the designation.
- 2010—President Obama withdrew funding for Yucca Mountain and the Department of Energy withdrew its request to the Nuclear Regulatory Commission to operate the facility. President Obama also established the Blue Ribbon Commission on America's Nuclear Future.
- 2012—The report of the Blue Ribbon Commission on America's Nuclear Future 2012 included the following statement: *Recommendation #1: The United States should undertake an integrated nuclear waste management program that leads to the timely development of one or more permanent deep geological facilities for the safe disposal of spent fuel and high-level nuclear waste.*
- 2013—A U.S. Court of Appeals ruling stated that the designation of Yucca Mountain as the nation's nuclear repository is still in effect and the Nuclear Regulatory Commission and the President cannot ignore the law and proceed with plans to close Yucca Mountain.
- The Future—The future is uncertain, but it is clear that no permanent solution for storing spent nuclear fuel is likely for decades.

Yucca Mountain

- Critical Thinking questions appear at the end of each chapter and require students to evaluate information, recognize bias, characterize the assumptions behind arguments, and organize information.

We recognize that it is important to focus on the positive.

Environmental science often seems to focus on the negative, since one of the outcomes of any analysis of an environmental situation is to highlight problems and point out where change is needed. We often overlook the many positive actions of individuals and organizations. Therefore, each chapter has two features that call attention to the positive:

- **Going Green** boxes describe actions that are having a positive environmental impact. Some of these actions are taken by governments, some are by corporations, and some are individual efforts.

Going Green

Increasing Populations of Red-Cockaded Woodpeckers

The red-cockaded woodpecker (*Picoides borealis*) is listed as an endangered species. This medium-sized bird (about the size of a cardinal) is a cooperative colony nester—the dominant male and female raise young with the support of nonbreeding members of the colony. They are only found in the southeastern United States—southern Virginia to eastern Texas—where native southern yellow pine forests occur. Several pine species, including slash pine, shortleaf pine, loblolly pine, and longleaf pine, are typical of this region. The original forests were fire-adapted in that mature trees were able to withstand moderate ground fires. This resulted in a rather open forest type. The woodpeckers typically construct their nesting cavities in older, diseased longleaf pine trees.

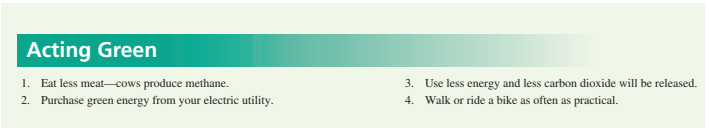
The trees these birds use for nesting are also commercially important. Thus, the amount of suitable breeding habitat has been severely reduced as older trees are harvested and natural stands of pines have been replaced with plantations, where large tracts are planted to a single species and the trees are harvested before they reach old age. Since much of the suitable habitat is privately owned, protecting populations of red-cockaded woodpeckers requires the cooperation of private landowners, conservation organizations, state and federal governments, and commercial forest products companies.

In 1998, International Paper entered into an agreement with the U.S Fish and Wildlife Service, which is responsible for monitoring the status of endangered species, to increase the amount of suitable nesting habitat on its lands. International Paper agreed to set aside particular parcels of forest to maintain colonies of red-cockaded woodpeckers. One of those parcels was the Southlands Experimental Forest near Bainbridge, Georgia. When the agreement was signed in 1998, there were three male red-cockaded woodpeckers at the site. By 2008, there were over 50 individuals. The increase is attributable to protection and improvement of the birds' habitat and transfer of birds to the area from other locations. Today there are about 15,000 red-cockaded woodpeckers throughout its range. In 2006, the company decided to sell nearly all of its land holdings in the United States. Many environmentally sensitive lands were sold to conservation organizations such as The Nature Conservancy and the Conservation Fund, as well as state governments. The Southlands Experimental Forest was sold to the state of Georgia with some funding assistance from the Conservation Fund. This land transfer protects the population gains made by this population of red-cockaded woodpeckers.

Red-cockaded woodpecker habitat

Red-cockaded woodpecker

- **Acting Green** is an end-of-chapter feature that asks students to consider making personal changes that are relatively simple and will have a positive environmental impact.



New to This Edition

The fourteenth edition of *Environmental Science: A Study of Interrelationships* is the result of extensive analysis of the text and the evaluation of input from environmental science instructors who conscientiously reviewed chapters during the revision. We have used the constructive comments provided by these professionals in our continuing efforts to enhance the strengths of the text. The following is a list of global changes we have made, along with a description of significantly revised chapters.

New Chapter Opening Feature This feature presents an example of a current issue that is germane to the chapter content. The issues involved in the example are easy to visualize and serve as an introduction to the topics covered in the chapter. In many cases, the material in the opening feature is specifically addressed or expanded upon in the chapter.


The Adaptation of Wildlife to Urban Environments

Climate change and habitat loss are driving coyotes, bears and mountain lions out of their habitats, but that is only part of the reason why so many animals are now moving into urban areas. While some animals such as pigeons, squirrels, and rodents may seem as much a part of the urban landscape as cement and streetlights, there are growing populations of new wild inhabitants that are a bit more unusual.

Coyotes have rapidly adapted to suburban and urban environments. Coyotes have appeared in cities from Los Angeles to New York. They have learned to live in much smaller territories than they do in rural areas and thrive in a city by hunting enough small rodents and sometimes cats to feed themselves and their young. In 2012, biologists in Los Angeles radio-collared the first mountain lion ever found in Griffith Park. Complaints about bears in Nevada around Lake Tahoe increased tenfold between 2002 and 2012. Some of those bears were so well fed on a continuous supply of garbage that they neglected to hibernate in the winter. In 2011, workers found a fox living on the 72nd floor of an unfinished building in London, England. The fox had been living on the construction workers' food scraps.

As South Florida's urban sprawl continues, there are increased interactions between people and alligators. While alligators are not as predatory toward humans as popular lore might say, it is nonetheless unsettling to come face to face with one in your backyard. Seagulls are invading towns and cities inland from the coasts because the decline of the fishing industry means they can no longer feed off the scraps from fishing boats. In addition, changes in how landfills are managed has eliminated a previous source of food for seagulls.

Although many animals are moving to the city because they are being displaced by climate change and habitat destruction, there are also other factors involved. One of the biggest factors with regard to the large carnivores is that there are more of them because of successful conservation efforts. In addition, as we make cities greener they become more attractive to humans and animals alike. Another factor is that the relationship between humans and large predators is changing. There are now generations of certain carnivores that have experienced low amounts of predation by people. These carnivores may view cities differently than their ancestors, who associated human encounters with a good chance of being shot.

While the new wild inhabitants keep their distance from people most of the time, conflict is inevitable when these animals and humans share space. Sometimes the conflict is between the invading predators and domesticated pets. More serious clashes are rare but not unheard of. In 2011, for example, a coyote attacked children in a Denver suburb on three separate occasions. Suburban grade schools in many states have ordered lockdowns in response to black bears prowling near the premises. Bears are growing fat on human hospitality from the outskirts of Los Angeles to the Beltway of Washington D.C.

There is no doubt that many different species of wildlife are adapting to urban life. Perhaps a bigger question is: Will humans be able and willing to adapt to the presence of these new neighbors?

Current Content As with previous editions the authors have incorporated the most recent information available at the time of publication.

Revised Art Program More than 100 new photos have been added or substituted throughout the text to depict real-life situations. Over 60 illustrations, graphs, and charts are new or revised to present detailed information in a form that is easier to comprehend than if that same material were presented in text form.

Several Significantly Revised Chapters Every chapter has a new chapter opening feature. In addition, many chapters have other significant changes, including:

Chapter 1 Environmental Interrelationships The section on Emerging Global Issues has three new sections: Population Growth, Maintaining Functional Ecosystems, and Food Security. The section on Environment and Health was completely revised. Sections on air pollution, water pollution, malaria, and accidental deaths were added, since they are major environmental health issues in the developing world. The section on Emerging Diseases was rewritten.

Chapter 2 Environmental Ethics The section on Environmental Ethics was substantially rewritten and there were significant additions to the section on Environmental Justice.

Chapter 3 Risk, Economics, and Environmental Concerns The chapter was completely rewritten around the central theme that risk and cost are intimately intertwined. Environmental risk factors and human health are used throughout the chapter to show how risks and costs are related. The sections on Perception of Risk, Ecosystem Services, Environmental Costs, Cost-Benefit Analysis, and Economics and Sustainable Development were substantially revised. The boxed readings Going Green: Green Collar Jobs and Science, Politics, & Policy: The Developing Green Economy were rewritten and the Issues & Analysis: The Economics and Risks of Mercury Contamination was updated to include recent changes in regulations of emissions from power plants.

Chapter 4 Interrelated Scientific Principles: Matter, Energy, and Environment There is a new Science, Politics, & Policy: The Return of Salmon to the Elwha River and a new Issues & Analysis: The End of the Incandescent Light Bulb.

Chapter 5 Interactions: Environments and Organisms There is a new Issues & Analysis on Wildlife and Climate Change. There are updates to the Going Green: Phosphorus-free Lawn Fertilizer and Science, Politics, & Policy: Emotion and Wolf Management.

Chapter 7 Populations: Characteristics and Issues The content was updated with the most recent data from the Population Reference Bureau and there is a new Science, Politics, & Policy: Funding the Unmet Need for Family Planning. The topic of invasive species is also discussed

Chapters 8, 9, and 10 all deal with aspects of energy. These chapters have been updated with the most current data available. Significant new concepts include the impact of newly industrialized countries on energy demands and evaluating energy alternatives through an accounting of energy return on investment. There are also expanded discussions of hydraulic fracturing, unconventional sources of oil and gas, and the renewable fuel mandate.

Chapter 16 Air Quality Issues Chapter 16 has been significantly changed, since the section on climate change was moved to its own chapter, Chapter 17 Climate Change: A Twenty-first Century Issue. The remaining content was reorganized to create a more logical progression of topics. The section on Control of Air Pollution was moved to follow discussions of Photochemical Smog, Acid Precipitation, and Ozone Depletion. There is a new section, 16.8 Air Pollution in the Developing World, that points out that air pollution is still a major problem in much of the developing world. There is a new Going Green: Going Solvent Free and a new Science, Politics, & Policy: A History of Mercury Regulations. Data on the amounts of air pollutants in the U.S. were updated to best available data.

Chapter 17 Climate Change: A Twenty-first Century Issue Chapter 17 is a new chapter. Material about climate change was consolidated into a separate chapter as requested by reviewers. In addition, there are several new sections including:

17.1 Earth Is a Greenhouse Planet describes the role of atmospheric gases in making the Earth habitable.

17.2 Geologic Evidence for Global Warming and Climate Change discusses evidence for past climate changes and their relevance to understanding current changes.

17.3 Growth in Knowledge of Climate Change lists the many kinds of research that contributed to our understanding of climate change.

17.5 The Current State of Knowledge about Climate Change incorporates information from the most recent report of IPCC Working Group I—*Climate Change 2013: The Physical Science Basis.*

17.6 Consequences of Climate Change describes the many disruptions to the hydrologic cycle that occur with climate change.

The section on International Agreements has an updated section on the meeting in Doha, Qatar in 2012 in which participating countries were unable to come to agreement on how to limit greenhouse gas emissions.

There is a new Focus On: Doubters, Deniers, Skeptics, and Ignorers that describes reasons why people question the science related to climate change and the techniques people use to refute climate change science.

Other new or significantly updated content occurs throughout the text and includes: information on wolf hunting, conflicting regulations concerning sea lions and salmon, the role of sanitation and safe drinking water to world health, the adaptation of wildlife species to urban environments, the impact of invasive species, concerns about overfishing of marine fisheries, water ownership rights, the growth of megacities, the use of plants to remediate polluted sites, and the economic and political value of biodiversity.

Acknowledgments

The creation of a textbook requires a dedicated team of professionals who provide guidance, criticism, and encouragement. It is also important to have open communication and dialogue to deal with the many issues that arise during the development and production of a text. Therefore, we would like to thank Brand Manager Michelle Vogler; Product Developer Robin Reed; Project Manager Laura Bies; Buyer Sandy Ludovissy; Content Licensing Specialist Lori Hancock; and Designer Tara McDermott for their suggestions and kindnesses. We would like to thank the following individuals who wrote and/or reviewed learning goal-oriented content for LearnSmart.

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Amy J. Wagner, *California State University at Sacramento*

Finally, we'd like to thank our many colleagues who have reviewed all, or part, of *Environmental Science: A Study of Interrelationships.* Their valuable input has continued to shape this text and help it meet the needs of instructors around the world.

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Additional Materials In Environmental Science

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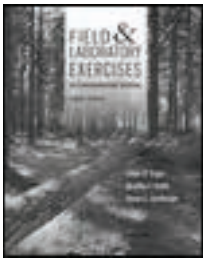
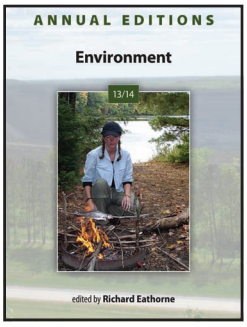


Field and Laboratory Exercises in Environmental Science, Eighth Edition, by Enger, Smith, and Lionberger, 978-0-07-759982-9

The major objectives of this manual are to provide students with hands-on experiences that are relevant, easy to understand, applicable to the student's life, and presented in an interesting, informative format. Ranging from field and lab experiments to social and personal assessments of the environmental impact of human activities, this manual presents something for everyone, regardless of the budget or facilities of each class. These labs are grouped by categories that can be used in conjunction with any introductory environmental textbook.

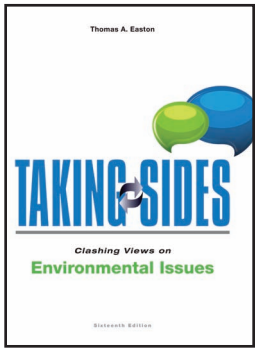


Annual Editions: Environment, by Richard Eathorne, 978-0-07-351562-5

Revised annually for more than 32 years, this text provides convenient, inexpensive access to current articles selected from some of the most respected magazines, newspapers, and journals published today. Instructional features include an annotated table of contents, a correlation guide to main textbooks, a topic guide for all articles, Internet references by unit for additional research, learning outcomes, and critical-thinking questions. An instructor resource guide with test materials is available for download, as well as a practical guide for *Using Annual Editions in the Classroom.*

Taking Sides: Clashing Views on Environmental Issues by Tom Easton; 978-1-259-16113-1

Revised bi-annually for more than 30 years, this text is a debate-style reader designed to introduce students to controversies in environmental policy and science. The readings present arguments by leaders in the field and have been selected for their liveliness and substance. Instructional features include an annotated table of contents, a correlation guide to main textbooks, a topic guide for all articles, Internet references by unit, learning outcomes, critical-thinking questions, and "Is There Common Ground?" questions to guide further research. An instructor resource guide with test materials is available for download, as well as a practical guide for *Using Taking Sides in the Classroom.*

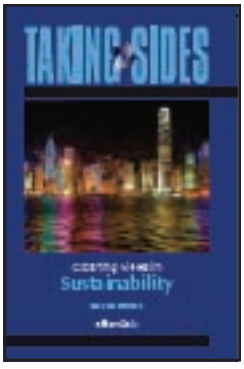


Classic Edition Sources: Environmental Studies, by Tom Easton; 978-0-07-352764-2

Available through our self-service website, Create, this collection brings together more than 40 selections of enduring intellectual value—classic articles, reviews, book excerpts, and research studies—that help define the study of the environment and our current understanding of it. These readings represent almost 150 years of ecological thought and application, with dates of publication ranging from 1864 to the present. Instructional features include an annotated table of contents, a correlation guide to main textbooks, a topic guide for all articles, and Internet references by unit to facilitate further research. An instructor resource guide with test materials is available for download.

Annual Editions: Sustainability by Nicholas Smith-Sebasto, 978-0-07-352874-8

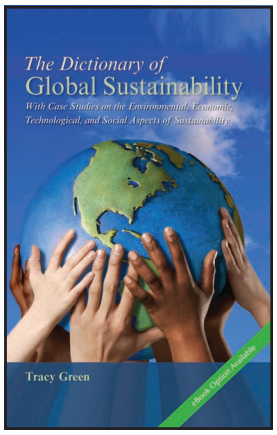
This new addition to the *Annual Editions* series provides carefully selected articles from the most respected magazines, newspapers, and journals published today. This volume contains interesting, well-illustrated readings by environmentalists, educators, researchers, scientists, and writers that provide perspective on the emerging field of sustainability. Instructional features include an annotated table of contents, a correlation guide to main textbooks, a topic guide for all articles, Internet references by unit for additional research, learning outcomes, and critical thinking questions. An instructor resource guide with test materials is available for download as well as a practical guide for *Using Annual Editions in the Classroom.*



Taking Sides: Sustainability by Robert Taylor, 978-0-07-351453-6

This new addition to the *Taking Sides* series introduces students to controversies in the emerging field of sustainability. The text presents arguments by policy analysts, scientists, economists, and environmentalists that have been selected for their liveliness and substance. Instructional features include: an annotated table of contents, a correlation guide to main textbooks, a topic guide for all articles, Internet references by unit, learning outcomes, critical thinking questions, and "Is There Common Ground?" questions to guide further research. An Instructor Resource Guide with test materials is available for download as well as a practical guide for *Using Taking Sides in the Classroom.*

The Dictionary of Global Sustainability by Tracy Green, 978-0-07-351452-9



This textbook serves as a quick reference guide to students and professionals seeking a better understanding of sustainability concepts. The volume provides nearly 2,800 key terms in this emerging field, as well as a listing of organizations and scholarly and trade journals—domestic and international—that will lead the reader to valuable research materials. It includes case studies that examine sustainability projects from around the world designed to illustrate the theory and practice of environmental, economic, technological, and social aspects of sustainability.

chapter
1

Environmental Interrelationships

CHAPTER OUTLINE

Environmental science is the study of interrelationships between humans and the natural world. This farmer in Uganda has cleared a portion of the original forest to create this small farm, which supplies food and income for the family.

OBJECTIVES

After reading this chapter, you should be able to:

- Recognize that the field of environmental science includes social, political, and economic aspects in addition to science.
- Describe examples that illustrate the interrelated nature of environmental science.
- Understand why most social and political decisions are made with respect to political jurisdictions but environmental problems do not necessarily coincide with these human-made boundaries.
- Understand the concept of sustainability.
- Recognize that human population growth contributes to environmental problems.
- Recognize that people rely on the services provided by ecosystems.
- Understand that food security is an issue for many people in the less-developed world.
- Recognize that there are governance issues that make it difficult to solve environmental problems.
- Recognize that the quality of the environment has an important impact on human health.
- Understand that personal security incorporates economic, political, cultural, social, and environmental aspects.
- Describe environmental impacts of globalization.
- Recognize the central role energy use has on environmental problems.

The Important Role of Wolves in Yellowstone

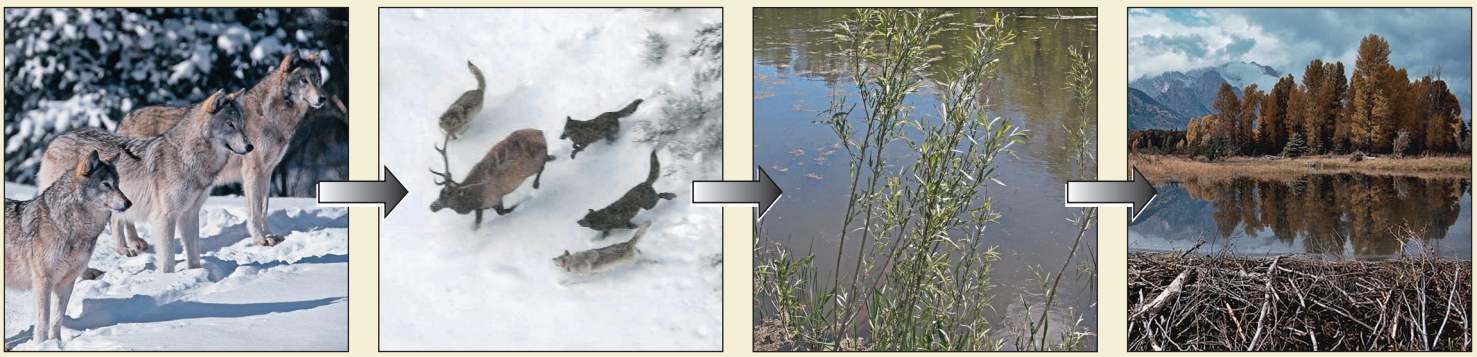
Early explorers of the lands west of the Mississippi River told of a place with fantastic geysers, mud pots, and other thermal features. They also told of abundant wildlife and rivers filled with fish. After several official government expeditions confirmed these tales, Yellowstone National Park was established as the world's first national park in 1872. As more people settled in the west and ranches and farms were established, there was pressure from farmers and ranchers as well as hunters to reduce the number of predator species on public lands in the west. It was also a generally held idea that predators reduced the numbers of elk, deer, and other species preferred by hunters. Thus the U.S. Congress in 1914 provided funding to eliminate wolves and other predators on public lands including national parks. By 1926 wolves had been eliminated from Yellowstone. The lack of wolves led to a cascade of unintended consequences:

- Since hunting of species other than predators was prohibited in the park, the population of elk increased. In addition, coyotes, which are normally killed by wolves, increased greatly. By 1935, park managers felt that overgrazing by the large population of elk was beginning to destroy the park's habitat. Therefore, a program of harvesting elk, bison, and pronghorns was instituted to protect the habitat. This program was discontinued in the 1960s as better knowledge of the habitat indicated that it was not overgrazed.
- Coyotes greatly reduced the number of small mammal species such as mice, squirrels, and rabbits.
- The number of pronghorn antelope also decreased because coyotes killed newborn pronghorns.
- Populations of cottonwood and willows along streams declined substantially due to browsing by elk.

Eventually, as park managers and biologists began to understand the profound changes caused by the elimination of wolves, the decision was made to reintroduced wolves to Yellowstone National Park. The initial introduction of 31 wolves in 1995 and 1996 has resulted in a current population of about 100 wolves. Several changes to the Yellowstone ecosystem can be directly attributed to the alterations brought about by the return of wolves:

- Wolves kill and eat elk. This has resulted in a significant reduction in the size of the elk herd from about 19,000 prior to wolf reintroduction to less than 4,000 now.
- The presence of wolves also has modified the behavior of elk. Because they must be more vigilant and move about more because of the predatory behavior of wolves, elk spend less time feeding on willow, cottonwood, and aspen. Both the change in behavior and the reduced size of the elk herd have allowed the regeneration of stands of cottonwood and willow along rivers. This has in turn resulted in increased numbers of beavers that use these streamside trees for food. The dams built by beavers tend to slow the flow of water and increase the recharge of groundwater. Furthermore, the stands of willow along the banks of streams cool the water and improve fish habitat. The stands of willow also provide needed habitat for some songbirds.
- Wolves directly compete with coyotes and kill them if they have the opportunity. Thus, since the reintroduction of wolves the coyote population has fallen significantly. There is evidence that the populations of the prey of coyotes—voles, mice, and other rodents—have increased. The increased availability of this food source has resulted in an increase in the number of foxes, hawks, and owls.

Thus, it is fair to say that the reintroduction of the wolf has changed how water flows through the landscape and has led to increased populations of many organisms—willow, cottonwood, beaver, songbirds, foxes, certain rodents, hawks, and owls; and to the decline in the population of other organisms—coyote and elk. Truly this is a story that illustrates the point made by the early naturalist John Muir (1838–1914)—*Tug on anything at all and you'll find it connected to everything else in the universe.*



Wolves reintroduced **Elk decline** **Willows increase** **Beavers increase**

1.1 The Nature of Environmental Science

Environmental science is an interdisciplinary field that includes both scientific and social aspects of human impact on the world. The word *environment* is usually understood to mean the surrounding conditions that affect organisms. In a broader definition, **environment** is everything that affects an organism during its lifetime. In turn, all organisms including people affect many components in their environment. **Science** is an approach to studying the natural world that involves formulating hypotheses and then testing them to see if the hypotheses are supported or refuted. However, because humans are organized into complex societies, environmental science also must deal with politics, social organization, economics, ethics, and philosophy. Thus, environmental science is a mixture of traditional science, individual and societal values, economic factors, and political realities that are important to solving environmental problems. (See figure 1.1.)

Although environmental science as a field of study is evolving, it is rooted in the early history of civilization. Many ancient cultures expressed a reverence for the plants, animals, and geographic features that provided them with food, water, and transportation. These features are still appreciated by many modern people. Although the following quote from Henry David Thoreau (1817–62) is over a century old, it is consistent with current environmental philosophy:

> I wish to speak a word for Nature, for absolute freedom and wildness, as contrasted with a freedom and culture merely civil . . . to regard man as an inhabitant, or a part and parcel of Nature, rather than a member of society.

The current interest in the state of the environment began with philosophers like Thoreau and scientists like Rachel Carson and received emphasis from the organization of the first Earth Day on April 22, 1970. Subsequent Earth Days reaffirmed this commitment. As a result of this continuing interest in the state of the world and how people both affect it and are affected by it, environmental science is now a standard course or program at many colleges. It is also included in the curriculum of high schools. Most of the concepts covered by environmental science courses had previously been taught in ecology, conservation, biology, or geography courses. Environmental science incorporates the scientific aspects of these courses with input from the social sciences, such as economics, sociology, and political science, creating a new interdisciplinary field.

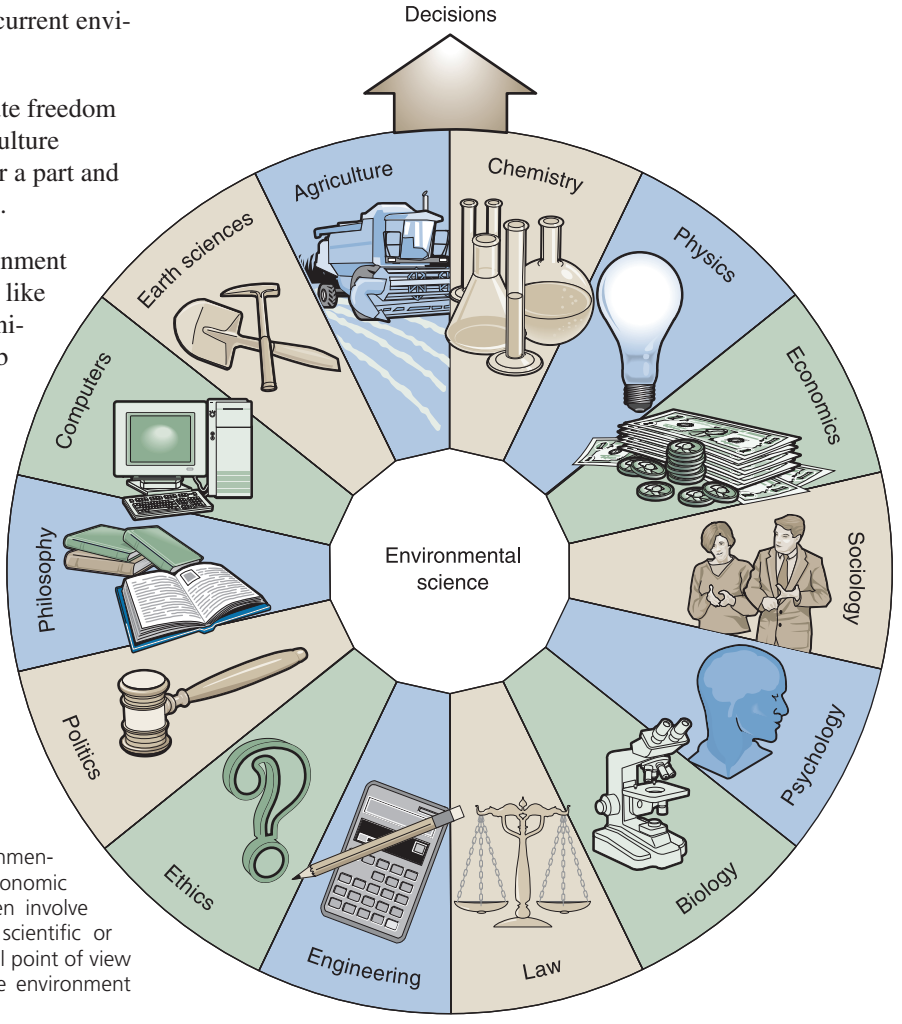


FIGURE 1.1 Environmental Science The field of environmental science involves an understanding of scientific principles, economic influences, and political action. Environmental decisions often involve compromise. A decision that may be supportable from a scientific or economic point of view may not be supportable from a political point of view without modification. Often political decisions relating to the environment may not be supported by economic analysis.

Interrelatedness Is a Core Concept

A central factor that makes the study of environmental science so interesting/frustrating/challenging is the high degree of interrelatedness among seemingly unrelated factors. The opening story about the relationship between wolves and elk in Yellowstone National Park illustrates the theme of interrelatedness very well. The absence of wolves led to an increase in elk and coyotes but to a decrease in beaver, streamside stands of willow and cottonwood, and habitat for some birds. The return of wolves resulted in a decrease in elk numbers and changes in elk behavior that allowed the vegetation to rebound and for beaver to increase in numbers. However, this interrelatedness theme does not just relate to the animal and plant actors in this drama. There is an important human-dominated drama as well that involves philosophical, economic, and political actors.

For example, although many biologists and environmentalists argued that it was important to restore the wolf to its former habitat for biological reasons, others looked at the issue in terms of ethics. They felt that humans had an ethical obligation to restore wolves to their former habitat. While park managers could easily see the problems created by a lack of wolves and a huge elk population, they could not simply make the decision to bring back the wolf. A long history of controlling animals that could prey on

livestock had to be overcome. Ranchers strongly opposed the reintroduction of wolves and saw this as an economic issue. If wolves left the park and killed their livestock, they would lose money. The farm lobby in Congress is very strong and fought long and hard to prevent the reintroduction. After a lengthy period of hearings and many compromises—including a fund to pay ranchers for cattle killed by wolves—the U.S. Fish and Wildlife Service was authorized to proceed with the reintroductions. Thus, the interconnectedness theme associated with the reintroduction of wolves to Yellowstone also applies to social, economic, and political realms of human activity.

An Ecosystem Approach

The idea of interrelatedness is at the core of the ecosystem concept. An **ecosystem** is a region in which the organisms and the physical environment form an interacting unit. Within an ecosystem there is a complex network of interrelationships. For example, weather affects plants, plants use minerals in the soil and are food for animals, animals spread plant seeds, plants secure the soil, and plants evaporate water, which affects weather.

Some ecosystems have easily recognized boundaries. Examples are lakes, islands, floodplains, watersheds separated by mountains, and many others. Large ecosystems always include smaller ones. A large watershed, for example, may include a number of lakes, rivers, streams, and a variety of terrestrial ecosystems. A forest ecosystem may cover hundreds of square kilometers and include swampy areas, openings, and streams as subsystems within it. Often the boundaries between ecosystems are indistinct, as in the transition from grassland to desert. Grassland gradually becomes desert, depending on the historical pattern of rainfall in an area. Thus, defining an ecosystem boundary is often a matter of practical convenience.

However, an ecosystem approach is important to dealing with environmental problems. The task of an environmental scientist is to recognize and understand the natural interactions that take place and to integrate these with the uses humans must make of the natural world.

Political And Economic Issues

Most social and political decisions are made with respect to political jurisdictions, but environmental issues do not necessarily coincide with these artificial political boundaries. For example, Yellowstone National Park is located in the northwest corner of Wyoming. (See figure 1.2.) Therefore, the citizens of the bordering states—Montana and Idaho—as well as the citizens of Wyoming were involved in arguing for or against the reintroduction of wolves to Yellowstone. Citizens recognized that once wolves returned to the park they would migrate to areas surrounding the park. Similarly, air pollution may involve several local units of government, several states or provinces, and even different nations. Air pollution generated in China affects air quality in western coastal states in the United States and in British Columbia, Canada. On a more local level, the air pollution generated in Juarez, Mexico, causes problems in the neighboring city of El Paso, Texas. But the issue is more than air quality and human health. Lower wage rates and less strict environmental laws have influenced some U.S. industries to move to Mexico for economic advantages. Mexico and many other developing nations are struggling to improve their environmental image and need the money generated by foreign investment to improve the conditions and the environment in which their people live.

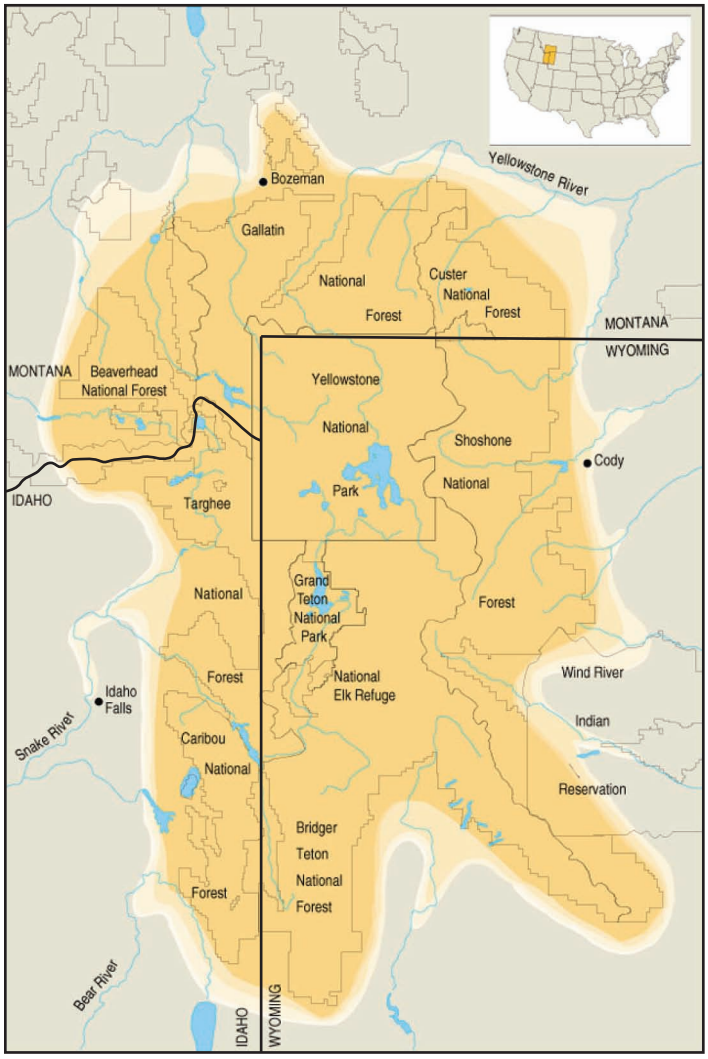


FIGURE 1.2 Environmental Issues often Involve Several Political Jurisdictions The location of Yellowstone National Park in the northwest corner of Wyoming means that citizens of Wyoming and the adjoining states of Idaho and Montana are affected by decisions about the park. In addition, there are several national forests, refuges, and an Indian reservation located near the park. These entities may have goals that differ from those of Yellowstone National Park.
Source: *National Park Service.*

1.2 Emerging Global Issues

Imagine a world in which environmental change threatens people's health, physical security, material needs, and social cohesion. This is a world beset by increasingly intense and frequent storms and by rising sea levels. Some people experience extensive flooding,

Going Green

Individual Decisions Matter

Note to Reader

Because environmental science is involved in highlighting problems, the many improvements and positive changes are often overlooked. To call attention to these bits of good news, this book will describe actions that have had a positive environmental impact. Each chapter will have a "Going Green" feature that highlights a particular green initiative. In addition, at the end of each chapter there is an "Acting Green" feature which suggests changes that you can make that collectively can help lead to a sustainable society.

There is a growing awareness that sustainability needs to be a core value if future generations are to inherit an Earth worth having. Those who support green initiatives are motivated in many different ways. Some are motivated by ethical or moral beliefs that they should "live lightly on the land." Some are motivated by the economic realities of rising energy costs or the costs associated with correcting environmental mistakes. Some simply want to be seen as having green values.

Regardless of their motivation, people around the world are making green decisions. Organizers of conferences and concerts are buying carbon credits to offset the impact of their events. Companies have discovered that consumers seek green products. Governments have passed laws that encourage their citizens to live more sustainably. Ultimately, however, green initiatives depend on individuals making everyday decisions. How many pairs of shoes do I really need? Do I really need the latest electronic gadget? Should I buy products that are produced locally? In the final analysis, most daily decisions have an environmental impact and you have a role to play.

Ten Things You Can Do To Protect Your Environment

1. Reduce your driving (walk, bike, take public transit, carpool). Choose a more efficient car.
2. Do not leave your TV, computers, DVD players on standby. They are using electricity on standby.
3. Recycle everything you can: newspapers, cans, glass bottles, motor oil, etc. Recycling one aluminum can saves enough energy to run a TV set for 3 hours or to light one 100-watt bulb for 20 hours. In 2011, 65 percent of aluminum cans were recycled.
4. Do not leave water running needlessly. Install a water-efficient showerhead and run only full loads in the washing machine or dishwasher. It takes energy to heat the water used by these devices.
5. Do not dispose of gasoline, oil, or weed killers and other lawn and garden pesticides down the drain, into surface water, onto the ground, or in the trash. Check with your local household hazardous waste collection agency for safe disposal of these types of products.
6. Eat a locally produced diet. Grow your own food or support local farmers, natural food stores, and food co-ops.
7. Take unwanted, reusable items to a charitable organization or thrift shop. They don't go to a landfill and someone else is able to use them.
8. Buy in bulk when you can and avoid excess packaging. Even recyclable packaging requires energy and resources to create. Also look for refillable containers.
9. Read labels on pesticides, cleaners, paints, and other products. Choose those with fewer hazardous contents.
10. Become an informed and active citizen. Vote; participate in public forums; get involved in local, state, national or international environmental concerns!

This list is only a start. Go to the website earth911.com. How many additional activities/actions can you add to this list?

while others endure intense droughts. Species extinction occurs at rates never before witnessed. Safe water is increasingly limited, hindering economic activity. Land degradation endangers the lives of millions of people.

This is the world today. Yet, as the World Commission on Environment and Development (Brundtland Commission) concluded in its 1987 report, *Our Common Future,* "humanity has the ability to make development sustainable." An important contribution of the report was a concise definition of **sustainability** as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Thus the Brundtland Commission addressed the links between development and environment, and challenged policymakers to consider the interrelationships among environmental, economic, and social issues when it comes to solving global problems. Emerging global challenges they identified included continued population growth, maintaining functional ecosystems, food security, environmental governance, health, security, globalization, and energy.

Population Growth

It is fair to say that a core cause of the current environmental crisis is the sheer number of people. If there were fewer people, the pressure on environmental resources and services would be much less. However, the causes of human population growth are not just biological. People have the ability and tools to make decisions about how many children they will have but for a variety of cultural and economic reasons they often have large families. Consequently, the human population continues to grow, with most of the increase in population occurring in poor countries. (See figure 1.3.) This growth puts pressure on resources and leads to the degrading of the environment and often locks people in a cycle of poverty.

Focus On

Campus Sustainability Initiative

The Association for the Advancement of Sustainability in Higher Education (AASHE) was founded in 2006 as a membership organization of colleges and universities in the United States and Canada. There are currently over 800 member colleges and universities. AASHE's mission is to promote sustainability in all aspects of higher education. Its definition of sustainability includes human and ecological health, social justice, secure livelihoods, and a better world for all generations. A core concept of AASHE is that higher education must be a leader in preparing students and employees to understand the importance of sustainability and to work toward achieving it. Furthermore, campuses should showcase sustainability in their operations and curriculum.

To accomplish its goals, AASHE sponsors conferences and workshops to educate members. It also provides networking opportunities and an e-bulletin to facilitate the exchange of information about sustainable practices on campuses.

AASHE has developed a rating system that allows educational institutions to assess their progress toward achieving sustainability. The Sustainability Tracking, Assessment, and Rating System (STARS) focuses on three major categories of activity: education and research, operations, and administration and finance.

Is your college a member? Go to the AASHE website and check its membership list.

FIGURE 1.3 Population Growth Most of the growth in human population is occurring in the less-developed world. The population growth rate for most of the economically developed world is stable or falling.

Poverty is often linked to poor health because of malnutrition and lack of access to affordable health care.

The economically developed countries generally have stable or falling populations and many encourage immigration from the less-developed parts of the world to provide the labor needed for their economies.

Maintaining Functional Ecosystems

As people seek to provide food and other resources for their families, they necessarily affect natural ecosystems. Much of the Earth's surface has been converted to agricultural use for raising crops or grazing cattle. When this conversion occurs natural ecosystems are destroyed or degraded. We are beginning to recognize that biodiversity and functional ecosystems have economic value and their loss can have profound economic consequences.

When a species of organism goes extinct, its loss has a ripple effect throughout its ecosystem. As was described in the chapter opening, the local extinction of wolves resulted in changes in the populations of plants and other animals. There is consensus among scientists that the current rate of extinction is similar to that which occurred in the mass extinctions of the geologic past.

A related concern is that the loss of ecosystems results in a loss or reduction in the services they provide. These **ecosystem services** include *provisioning services,* such as food, minerals, renewable energy, and water; *regulating services,* such as waste decomposition, pollination, purification of water and air, and pest and disease control; *cultural services,* such as spiritual, recreational, and cultural benefits; and *supporting services,* such as nutrient cycling, photosynthesis, and soil formation. (See figure 1.4.) Environmental changes that alter these services affect human security. Although all people rely on ecosystem services, the world's poorest people are especially dependent on environmental goods and services for

FIGURE 1.4 Ecosystem Services Pollination is an important ecosystem service.

their livelihoods, which makes them particularly sensitive and vulnerable to environmental changes.

Food Security

The world is divided into those who have abundant food, those who have adequate food, and those who often lack food. The poor of the world are often subsistence farmers who rely on the food they grow to feed their families. (See figure 1.5.) Environmental disasters such as droughts, floods, or outbreaks of disease in their animals or crops often result in a lack of food and malnutrition.

The amount of food produced in the world is currently able to feed all people adequately. When people face a food shortage, food can be shipped from those that have a surplus to those that need food. However, this is not as simple as it sounds. The poor cannot pay for the food or the cost of shipping it to them. Humanitarian organizations or governments that provide food must fund these emergency programs. A related problem is that the people who need food often must migrate to areas where food is being distributed, which leads to the establishment of refugee camps or increased squatter populations in and around cities.

Therefore, major efforts are being made to provide farmers with better farming methods, improved seeds, and with crops that provide food but do less damage to the land.

Environmental Governance

Despite a greater understanding of the ties between environment and development, real progress toward sustainable development has been slow. Many governments continue to create policies concerned with environmental, economic, and social matters as separate issues. As a result, strategies for economic development often ignore the need to maintain the ecosystem on which long-term development depends. A good example of this disconnect is the continued building of housing on coastlines and floodplains that are subject to flooding. The extent of the damaged caused by hurricane Katrina in 2005 and hurricane Sandy in 2012 was at least partly due to the failure of some government agencies to see

FIGURE 1.5 Food Security In much of the less-developed world, small-scale farms provide the food that people need. If environmental disasters affect crops, people go hungry.

the link between destruction of coastal wetlands and the increased vulnerability of coastal communities to storms.

The issue of declining salmon stocks in the Pacific Northwest of the United States and British Columbia, Canada illustrates another aspect of the problem of governance. (See figure 1.6.) There is typically political and economic friction associated with a resource that crosses political boundaries. From the U.S. perspective alone there are five federal cabinet-level departments, two federal agencies, five federal laws, and numerous tribal treaties that affect decisions about the use of this resource. Furthermore, commercial fishers from several states and provinces are economically affected by any decisions made concerning the harvesting of these fish. They are all politically active and try to influence the laws and rulings of state, provincial, and national governments. It is also safe to say that good science is not always the motivator for the laws and policies.

Environment and Health

The health of countless people around the world is affected by human-induced changes in the environment. According to the World Health Organization (WHO), almost one-quarter of all diseases are caused by environmental exposure. WHO estimates that 13 million deaths worldwide could be prevented every year by environmental improvement.

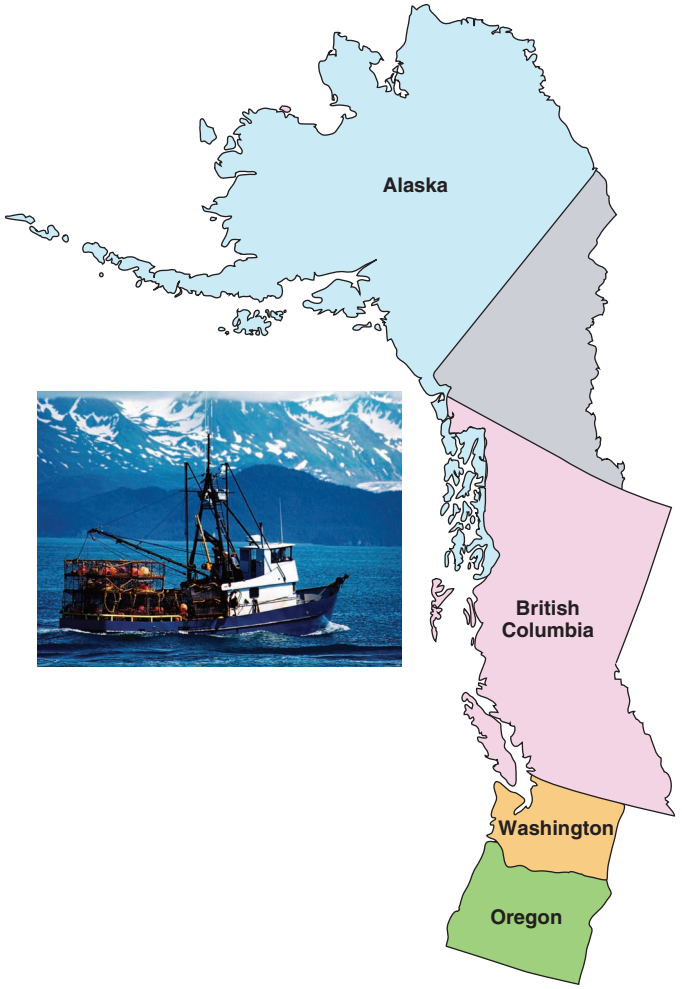


FIGURE 1.6 The Regional Nature of Environmental Problems The regulation of salmon fishing in the Northwest involves several states and the Canadian province of British Columbia. These political entities regulate fishing seasons and the kind of gear that can be used.

In the poorer countries of the world about one third of deaths have environmental causes. Environmental risks including air and water pollution, hazards in the workplace, traffic-related injuries, ultraviolet radiation, noise, and climate and ecosystem change all need to be addressed to generate better global health. The following examples show how environmental conditions and human health are linked.

Air pollution is a serious problem in much of the developing world. In many urban areas the general public is exposed to poor air quality that results from unregulated industrial sources and vehicles with poor pollution control devices. In addition, many people are exposed to high levels of air pollution in their workplaces, and people are exposed in their homes because burning of wood for cooking and heating releases wood smoke. Cigarette smoking exposes the user, and those who live and work with smokers are exposed secondhand. Common diseases related to air pollution are pneumonia, emphysema, and bronchitis, which are responsible for about 6 million deaths per year.

Water pollution results from industrial and municipal releases of pollutants into waterways. Many people in the developing world do not have access to a safe drinking water source or sanitary facilities. When untreated human wastes contaminate water, disease organisms are easily spread from person to person. Diarrhea that results from contaminated drinking water causes dehydration and malnutrition and leads to nearly 2 million deaths per year. The majority of deaths occur in children.

Malaria is caused by a protozoan parasite carried by mosquitos. Programs to protect people from being bitten by infected mosquitos have eliminated the disease in much of the developed world. However, it still results in over half a million deaths per year primarily in children in Sub-Saharan Africa. Once a person is infected with malaria, they continue to have episodes of the disease and when bitten by mosquitos can cause mosquitos to become infected and carry the disease to other persons. Breaking the cycle of disease involves altering the environment so that mosquitos have fewer breeding places and preventing people from being bitten by mosquitos.

Accidents in the home and workplace and those that result from traffic cause about 900,000 deaths per year. Over half the accidental deaths result from traffic accidents. In much of the less-developed world, road conditions are poor, vehicles are poorly maintained, and the mix of pedestrians, bicycles, animals pulling carts, and motor vehicles on roads and streets results in many accidents.

Cancer and coronary heart disease cause about 4 million deaths per year. They are common throughout the world but are most prevalent in developed countries. The environmental causes of these diseases are varied but include exposure to cigarette smoke, exposure to ultraviolet light, and the kinds and amounts of foods eaten. Obesity is a contributing cause.

Emerging diseases result from new organisms or those that become a problem because of environmental changes. Since 1980, more than 35 infectious diseases have emerged or taken on new importance. Often these diseases result from interactions between animals and humans that result in the transfer of animal diseases to humans. The AIDS virus and several flu viruses are examples. In other cases, human changes to the environment lead to changes in organisms that make them more deadly. For example, the wide use of antibiotics has caused the evolution of antibiotic-resistant bacteria such as tuberculosis and methicillin-resistant *Staphylococcus aureus* (MRSA).

Figure 1.7 illustrates several links between environment and health.

Environment and Security

A person's security incorporates economic, political, cultural, social, and environmental aspects. It means having stable and reliable access to resources and the ability to be secure from natural and human disasters. Environmental resources are a critical part

(a) Obesity

(b) Water Pollution

(c) Air Pollution

(d) Traffic Congestion

FIGURE 1.7 Environment and Health Figure 1.7a depicts obesity, which is a major health concern in a growing number of developed countries. Figure 1.7b shows women washing clothes in polluted water in an urban slum in India. People will also use the same water downstream to wash vegetables, increasing the risk of spreading disease. Figure 1.7c shows air pollution in Shanghai, China. Air pollution is a major health issue in China. Figure 1.7d shows traffic congestion in Chengdu, China. This kind of traffic situation often results in accidents that lead to injuries and deaths.

of the livelihoods of millions of people, and when these resources are threatened through environmental change, people's security is also threatened making conflict and social instability common. (See figure 1.8.) For example, disputes over water quantity and quality are ongoing in many parts of the world, and when land ownership is concentrated in the hands of a few rich people, revolution and redistribution of land often result.

Human migration and urbanization have complex relationships with environmental change. Natural disasters such as floods and droughts and human disasters such as war cause many people to migrate to new areas. The local increase in population caused by new immigrants puts increased demands on the local environment to supply resources and provide adequate ecosystem services. Thus, local ecosystems are typically degraded.

Urbanization in particular can cause significant pressure on the environment. Rapid urban growth often overwhelms the ability of cities to provide adequate services to their inhabitants and industrial and human wastes pollute the local environment. On the