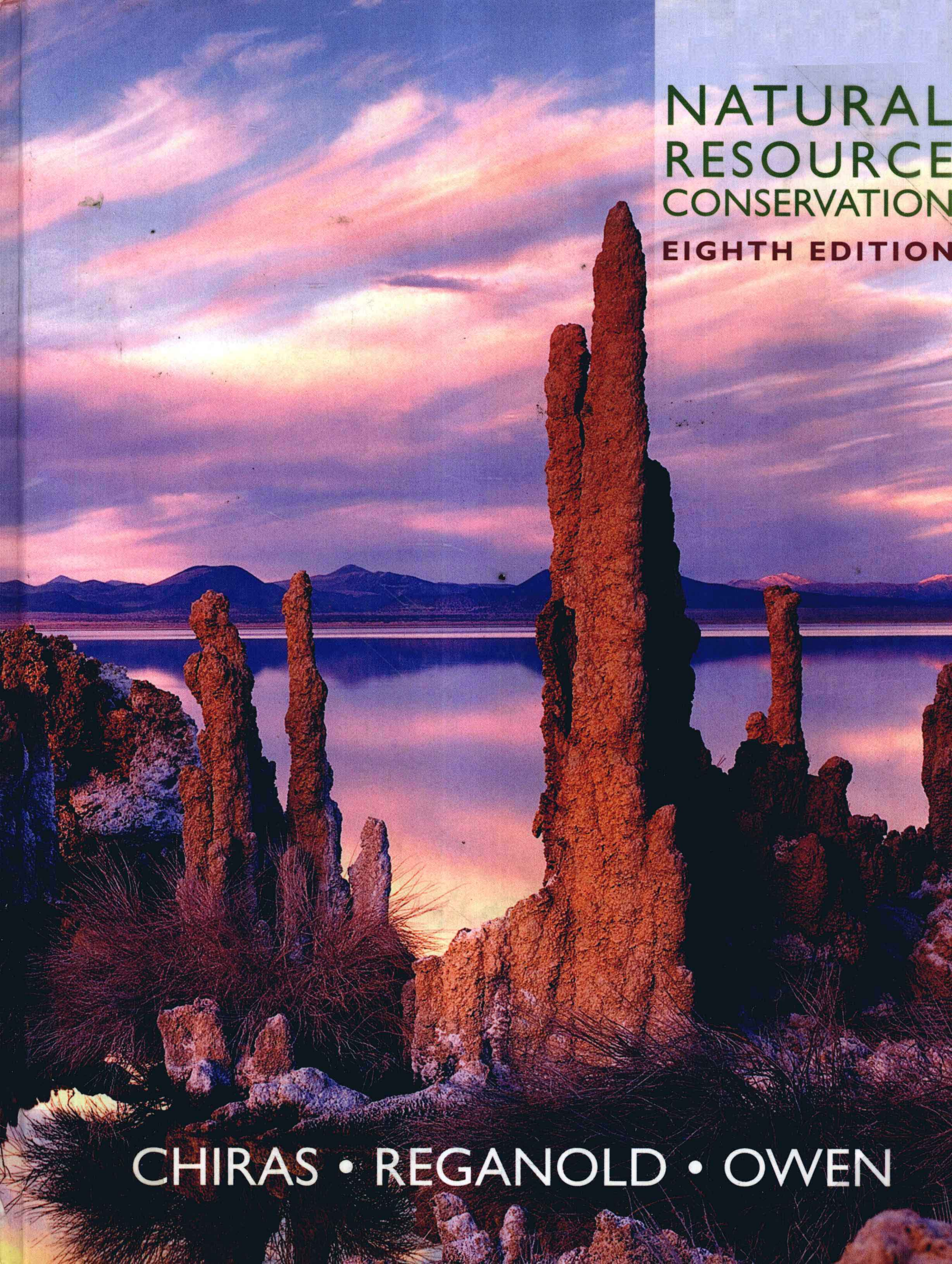

# NATURAL RESOURCE CONSERVATION

EIGHTH EDITION

CHIRAS • REGANOLD • OWEN

# NATURAL RESOURCE CONSERVATION

## MANAGEMENT FOR A SUSTAINABLE FUTURE

**Eighth Edition**

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# Preface

*Natural Resource Conservation* is written for the introductory resource conservation course. It is designed toprovide comprehensive coverage of a variety of local, regional, national, and global resource and environmental issues from population growth to wetlands to sustainable agriculture to global air pollution.

The first edition of this book was published in 1971, a year after the first Earth Day by our esteemed colleague, the late Oliver S. Owen. To many observers, Earth Day marked the formal beginning of the environmental movement in the United States. Since that time, impressive gains have been made in air and water pollution control, species protection, forest management, and rangeland management.

Despite this progress, many environmental problems still remain. Many others have grown worse. In 1970, for instance, the world population hovered around 3 billion. Today it has exceeded the 6 billion mark and is growing by approximately 84 million people a year. Hunger and starvation have become a way of life in many less developed nations. An estimated 12 million people die each year of starvation and disease worsened by hunger and malnutrition. Species extinction continues as well. Today an estimated 40 to 100 species become extinct every day. In the United States and abroad, soil erosion and rangeland deterioration continue.

Added to the list of growing problems are a whole host of new ones that have cropped up along the way. Groundwater pollution, ozone depletion, acid deposition, global warming, and growing mountains of urban trash top the list. Yet, along with the new problems are new and exciting solutions.

If we work together in solving these problems, then there is much hope. However, to address these problems in meaningful ways will require dramatic changes in the way we live our lives and conduct commerce. We need a way that is sustainable—a way of doing business and living on the planet that does not bankrupt the Earth. Most people call this *sustainable development.* Sustainable development is about creating a new relationship with the Earth. It is about creating a sustainable economy and a sustainable system of commerce. It is about creating sustainable communities and sustainable lifestyles. It requires new ways of managing resources using the best available scientific knowledge and understandings of complex systems and how they are maintained, even enhanced, over time. It will entail changes in virtually every aspect of our society, from farming to forest management to energy production.

We believe that establishing a sustainable relationship with the Earth will require us to use resources more frugally—using only what we need and using all resources much more efficiently than we do today. Creating a sustainable way of life will very likely mean a massive expansion of our recycling efforts, not just getting recyclables to markets, but encouraging manufacturers to use secondary materials for production and encouraging citizens to buy products made from recycled materials.

Creating a sustainable society will also very likely mean a shift to clean, economical renewable energy supplies, such as solar and wind energy. Another vital component of a sustainable society is restoration—replanting forests, grasslands, and wetlands—to ensure an adequate supply of resources for future generations as well as for the many species that share this planet with us.

Essential to the success of our efforts to create a sustainable society are efforts to slow down, even stop, world population growth. But that means stopping population growth in all nations, not just the poorer less developed nations. Population growth, in the rich nations, combined with our resource-intensive lifestyles, is contributing as much to the current global crisis as population growth in the less developed nations.

Curtailing population growth also entails efforts to better manage how we spread out on the land—that is, how and where our cities and towns expand. By adhering to judicious growth measures we can preserve farmland, forests, pastures, wildlands, and fisheries—all essential to our future and often crucial to the well-being of the countless species that share this planet with us.

In this book, we present the case for building a sustainable future based on conservation, recycling, renewable resources, restoration, and population control. We dub these the operating principles of a sustainable society. We believe that by putting these principles into practice in all sectors of our society, from agriculture to industry to transportation, we can build an enduring relationship with the planet.

The operating principles, however, must be complemented by a change in attitudes. No longer can we afford to regard the earth as an infinite source of materials for exclusive human use. Many of the Earth's resources, upon which human beings depend, are finite. The Earth offers a limited supply of resources. We ignore this imperative at our own risk.

We and many others believe that humans must adopt an attitude that seeks cooperation with, rather than domination of, nature. Our efforts to dominate and control nature are often in vain and sometimes backfire on us. Cooperation may be one of the keys to our long-term success. By cooperation, we mean fitting into nature's cycles—creating production systems, for instance, on farms that more closely correspond with nature's cycles.

Finally, we believe it is time to rethink our position in the ecosystem. Humans are not apart from nature but a part of it. Our lives and our economy are vitally dependent on the environment. The Earth is the source of all goods and services and the sink for all of our wastes. What we do to the environment we do to ourselves. The logical extension of this simple truth is that planet care is the ultimate form of self-care.

Despite the wonderful accomplishments of human society over many centuries, it is time to realize that humans are not the crowning achievement of nature, but rather members in a club comprised of all of Earth's living creatures. To achieve a sustainable relationship, many observers argue, it is time to recognize and respect the rights of other species to exist and thrive alongside humans. In this sense, natural resources may be viewed as the Earth's endowment to all species. Such a view may mean curbing our demands and finding new ways to live on the planet. In the long run, such changes will benefit all of us.

## Focus on Principles, Problems, and Solutions

This book describes many important principles of ecology and resource management, concepts that will prove useful throughout your lifetime. It also outlines many of the local, regional, national and global environmental problems and offers a variety of solutions to these problems. Solutions take three basic forms: legislative (new laws and regulations), technological (applying existing or new and improved technologies), and methodological (changing how we do things). Applying these solutions is a responsibility we all have in common. It is not just the domain of government. Citizens, business people, and government officials all have an important role to play in solving the environmental crisis and in building a sustainable society.

On the personal level, what we do or what we fail to do can have a remarkable impact on the future. We encourage you to take active steps to find ways to reduce your impact.

## Learning Aids

To help students learn key terms and concepts, we have included three learning aids: key words and phrases, chapter summaries of key concepts, and critical thinking and discussion questions. To help students deepen and broaden their knowledge, we have included Ethics in Resource Conservation boxes, a section on critical thinking, Case Studies, and numerous Suggested Readings.

### Key Terms

At the end of each chapter is a list of key words and phrases. We recommend that students read this list before reading the chapter. After reading the chapter, take a few moments to define the terms and phrases.

### Summary of Key Concepts

Each chapter in the book also contains a summary of important facts and concepts. These short summaries will help students review material before tests. Before reading the chapter, we think it is a good idea to read through the summary or study the major headings and subheadings to orient yourself.

### Critical Thinking and Discussion Questions

Discussion questions at the end of each chapter also provide a way of focusing on important material and reviewing concepts and crucial facts. We have written many questions to encourage you to tie information together and to draw on personal experience. We have also included a number of questions that ask you to think critically about various issues.

### Ethics in Resource Conservation

This book contains eight essays on ethics and resource management. These brief pieces present important ethical issues that confront resource managers and people like yourself on a daily basis. The ethics boxes were designed to encourage you to think about your own values and how they influence your views. They will help you understand others, too.

### Critical Thinking

Critical thinking is a vital skill for all of us, but it is especially important in resource conservation and management. In Chapter 1, we present a number of critical thinking rules that will help you analyze the material we present.

### Case Studies

The case studies delve into controversial issues or provide detailed information that may be of interest to students pursuing a career in natural resource management. In this edition, we have removed outdated case studies and replaced them with newer ones. We have also eliminated a few to keep the number more manageable.

## Suggested Readings

The Suggested Readings section in each chapter lists articles and books that are worthwhile reading for students who want to learn more about the environment.

## New to the Eighth Edition

Because this field changes rapidly, we have carefully updated the text with recent statistics, recent examples, and new photographs. In addition, we have expanded coverage of pressing issues such as global climate change, ozone depletion, acid deposition, species extinction, and wetlands protection. We've added material on carrying capacity, genetic engineering, genetically modified crops, brownfield development, environmental justice, alternative fuels, and alternative vehicles.

In this edition, we have added information on geographic information systems and remote sensing. Chapter 1, for instance, presents an overview of these resource management tools. GIS and Remote Sensing case studies re'searched and written by John Hayes at Salem State University and Dr. Chiras give examples of the application of these tools.

This edition contains expanded coverage of policy. New international treaties, new federal laws, and other policy tools are discussed in appropriate chapters.

This edition also greatly expands previous coverage of ecosystem management and watershed management. We have continued to look for ways to expand the critical thinking theme and have, as we have in previous editions, tried to maintain an objective approach, offering both sides of many issues. The reader will also find useful our new web page: http://www.prenhall.com/chiras.

Finally, we have made a special effort to expand the scope of this book to include more examples of environmental and resource issues and solutions from other countries. In short, we have attempted to "internationalize" this book. Many examples from Canada were added in this effort.

# Acknowledgments

We thank the staff at Prentice Hall, especially our editor, Teresa Ryu, who has helped us improve the quality of this book in many ways. Her insights and enthusiasm have been most appreciated. Teresa has been a pleasure to work with throughout this project, for which we are eternally grateful. We also thank Teresa's assistant, Colleen Lee, for her help throughout the project. Many thanks to our photoresearcher, Linda Sykes, for her hard work and persistence in researching photographs, and to Martin Barr, who edited the manuscript. Many thanks to Kandis Elliot and James Jaeger, our artists. Patrick Burt of WestWords, handled the production of this title expeditiously and thoughtfully. It was a pleasure working with him.

Many thanks to Linda Klein for co-authoring Chapter 9 and to Linda Stuart for her diligence and thoroughness in updating the statistics and preparing the index. Many special thanks to Professor John Hayes for his excellent assistance with the newest feature of the book, the GIS and Remote Sensing case studies. John presented us with numerous excellent ideas for boxes, then researched and wrote first drafts, which we then massaged to be consistent with the writing style of the book.

Finally, we thank our families for their love and support during the writing and production of this book.

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# Biographies

Dan Chiras earned his Ph.D. in reproductive physiology in 1976 from the University of Kansas Medical School. He is currently an adjunct professor at the University of Colorado in Denver and at the University of Denver, where he teaches courses on sustainable development and global environmental issues. He has published 17 books and over 200 articles in journals, magazines, newspapers, and encyclopedias. Dr. Chiras lectures about a variety of topics, including ways to build a sustainable society. His newest book is *The Natural House: A Complete Guide to Healthy, Energy-Efficient, Environmental Homes*. Besides his scientific and environmental pursuits, Dr. Chiras is a river runner, cross-country skier, bicyclist, organic gardener, and musician. He and his sons live in a nearly self-sufficient home in Evergreen, Colorado, overlooking the snowcapped Rocky Mountains.

John Reganold received his Ph.D. in soil science from the University of California at Davis in 1980. As a professor of soil science at Washington State University, he teaches courses on introductory soils, land use, and soil management and conducts research in land use and sustainable agriculture. He also advises undergraduate and graduate students in soil science and environmental science. His excellence in teaching and research has been recognized by several awards from Washington State University. Dr. Reganold's research focuses on the effects of alternative and conventional farming systems on soil and crop quality, farm profitability, environmental quality, and energy efficiency. In addition to his research, he enjoys spending time outdoors, swimming, cycling, and backpacking.

# Brief Contents

# Contents

# Natural Resource Conservation and Management: Past, Present, and Future

The late Aldo Leopold once defined conservation as "a state of harmony between man and the land." For Leopold, conservation required equal portions of reflection and action. Leopold believed strongly that effective conservation depends primarily on a basic human respect for natural resources. He called such respect a land ethic. Each of us, he said, is individually responsible for maintaining "the health of the land." A healthy land has "the capacity for self-renewal." "Conservation," he concluded, "is our effort to understand and preserve that capacity." It is this concept of conservation that has guided and influenced the writing of this book over the past three decades.

## 1.1 A Crisis on Planet Earth?

Effective conservation and management of natural resources in the United States and other countries is becoming more and more urgent, for many reasons. First and foremost, the human population is growing by leaps and bounds. Eighty-four million new people are added to the planet each year. Second, along with this growth is an unprecedented growth in the human economy. As the world's population expands and our economic activity increases, human society is rapidly degrading the natural environment. The environment is the source of all the resources that fuel the economy and make our lives possible, and a sink for all of our wastes. In short, the Earth is vital to our well-being. The damage we create threatens our own future and the future of our children and the many species that share the planet with us.

Ironically, humankind prides itself on conquering outer space and on its many new technologies that make space exploration possible. Yet, after two centuries of technological progress, we still fail to adequately manage the space around us here on planet Earth. This failure has led to an environmental crisis that results from three interrelated problems: (1) a large and rapidly growing human population, (2) excessive resource consumption and depletion, and (3) local, regional, and global pollution.

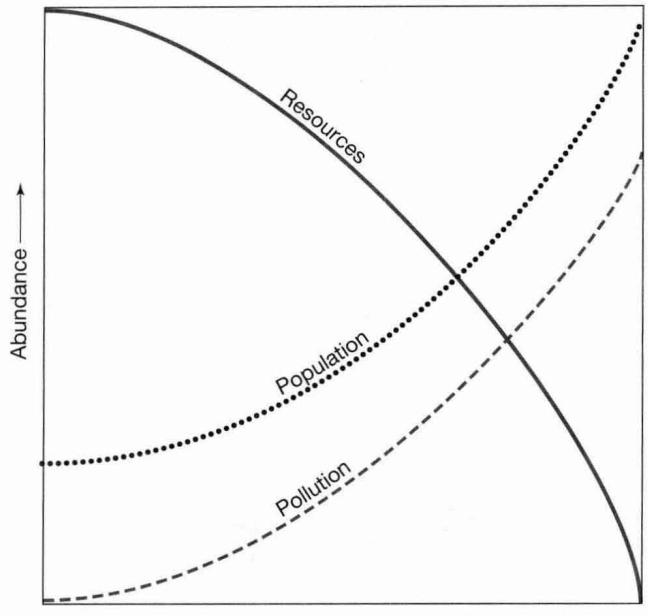



**FIGURE 1.1** *Population, resources, and pollution. This simple diagram illustrates a very fundamental relationship between people, the resources they require, and environmental destruction and pollution.*

Before we examine each of these facets of the crisis, it is important to point out that even if there were no crisis, it would be important to manage natural resources and the environment better and to create a more positive relationship between people and the planet. The planet with the living organisms that inhabit it is, as just mentioned, the basis of all life. Our health and well-being are intimately tied to the planet's health. So, whether you believe there is an environmental crisis or not, this book will help you understand ways to live on the planet that are keenly important to a healthy human community.

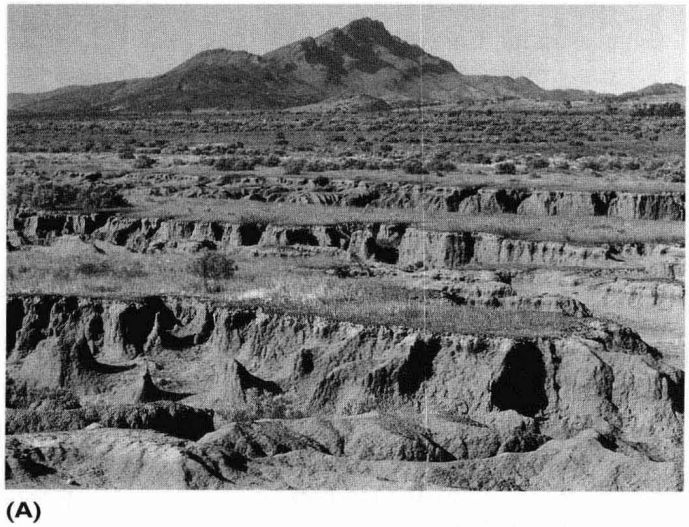
## Population Increase

The human population is growing rapidly. At the current rate of growth, global population will surge from more than 6 billion in the year 2000 to more than 8 billion by the year 2025. This cancerous growth of the human population clouds the future on planet Earth and is the main driving force behind the depletion of resources and the pollution of our planet. Why is population growth such an important force?

As a general rule, every increase in population results in an increase in the demand for food, water, clothing, shelter, and other goods and services. In meeting these needs, we draw on the Earth's natural resources, many of which are already in short supply or are declining in quality. Meeting our demands for these resources also increases environmental pollution (Figure 1.1). Evidence of this simple but powerful relationship is all around us. For example, the rapid increase in population in many less developed countries (LDCs) such as those in Africa result in rampant environmental damage. Population growth in LDCs as well as the wealthier more developed nations also causes problems, among them overcrowding and degraded landscapes (Figure 1.2). In fact, there's not an environmental problem that can't be linked to human population growth. Even many social problems such as drug abuse, mental illness, crime, and suicide are all thought to increase as a result of overcrowding.

The evidence is pretty clear: rising population is resulting in a decline in the overall standard of living in virtually all nations of the world. Unless population growth is halted within the very near future, even the most soundly conceived and effectively implemented conservation and environmental practices will be to no avail.

How fast is the human population growing? By this time tomorrow, nearly 225,000 people will join the global family; in a week, 1.6 million more will be here; and by next year, an additional 84 million will be making demands for food and other necessities. On Memorial Day, our nation honors the memory of



(A)

(B)

**FIGURE 1.2** *Overpopulation and other factors like poverty cause a host of environmental problems from degraded landscapes (A) to crowded, squalid living conditions (B).*

those Americans who gave their lives for their country on the world's battlefields. The fatalities have indeed been numerous—57,000 in the Vietnam War alone. Yet, the rate of population growth is so high that all the battlefield deaths of soldiers the world over since the voyages of Christopher Columbus will have been replaced in about 6 months.

### Excessive Resource Consumption and Depletion

All people need resources. The most noticeable demand for those resources comes from the world's industrialized or more developed nations (MDCs), which are consuming many natural resources (coal, oil, gas, copper, zinc, and cobalt, for example) at an accelerating pace. The United States ranks first in per capita consumption—that is, consumption per person. Although our nation has only 5 percent of the global population, it consumes 30 percent of the world's resources.

Americans are the most overfed, overhoused, overclothed, overmobilized, and overentertained people in the world. Our enormous consumption of cars, color television sets, dishwashers, air conditioners, golf carts, home computers, swimming pools, CD players, and video cassette recorders satisfies a wide range of longings, far beyond our basic needs. Through such excessive production and consumption, the United States and other highly industrialized nations such as Canada and Japan are accelerating the depletion of our planet's resources.

Resource demands are extraordinary in the heavily populated less developed nations, too. But in this instance, demands are due in large part to meeting basic needs of the people for food, shelter, and clothing. A large part of the demand is also due to the exportation of raw materials and goods for industrial nations. Whatever the cause, it is clear that the natural environments and resource bases of less developed nations such as India, China, and Bangladesh, for example, all suffer enormously under the strain of large and rapidly growing populations.

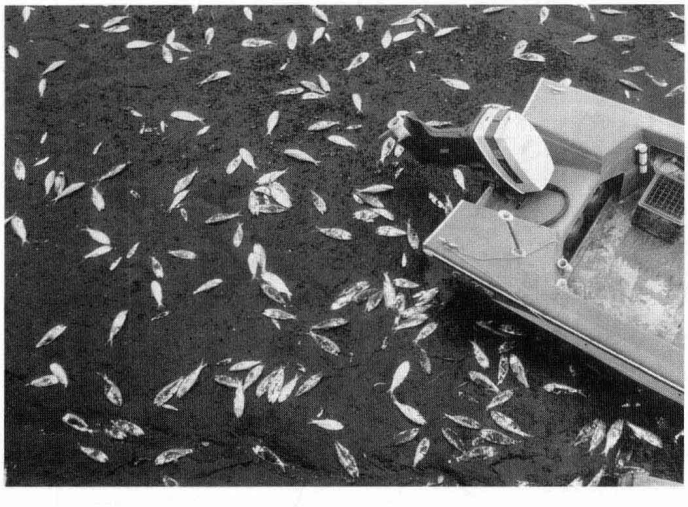


**FIGURE 1.3** *The United States and other nations have polluted their lakes and streams with sewage, industrial wastes, radioactive materials, heat, detergents, agricultural fertilizers, and pesticides. Massive fish kills are often the result.*

**FIGURE 1.4** *Like many cities, Los Angeles is often blanketed in a thick layer of pollution from cars, busses, trucks, motorcycles, lawnmowers, factories, powerplants, backyard grills, and other sources.*

### Pollution

People produce pollution directly and through the extraction and use of resources (Figure 1.1). Rich and poor nations alike are responsible for widespread pollution problems. The United States, the world's most affluent nation, has also become its most effluent (Figures 1.3 and 1.4). Like other industrialized nations, we have degraded our environment with an enormous variety and volume of contaminants. We have polluted lakes, streams, oceans, and groundwater with sewage, industrial wastes, radioactive materials, heat, detergents, fertilizers, pesticides, and plastics. Millions of tons of sulfur dioxide and carbon dioxide are spewed into the air each year from the combustion of fossil fuels, such as coal and oil, and are causing serious environmental effects, not only in the United States but in other nations as well. Our dependence on nuclear power, as well as on nuclear arms, has led to the accumulation of large amounts of radioactive waste.

Pollution also abounds in less developed nations where sewage, animal waste, and sediment from farms and deforested lands contaminate the air, water, and land. Making matters worse for the environment, many less developed nations are industrializing. As industry expands and standards of living improve, the environment often becomes more polluted.

## 1.2 Differing Viewpoints: Are We on a Sustainable Course?

The Earth and its ecosystems are the life support system of the planet. Can the Earth and its ecosystems support the reasonably high standard of living many of us now enjoy through the year 2050? Can they support the rising level of affluence in less developed nations? Will they be able to support the

human population by the year 2100? These important questions are almost impossible to answer with any degree of certainty. Why?

The reason for our inability to answer these simple questions is that are so many interacting variables that influence the issue. In 1972, a research group at the Massachusetts Institute of Technology set out to find an answer to such questions using computers. They published their results in a landmark book, entitled *The Limits to Growth.*

The researchers showed through computer analysis that the human population would exceed the planet's carrying capacity within a century if exponential growth continued. Figure 1.5 summarizes the findings. The computer program they devised shows that as the world population expands, resource supplies begin to fall. This is accompanied by a decline in the amount of food available on an individual basis (food per capita) and a decline in industrial output per capita. In time, the human population begins to decrease in number, largely as a result of starvation.

What would happen if resource supplies were much larger than the researchers estimated? To address this question, the team doubled their estimated available supply of nonrenewable resources—things like oil and minerals. What they found was that the human population would still overshoot the Earth's resource supplies, just a couple decades later. In another scenario, the authors assumed that world resources were unlimited. Under these conditions, population growth was still halted by rising levels of pollution.

The conclusions of the MIT study were unequivocal. Any way you look at it, if human civilization continues to increase in number, we will reach a perilous state where we exceed the planet's ability to support human life—the human carrying capacity of the planet.

All of this suggests that our current path cannot be sustained. Put another way, our society is unsustainable. Don't get us wrong: this doesn't mean we're doomed and that you should abandon hope. It means our course cannot be sustained. Steering onto a sustainable course will require efforts by individuals like you, business, and governments. That's largely what this book is about—outlining problems and proposing personal, governmental, and corporate solutions. But action must occur soon. Although there are areas of marked improvement, the level of environmental destruction continues at an unsustainable rate.

Moreover, there are signs that we've already overstepped the planet's carrying capacity (its ability to support life) in several vital areas. In fact, in 1992, three members of the original *Limits to Growth* team re-examined their findings and re-analyzed the state of the world in a book entitled *Beyond the Limits.* Their conclusion: that their earlier projections were wrong. Humans have already exceeded critical thresholds and are dangerously close to others. Put another way, the authors' previous projections had underestimated the hazards of continued population growth with its accompanying rise in resource demand and pollution.

## Viewpoint of the Optimists

Not everyone agrees with these somber projections and the need for swift action. In fact, the *Limits to Growth* study has been severely criticized by many. Especially vocal are those who believe that technology can solve our resource and environmental problems. History, they like to point out, is full of examples showing how necessity fosters new inventions and cultural changes. We call such folks the optimists. They argue that the Western world is on the brink of another tech-

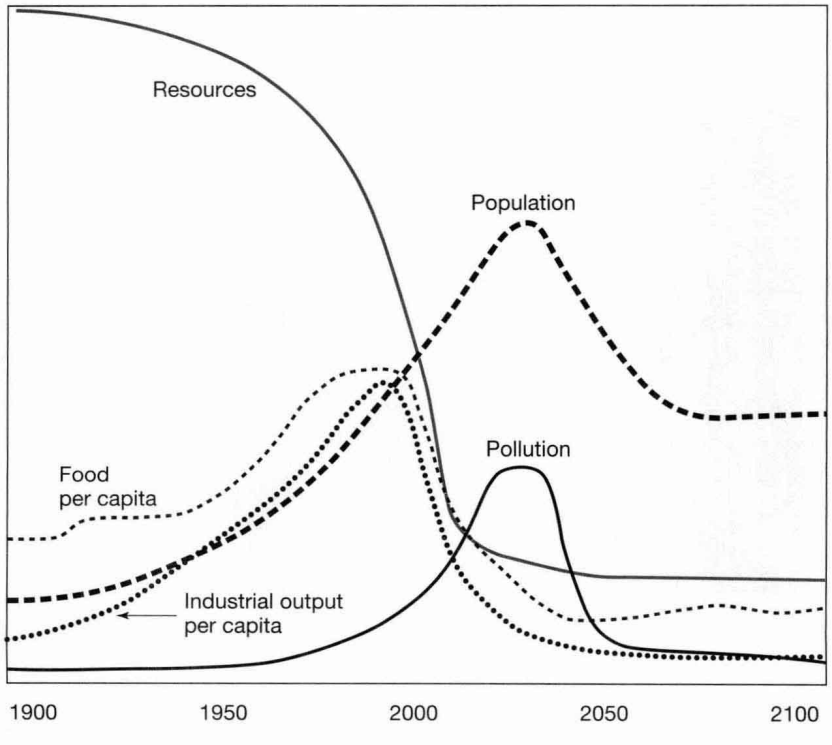



**FIGURE 1.5** The Limits to Growth *study. Researchers used the computer to predict the fate of human society if current trends continue. This graph shows that if the population continues to grow, resources will decline dramatically. Pollution levels will increase. The combined effect is a decline in human population and considerable environmental damage.*