NATURAL RESOURCE CONSERVATION

SIXTH EDITION

Management for a Sustainable Future

Oliver S. Owen ✒ Daniel D. Chiras

Sixth Edition

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Management for a Sustainable Future

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To my loving wife Carol, our dear children Tom, Tim, and Stephanie, and our grandson Amati.

May they never be denied the privilege of hiking through a forest wilderness, stalking a deer, or listening to the dusk-chant of a whippoorwill.

O.S.O.

To my generous parents and my two precious sons, Skyler and Forrest, with love and affection.

This book is dedicated to their future and the future of all people and all species that call the Earth their home.

D.D.C.

PREFACE TO THE SIXTH EDITION

Natural Resource Conservation is written for the introductory resource conservation course. The first edition of this book was published in 1971, a year after the first Earth Day. To many observers, Earth Day marked the beginning of the formal environmental movement in the United States. Since that time, impressive gains have been made in air and water pollution control and species protection.

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 is over 5.5 billion and growing by 93 million people a year. Hunger and starvation have become a way of life in Third World 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. Globally, 24 billion tons of topsoil are lost each year. To put that number in perspective, soil erosion at a rate of 24 billion tons per year would, over a decade, rob the world's cropland of 240 billion tons—an amount equal to one half of America's cropland soils.

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. Solving these problems will not be easy.

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 life-styles.

We believe that establishing a sustainable relationship will require using resources more frugally—using 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 energy and wind. 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 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 growth in all nations, not just the poor developing nations. Population growth in the rich nations, combined with our resource-intensive life-styles, is just as important in 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 judicious growth controls we can preserve farmland, forests, pastures, and wildlands—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 argue that conservation, recycling, renewable resources, restoration, and population control are the operating principles of a sustainable society. By putting them 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 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 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. Thus, 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 one's life. It also outlines many of the national and international 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 methods). 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 focus on key terms and concepts, we have included three learning aids: key words and phrases, chapter summaries, and discussion questions.

Key Words and Phrases

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.

Rapid Review

Each chapter in the book also contains a summary of important facts and concepts in the Rapid Review section. 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.

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.

Furthering Your Education

To help students deepen and broaden their knowledge, we have provided a number of case studies in boxes, and suggested readings.

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.

Suggested Readings. The Suggested Readings list articles and books that are worthwhile reading for students who want to learn more about the environment.

NEW TO THE SIXTH EDITION

The sixth edition of *Natural Resource Conservation* has undergone a substantial revision. We have updated material and expanded coverage of pressing issues to bring you the latest in natural resource issues. Our coverage of sustainable resource management has expanded considerably and can be found in most chapters.

We have also added a new chapter on economics, ethics, and critical thinking. This chapter provides an overview of key concepts essential to understanding and solving a variety of resource issues. Presented early in the book, these concepts serve as a foundation of understanding as you proceed through your course.

We have also added eight boxes that focus on ethics in resource management. These brief statements present important ethical issues that confront resource managers and global citizens, helping you more fully understand this important aspect of human society. The ethics boxes are also designed to help you probe your own beliefs and understand the ethical position of others.

ACKNOWLEDGMENTS

This book is the result of the hard work of many people, whom we would like to thank heartily. Numerous reviewers (listed at right) graciously gave their time to comment on the manuscript and suggested many useful changes. For their help, many thanks.

We would like to thank the staff at Prentice Hall, especially our editor, Sheri Snavely, who has helped us improve the quality of this book in many ways. Her insights and enthusiasm have been most appreciated. We also thank our photo researcher, Chris Migdol, for his hard work and persistence in researching photographs, and Marjorie Pannell, scientific editor for the Field Museum of Natural History, who edited the manuscript. Jennifer Carey, of J. Carey Publishing Service, handled the production of this title expeditiously and deserves a large debt of gratitude for her attention to detail and cheerfulness despite a tight production schedule. Many thanks to Carole Newman my (D.C.C.'s) research assistant for help in proofing the text.

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Chapter 1

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

The late Aldo Leopold, the senior author's ecology professor, once defined **conservation** as "a state of harmony between man and the land." For Leopold, conservation required equal portions of reflection and action. He wrote: "The real substance of conservation lies not in the physical projects of government, but in the mental processes of citizens." 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.

THE CRISIS ON PLANET EARTH

Effective conservation and management in the United States and other countries is becoming more and more urgent, for human society is rapidly degrading the natural environment. The damage is so severe that many experts believe that the long-term future of society is in jeopardy. Ironically, humankind prides itself on conquering outer space and on its many new technologies that make space exploration and modern medicine possible. Yet, after two centuries of technological progress, we still fail to manage well the space around us here on planet Earth (Figure 1-1). This has led to an environmental crisis resulting from three interrelated problems: (1) rapid population increase, (2) excessive resource consumption and depletion, and (3) pollution.

Figure 1-1 Despite their extraordinary mental abilities, humans are directly responsible for many serious environmental problems.

Population Increase

At the current rate of growth, global population will surge from nearly 5.6 billion in 1993 to roughly 8 billion by 2020 (Figure 1-2). This cancerous growth of the human population clouds the future on planet Earth and is an underlying cause of our resource-environmental crisis. An increase in population means an increase in the pollution of air, water, and land. It means an accelerated depletion of natural resources, many of

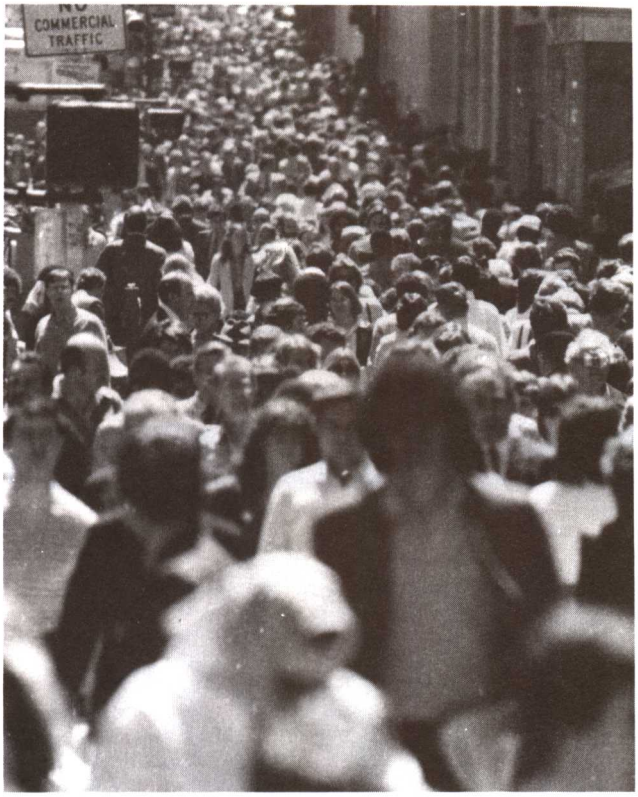

Figure 1-2 The rapidly growing global population strains the limits of our resources. Urban populations concentrate millions of people in limited space, resulting in elevated pollution levels.

which are already in short supply or are declining in quality. It means that massive starvation, as in Africa today, will spread to other parts of the world. It means that greater numbers of people, living in overcrowded conditions, will suffer from increasing emotional stress and will make increasing demands on wilderness and recreation areas in order to "get away from it all." Drug abuse, mental illness, crime, and suicide will be more common. Each surge in population will bring a corresponding decline in our overall standard of living. 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.

After nearly 4 million years of human history, global population has turned the bend of the J-curve and is now moving almost straight up. By this time tomorrow, there will be 280,000 more people on the planet; by next week, 1.8 million more; and by next year, an additional 95 million. On Memorial Day, our nation honors the memory of those Americans who have given 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 only 6 months.

The people added to the world's population each year must be fed. For a number of political, social, economic, and ecological reasons, however, food is not available. During the hour it takes the average American family to polish off its Thanksgiving turkey (and cranberry sauce, and apple pie, and so on), 1,400 people take their last breath—dying either directly or indirectly from a lack of food. One year from now, an estimated 12 million people will have starved or succumbed to infectious and parasitic diseases worsened by malnutrition.

Excessive Resource Consumption and Depletion

The world's industrialized nations are consuming nonrenewable resources (coal oil, gas, copper, zinc, and cobalt, for example) at an accelerating pace. The United States ranks first in per capita consumption. *Although our nation has only 5 percent of the global population, it consumes 30 percent of the world's resources.*

Many demands made by Americans on natural resources are excessive and do not contribute substantially to human happiness. 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, speedboats, and video cassette recorders certainly does not stem from need.

Through such excessive production and consumption, called **throughput** by economists, the United States and other highly industrialized nations are accelerating the depletion of our planet's resources.

Pollution

The United States, the world's most *affluent* nation, has also become the 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 climatic effects, not only in the United States but in other nations as well. Our increasing dependence on nuclear power, as well as on nuclear arms, has led to the accumulation of large amounts of radioactive waste, some of which threatens human health and life.

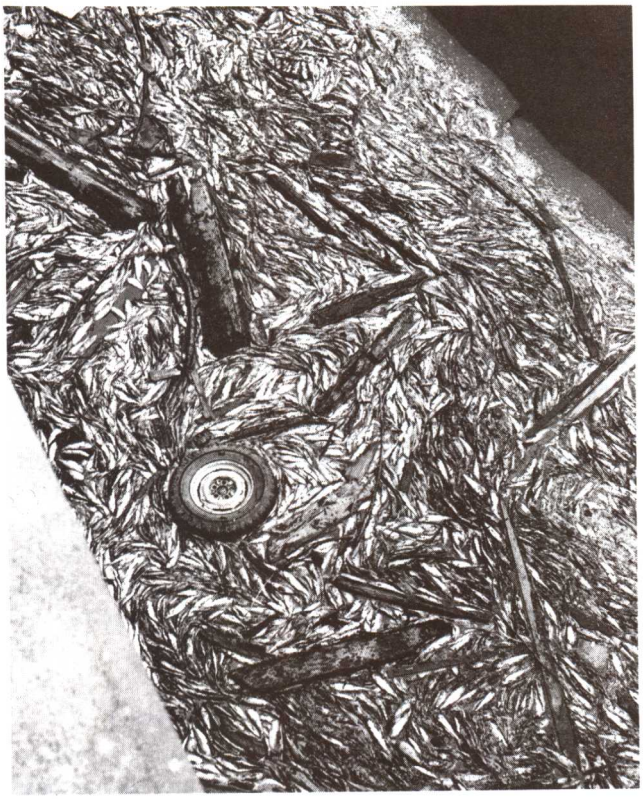

Figure 1-3 The United States has polluted its lakes and streams with sewage, industrial wastes, radioactive materials, heat, detergents, agricultural fertilizers, and pesticides. Massive fish kills have been the result.

QUALITY OF HUMAN LIFE ON PLANET EARTH

Can planet Earth support into the year 2050 the reasonably high standard of living many of us now enjoy? Or into the year 2100? This important question is almost impossible to answer with any degree of certainty. The problem is that there are so many interacting variables: population levels, resource availability, degree of environmental pollution, climatic patterns, industrial production, national and international politics, social attitudes, changing patterns of war and peace, and so on. In fact, the task we face in maintaining a reasonably high standard of living is much more formidable than that of developing the atomic bomb or putting a person on the moon!

Some years ago, a research group at the Massachusetts Institute of Technology published a book entitled *The Limits to Growth.* This book summarized their computer studies of the projected future of humans on Earth. The scientists wanted to determine the changes in environmental quality that might take place through the year 2100, assuming that population growth, resource depletion, pollution, industrial production, and so on would continue at exponential rates—in other words, moving almost straight up the J-curve. The graphed projections that appeared on their computer printout sheets are of extreme interest, and highly disturbing.

Figure 1-5 shows that the global population climbs until about 2040. Food production per capita, however, drops long before population peaks. Industrial output

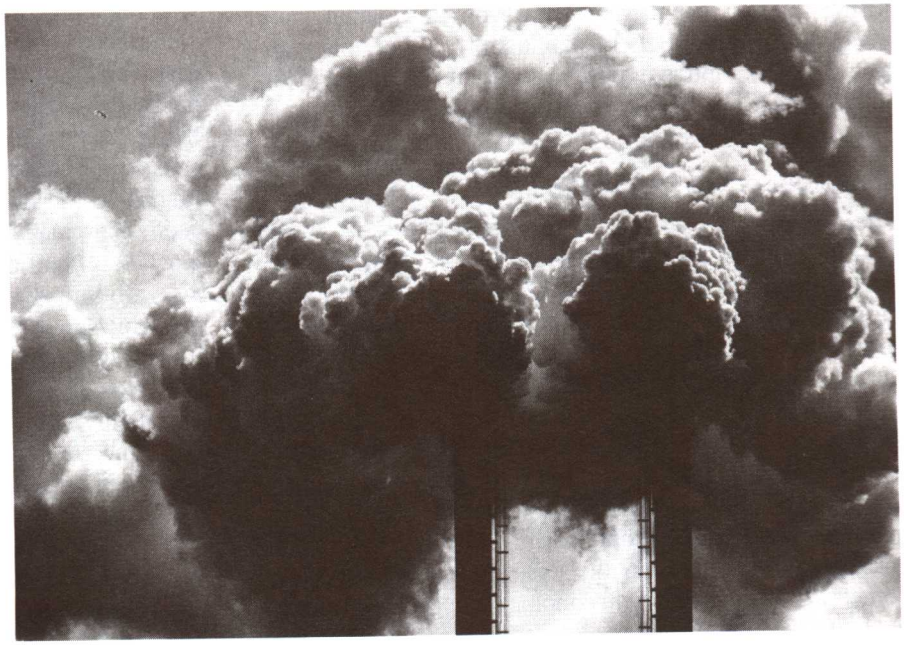

Figure 1-4 Industrial smokestacks have spewed large volumes of pollutants into our nation's atmosphere.

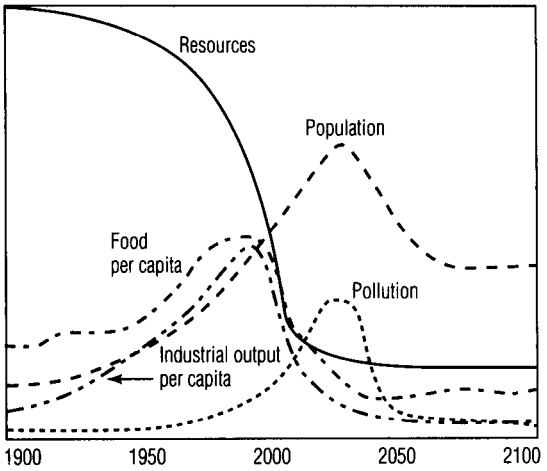

Figure 1-5 Computer predictions of different variables (food, population, industrial output, pollution, resources) if current trends continue. This graph shows that if population continues to grow, resources will decline dramatically. Pollution levels will increase. The combined effect is a decline in human population and considerable environmental damage.

per capita follows a similar pattern. By the year 2030, the quality of human life has deteriorated. Several decades later, many natural resources are either so severely depleted (fertile soil, oil, and metals) or so seriously polluted (air, water, and land) that both food and industrial production drop off sharply. Aggravating the problem then is the continuing upsurge in global population. Eventually, after the year 2050, well within the lifetime of your children, there will be a massive reduction in the human population, primarily as the result of starvation. The prospects for human survival beyond 2100 appear poor, simply because the global stock of natural resources, upon which humans have depended during their 4-million-year tenure on this planet, will have reached the point of exhaustion. All of this suggests that our current path cannot be sustained. Put another way, our society is unsustainable.

Viewpoint of the Optimists

These somber projections have been criticized by those who believe that technology will solve our resource and environmental problems. History is full of examples showing that necessity is the mother of invention. The optimists suggest that the Western world is on the brink of another technological revolution. After all, isn't the current crisis the greatest in human history? If small crises result in small innovations, then today's composite population-resources-pollution dilemma may be the necessary stimulus for the greatest technological breakthroughs of all time. These optimists confidently claim that "a breakthrough a day will keep the crises at bay." Whenever something has gone awry, technology will provide a "fix."

Athelstan Spilhaus of the University of Minnesota is a leading spokesperson for this school of thought. He has suggested, for example, that "energy is the ultimate currency of civilization"; in other words, if enough cheap energy is available, all things can be accomplished, pollution will be controlled, food will be available for all, and clothing and shelter for the needy millions will be provided. Indeed, the nuclear power enthusiasts are predicting unlimited energy supplies once the breeder reactor has been perfected (see Chapter 22). To increase food production, the optimists suggest a variety of schemes ranging from fish farming to synthesizing food in test tubes; from yeast and algal culture to irrigating deserts; from draining swamplands to using genetic engineering to produce miracle wheats and supercorn. We can derive oil from worn-out rubber tires, say the optimists, refine methane gas from manure, and obtain construction materials from broken glass and fly ash. According to these optimists, we can always depend on human ingenuity and skill to "pull another rabbit out of our technological hat."

Viewpoint of the Pessimists (or Realists?)

Unfortunately, say the pessimists, technology will not solve all of our problems. For one, there isn't enough time to find technological fixes to problems that need solutions today.

Why is time so crucial? The key to the answer is the word **exponential.** Remember the J-curve? It represents exponential growth—of population, of resource depletion rates, of pollution. Such growth increases *geometrically,* as symbolized by the numerical sequence 1, 2, 4, 8, 16, and so on. This is in contrast to *arithmetic* growth, which is symbolized as 1, 2, 3, 4, 5, 6, and so on. The rapidity of exponential growth is best understood through an analogy.

Suppose there is a cancerous tumor in the windpipe that carries oxygen to your lungs—a tumor that doubles in size each day. Assume that it will take only 30 days for this cancer to close off your windpipe completely and cause your death from suffocation. On day 29 you are rushed to the hospital for emergency surgery. The surgeon examines the tumor and discovers that it has blocked off half of your windpipe. Now, if he is unfamiliar with the dynamics of exponential growth, he will probably suppose that he has plenty of time to remove the tumor and save your life. Wrong. He has just one day left.

In this analogy, the windpipe represents the fragile and highly vulnerable life support systems for humans. The cancerous tumor represents the exponentially growing global population, resource consumption, and pollution. Even though the world's best scientists, technologists, ecologists, sociologists, and economists struggle valiantly to remove this rapidly growing environmental cancer, it will be too late. *Day 29 is rapidly approaching!*

Viewpoint of the Moderates

Which viewpoint, optimistic or pessimistic, is closer to the truth? Unfortunately, we cannot be sure. Perhaps, however, as in many other instances, a moderate viewpoint is more correct. The moderates view our current resource-environmental posture with justifiable concern. Yet they feel that there is still sufficient time, if we start *now,* to shift from today's **spendthrift society** to a **sustainable society**—one that lives within the Earth's limits. A sustainable society is defined here as one that meets its needs without preventing future generations and other species from meeting their needs.

Fortunately, numerous writers, teachers, and even political leaders have described sound strategies for building a sustainable society. In *Lessons from Nature: Learning to Live Sustainably on the Earth* and other writings, the junior author of this book outlines six key ecological principles of sustainability: (1) conservation, (2) recycling, (3) renewable resource use, (4) restoration, (5) population control, and (6) adaptability. These biological rules of the road explain why natural systems sustain themselves. For example, natural biological systems or **ecosystems** tend to persist because organisms use what they need and use resources with efficiency (the conservation principle). Natural systems all recycle wastes for reuse and depend in large part on renewable resources. Natural systems also restore damage. Finally, organisms can adapt to changes. Studies by the junior author and others suggest that these principles can be successfully applied to human societies and that they could help steer human society on a sustainable course.

Many political scientists, sociologists, economists, and ecologists are convinced that eventually our life-styles will simplify. We can achieve a sustainable society, shown in Figure 1-6, with an emphasis on cultural, intellectual, moral, and spiritual values rather than on material wealth. Life-styles in this sustainable society, which can be attained by 2025, would be much simpler than those of today. The average American, for example, would get along without some of the traditional status symbols, such as a large, energy-wasteful home, a second or third family car, a recreational vehicle, and a speedboat. This life-style, however, would be ecologically sound rather than ecologically suicidal and probably might offer us a better chance of finding real happiness. Attaining a sustainable society may ultimately depend on sharing knowledge and, possibly, on a redistribution of our planet's limited resources so that all of its inhabitants get their *fair share.* This idea, admittedly, is not without its critics.

If resource redistribution is not brought about, it is likely that the frustrated hopes of the poor nations will lead to more political unrest, riots, revolution, and even nuclear war. The British philosopher Bertrand Russell noted that "nothing is more likely to lead to an H-bomb war than the threat of universal destitution through overpopulation." Newspaper columnist Smith Hempstone makes the following somber prediction: "Neither democracy nor peace will survive in areas where the roots of both are weak. Governments will fall like tenpins and hungry nations will go to war in an effort to seize what they cannot produce." A nuclear exchange, of course, could impose a *simple* life on humankind. However, it would not be characterized by happiness, but rather by a primitive level of existence, with remnant populations literally scratching for survival on what is left of planet Earth.

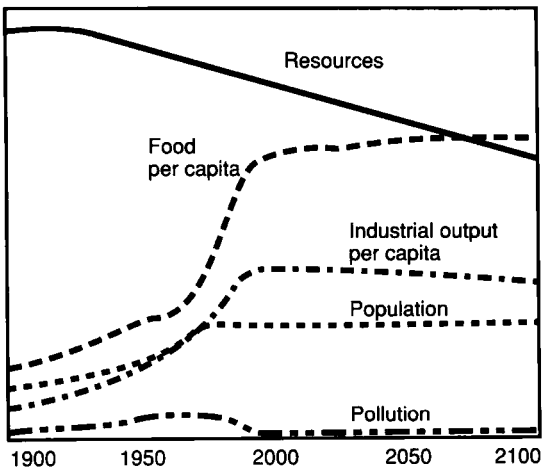

Figure 1-6 If strenuous attempts are made now to stabilize population size, a sustainable, steady-state type of society may be achieved by 2025. The finite resource base will continue to fall, however, suggesting the need to turn to renewable resources.

Our task—to achieve a truly sustainable society—is difficult and challenging. It requires the dedicated, highly coordinated, and long-sustained efforts of many different types of people, from factory workers to business executives, from college students to farmers, from scientists to politicians, from food specialists to geographers. It requires imaginative and inspirational leadership from government leaders at all levels, from small-town mayors to presidents of the United States and other industrialized nations, from village tribal chiefs in Africa to benevolent despots in South America. Some of the required changes have already begun.

A BRIEF HISTORY OF THE RESOURCE CONSERVATION AND ENVIRONMENTAL MOVEMENTS

Conservation in the Nineteenth Century

Although progress toward conservation was relatively slow in the nineteenth century, several notable advances in the United States were made. In the early 1800s,