

NATURAL
RESOURCE
CONSERVATION
EIGHTH EDITION

CHIRAS • REGANOLD • OWEN

NATURAL RESOURCE CONSERVATION

MANAGEMENT FOR A
SUSTAINABLE FUTURE

Eighth Edition

DANIEL D. CHIRAS

University of Denver

JOHN P. REGANOLD

Washington State University

OLIVER S. OWEN

University of Wisconsin, Eau Claire

Prentice
Hall

PRENTICE HALL Upper Saddle River, New Jersey 07458

Library of Congress Cataloging-in-Publication Data

Chiras, Daniel D.

Natural resource conservation : management for a sustainable future / Daniel D. Chiras,

John P. Reganold, Oliver S. Owen.—8th ed.

p. cm.

Rev. ed. of: Natural resource conservation / Oliver S. Owen, Daniel D. Chiras, John P.

Reganold. 7th ed. 1998.

Includes bibliographical references (p.).

ISBN 0-13-033398-0

1. Conservation of natural resources. 2. Natural resources—Management. 3. Sustainable development. 4. Environmental protection. 5. Conservation of natural resources—United States. 6. Natural resources—United States—Management. 7. Sustainable development—United States. 8. Environmental protection—United States. I. Reganold, John P. II. Owen, Oliver S., Natural resource conservation. III. Title.

S938 .O87 2002

333.7'2—dc21

2001019899

Executive Editor: Teresa K. Ryu

Editor in Chief, Biology: Sheri L. Snavelly

Project Manager: Travis Moses-Westphal

Vice President of Production and Manufacturing: David W. Riccardi

Executive Managing Editor: Kathleen Schiaparelli

Marketing Manager: Jennifer Welchans

Manufacturing Buyer: Michael Bell

Director of Design: Carole Anson

Director of Creative Services: Paul Belfanti

Manufacturing Manager: Trudy Piscioti

Art Director: Jonathan Boylan

Managing Editor, Audio/Visual Assets: Grace Hazeldine

Art Tech Support: Debra Lowenfish

Text/Cover Designer: Alamani Design

Cover Photograph: Clouds over Tufa Towers at Millennium Sunset, Mono Lake, California, photograph by Leping Zha

Photo Researcher: Linda Sykes

Editorial Assistant: Colleen Lee

Text Composition: WestWords

Index: Linda M. Stuart

Prentice
Hall

© 2002, 1998, 1995, 1990, 1985, 1980, 1975, 1971 by Prentice-Hall, Inc.
Upper Saddle River, New Jersey 07458

All rights reserved. No part of this book may be reproduced, in any form or by any means, without permission in writing from the publisher.

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

ISBN 0-13-033398-0

Prentice-Hall International (UK) Limited, *London*

Prentice-Hall of Australia Pty. Limited, *Sydney*

Prentice-Hall Canada Inc., *Toronto*

Prentice-Hall Hispanoamericana, S.A., *Mexico*

Prentice-Hall of India Private Limited, *New Delhi*

Prentice-Hall of Japan, Inc., *Tokyo*

Pearson Education Asia Pte, Ltd.

Editora Prentice-Hall do Brasil, Ltda., *Rio de Janeiro*

Preface

Natural Resource Conservation is written for the introductory resource conservation course. It is designed to provide 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.

REVIEWERS

Donald F. Anthrop, *San Jose State University*

Thomas B. Begley, *Murray State University*

Ronald E. Beiswenger, *University of Wyoming*

Mikhail Blinnikov, *St. Cloud State University*

Michael Brody, *Montana State University*

Peter T. Bromley, *North Carolina State University*

Conrad S. Brumley, *Texas Tech University*

Neal E. Catt, *Vincennes University*

Thomas Daniels, *SUNY, Albany*

Ray DePalma, *William Rainey Harper College, Illinois*

Donald Friend, *Minnesota State University*

Eric Fritzell, *University of Missouri*

Ken Fulgham, *Humboldt State University*

Jerry D. Glover, *Washington State University*

Paul K. Grogger, *University of Colorado*

Jeanne Harrison, *Rockingham Community College*

John Hayes, *Salem State College*

Bill Kelly, *Bakersfield College*

William E. Kelso, *Louisiana State University*

Linda R. Klein, *LRK Communications*

John Lemberger, *University of Wisconsin, Oshkosh*

Jim Merchant, *University of Kansas*

Frederick A. Montague, Jr., *Purdue University*

Gary Nelson, *Des Moines Area Community College*

Wanna D. Pitts, *San Jose State University*

Jerry Reynolds, *University of Central Arkansas*

David W. Willis, *South Dakota State University*

Gary W. Witmer, *USDA Animal and Plant Health
Inspection Service, Fort Collins, Colorado*

Richard J. Wright, *Valencia Community College, Florida*

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

Preface	x
Acknowledgments	xiii
Biographies	xiv
1. Past, Present, and Future: Natural Resource Conservation and Management	1
2. Foundations of a Sustainable Future: Economics and Ethics	22
3. Lessons from Ecology	45
4. The Human Population Challenge	78
5. World Hunger: Solving the Problem Sustainably	97
6. The Nature of Soils	115
7. Soil Conservation and Sustainable Agriculture	134
8. Pesticides: Protecting Our Crops, Our Health, and Our Environment	161
9. Aquatic Environments	186
10. Managing Water Resources Sustainability	219
11. Water Pollution	249
12. Fisheries Conservation	299
13. Rangeland Management	341
14. Forest Management	366
15. Plant and Animal Extinction	400
16. Wildlife Management	426
17. Sustainable Waste Management	454
18. Air Pollution	476
19. Air Pollution: Global Problems	506
20. Minerals, Mining, and a Sustainable Society	531
21. Nonrenewable Energy Resources: Issues and Options	544
22. Creating a Sustainable System of Energy: Efficiency and Renewable Energy	576
Afterword	599
Glossary	601
Illustration Acknowledgments	618
Index	

Contents

Preface	x		
Acknowledgments	xiii		
Biographies	xiv		
1. Natural Resource Conservation and Management: Past, Present, and Future	1		
1.1 A Crisis on Planet Earth?	1		
1.2 Differing Viewpoints: Are We on a Sustainable Course	3		
1.3 A Brief History of the Resource Conservation, Environmental, and Sustainability Movements	6		
Case Study 1.1 The Earth Summit and Beyond	10		
1.4 Classification of Natural Resources	12		
1.5 Approaches to Natural Resource Management	12		
1.6 Changing Realities: The Nemesis Effect	15		
1.7 New Tools for Resource Management: Geographic Information Systems and Remote Sensing	16		
2. Economics and Ethics, and Critical Thinking: Tools for Creating a Sustainable Future	22		
Ethics in Resource Conservation 2.1			
Ethics Versus Economics	23		
2.1 Understanding Economics	24		
2.2 Creating a Sustainable Economy	28		
2.3 Toward Sustainable Ethics	35		
Case Study 2.1 Geographic Information Systems and Ecological Justice	38		
2.4 Critical Thinking and Sustainable Development	38		
3. Lessons from Ecology	45		
3.1 Levels of Organization	45		
3.2 Scientific Principles Relevant to Ecology	47		
3.3 The Flow of Energy through Ecosystems	50		
3.4 Principles of Ecology	62		
3.5 The Biomes	67		
Case Study 3.1 Life Returns to Mount St. Helens: A Dramatic Example of Succession	68		
3.6 Ecology and Sustainability	74		
4. The Human Population Challenge	78		
4.1 Understanding Populations and Population Growth	79		
4.2 The Impacts of Over Population	85		
4.3 Population Growth in the More Developed Nations: A Closer Look	87		
Ethics in Resource Conservation 4.1			
Is Reproduction A Personal Right?	88		
4.4 Population Growth in the Less Developed Nations: A Closer Look	89		
4.5 Controlling the Growth of the World's Population	89		
4.6 Human Population and the Earth's Carrying Capacity	92		
Case Study 4.1 China: One of Family Plannings Success Stories?	94		
5. World Hunger: Solving the Problem Sustainably	97		
5.1 World Hunger: Dimensions of the Problem	97		
5.2 Increasing Food Supplies Sustainably: An Overview	100		
Ethics In Resource Conservation 5.1			
Feeding People or Controlling Population Growth	101		
5.3 Poverty Conflict and Free Trade: Vital Strategies Needed to Feed the Worlds People	111		
6. The Nature of Soils	115		
6.1 Value of Soil	115		
6.2 Characteristics of Soil	115		
6.3 Soil Formation	122		
6.4 The Soil Profile	125		

6.5 Soil Classification	127	GIS and Remote Sensing GIS Aids Snow Monitoring and Modeling at the National Weather Service	230
7. Soil Conservation and Sustainable Agriculture	134	10.3 Water Shortages: Issues and Solutions	235
7.1 The Nature of Soil Erosion	134	10.4 Irrigation: Issues and Solutions	240
7.2 The Dust Bowl	135	11. Water Pollution	249
7.3 The Shelterbelt Program	138	11.1 Types of Water Pollution	249
7.4 Soil Erosion Today	139	11.2 Major Pollutants and Their Control	251
7.5 Factors Affecting the Rate of Soil Erosion by Water	140	Case Study 11.1 The Zebra Mussel: A Water Contaminant From Europe	264
7.6 Controlling Soil Erosion by Water	142	11.3 Sewage Treatment and Disposal	273
Case Study 7.1 A 100-Year Study of the Effects of Cropping on Soil Erosion	143	Case Study 11.2 Invisible Threat: Toxic Chemicals in The Great Lakes	276
A Closer Look 7.2 The Universal Soil Loss Equation	147	11.4 Legislating Water Pollution Control	283
7.7 Alternative Agriculture	150	11.5 Pollution of Oceans	285
7.8 Sustainable Agriculture	153	11.6 A World View of Water Pollution	294
GIS and Remote Sensing GIS, Remote Sensing, and Precision Farming	157	12. Fisheries Conservation	299
8. Pesticides: Protecting Our Crops, Our Health, and Our Environment	161	12.1 Freshwater Fisheries	300
8.1 Where Do Pests Come From?	161	12.2 Environmental Limitations to the Reproductive Potential of Freshwater Fish	301
8.2 Types of Chemical Pesticides: An Historical Perspective	164	Case Study 12.1 The Sea Lamprey Scourge of The Great Lakes	308
8.3 How Effective Are Pesticides?	165	12.3 Sustainable Freshwater Fisheries Management	311
8.4 How Hazardous Are Pesticides?	168	Case Study 12.2 Rebuilding Fish and Wildlife Populations on the Columbia River Drainage System	313
8.5 Sustainable Pest Control	172	A Closer Look 12.3 Salmon Fever in The Great Lakes	317
GIS and Remote Sensing Using Satellite Remote Sensing to Detect Pest Damage in Oregon's Forests	173	12.4 Marine Fisheries	323
Case Study 8.1 Tsetse Flies Brought Under Control in Zanzibar	178	12.5 Problems Facing the Marine Fisheries Industry	325
8.6 Are Pesticides Adequately Regulated?	181	12.6 Sustainable Marine Fisheries Management	329
9. Aquatic Environments	186	12.7 Aquaculture	333
9.1 Wetlands	186	13. Rangeland Management	341
9.2 The Lake Ecosystem	194	13.1 Ecology of Rangelands	341
9.3 The Stream Ecosystem	197	A Closer Look 13.1 Prairie Restoration and the National Grasslands Story	342
9.4 The Coastal Environment	200	13.2 Brief History of Range Use in the United States	347
9.5 The Ocean	211	A Closer Look 13.2 Causes of Desertification	349
10. Managing Resource Sustainability Waters	219	13.3 Rangeland Resources and Condition	351
10.1 The Water Cycle	221	A Closer Look 13.3 Range Wars: Rancho Versus Environmentalists	354
10.2 Flooding: Problems and Solutions	225		
Case Study 10.1 The Great Mississippi Flood of 1993	228		

13.4 Range Management	356	A Closer Look 16.1 The Hunting Controversy	435
Case Study 13.4 Methods of Coyote Control	363	16.4 Wildlife Management	437
14. Forest Management	366	16.5 Regulating Populations	443
14.1 Forest Ownership	367	Case Study 16.2 The Everglades: Water Troubles in A Wildlife Paradise	446
14.2 The U.S. Forest Service	367	Ethics in Resource Conservation 16.3 To Kill or Not to Kill	448
14.3 Harvesting Trees	371	16.6 Nongame Wildlife	451
A Closer Look 14.1 The Monoculture Controversy	372	17. Sustainable Waste Management	454
14.4 Reforestation	377	17.1 Municipal Waste: Tapping a Wasted Resource	454
A Closer Look 14.2 Genetic Engineering: The Key to Tomorrow's Superforests	378	17.2 Managing Our Municipal Solid Wastes Sustainably	456
14.5 Control of Forest Pests	379	Ethics in Resource Conservation 17.1 Do We Have an Obligation to Future Generations?	457
14.6 Fire Management	382	17.3 Waste Disposal: The Final Option	462
A Closer Look 14.3 Controlling Insect Outbreaks with Heterotypes	383	17.4 Hazardous Wastes	464
14.7 Meeting Future Timber Demands	385	Case Study 17.2 The Chemical Time Bomb at Love Canal	465
14.8 Preserving Wilderness	386	Case Study 17.3 Exportin Toxic Troubles	472
A Closer Look 14.4 Forest Conservation by Efficient Utilization	387	18. Air Pollution	476
14.9 Protecting Natural Resources: National Parks	388	18.1 Pollution of the Atmosphere	477
A Closer Look 14.5 The Wilderness Controversy	389	18.2 Major Atmospheric Pollutants	478
14.10 Reversing Tropical Deforestation	393	A Closer Look 18.1 The Clean Air Act	480
15. Plant and Animal Extinction	400	18.3 Factors Affecting Air Pollution Concentrations	483
15.1 Extinction: Eroding the Earth's Biological Diversity	401	18.4 Effects of Air Pollution on Local Climate	485
15.2 Understanding Population Dynamics	402	18.5 Effects of Air Pollution on Human Health	486
15.3 Causes of Extinction	406	Case Study 18.1 Asbestos: The Dangers of a Useful Product	489
Case Study 15.1 Dam Versus Darter: A Classic Confrontation	408	18.6 Air Pollution Abatement and Control	491
Case Study 15.2 The Passenger Pigeon: The Many Causes of Extinction	409	Case Study 18.2 Getting Charged Up Over Electric Cars	498
GIS Remote Sensing Mapping Noxious Weeds With GIS	413	18.7 Indoor Air Pollution	499
Ethics in Resource Management 15.3 Do Other Species have a Right to Exist?	414	Case Study 18.3 Tobacco Smoke: The Deadliest Air Pollutant	500
15.4 Methods of Preventing Extinction	417	19. Air Pollution: Global Problems	506
15.5 The Endangered Species Act	420	19.1 Global Climate Change	506
16. Wildlife Management	426	19.2 Acid Deposition	512
16.1 Wildlife	427	GIS and Remote Sensing GIS Aids Emergency Response and Survival Strategies in Bangladesh	513
16.2 Types of Animal Movements	430	19.3 Depletion of Stratospheric Ozone	522
16.3 Mortality Factors	430		

Ethics in Resource Conservation 19.1 Debate Over Global Warming and Ozone Depletion: Do We Have an Obligation to Other Countries?	528	21.3 The Nuclear Energy Option: Is It Sustainable?	556
20. Minerals, Mining, and a Sustainable Society	531	21.4 Fusion Reactors	569
20.1 Supply and Demand	532	21.5 America's Energy Future	572
20.2 Can We Expand Our Mineral Supplies?	535	22. Creating a Sustainable System of Energy: Efficiency and Renewable Energy	576
20.3 Mineral Conservation Strategies	537	22.1 Conservation	576
20.4 Environmental Impacts of Mineral Production	539	22.2 Renewable Energy Strategies	581
21. Nonrenewable Energy Resources: Issues and Options	544	Afterword	599
21.1 Global Energy Sources: An Overview	545	Glossary	601
21.2 A Closer Look at Nonrenewable Energy Resources	546	Illustration Acknowledgments	618
		Index	621

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.

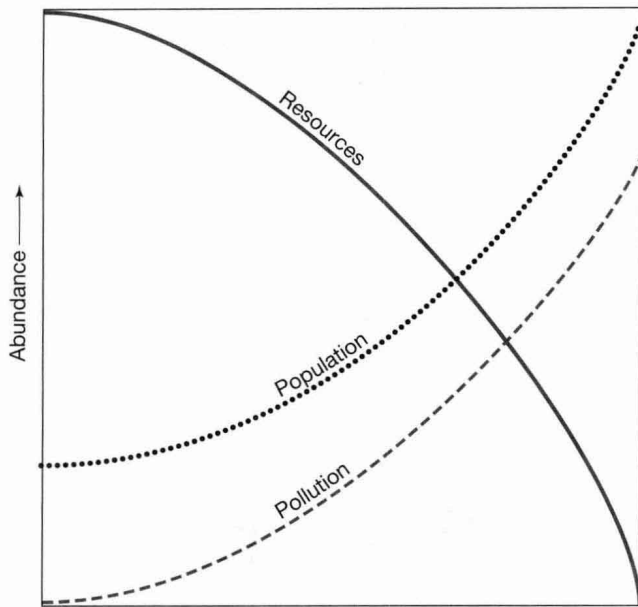


FIGURE 1.1 Population, resources, and pollution. This simple diagram illustrates a very fundamental relationship between people, the resources they require, and environmental destruction and pollution.

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



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.

India, China, and Bangladesh, for example, all suffer enormously under the strain of large and rapidly growing populations.

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.

I.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

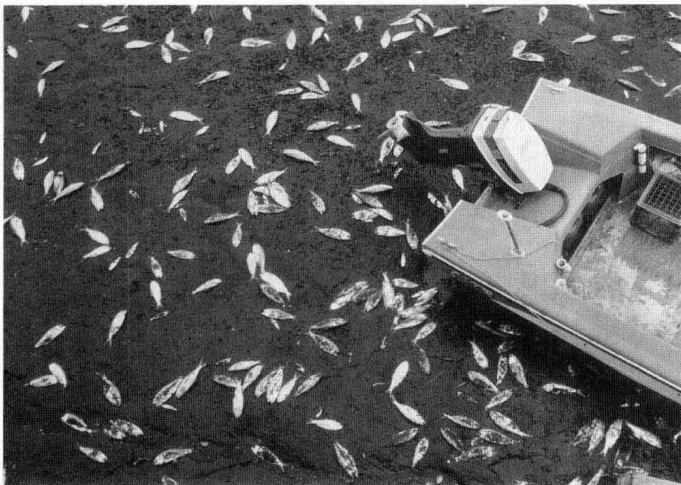


FIGURE 1.3 The United States and other nations have polluted their lakes and streams with sewage, industrial wastes, radioactive materials, heat, detergents, agricultural fertilizers, and pesticides. Massive fish kills are often the result.

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 there 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-

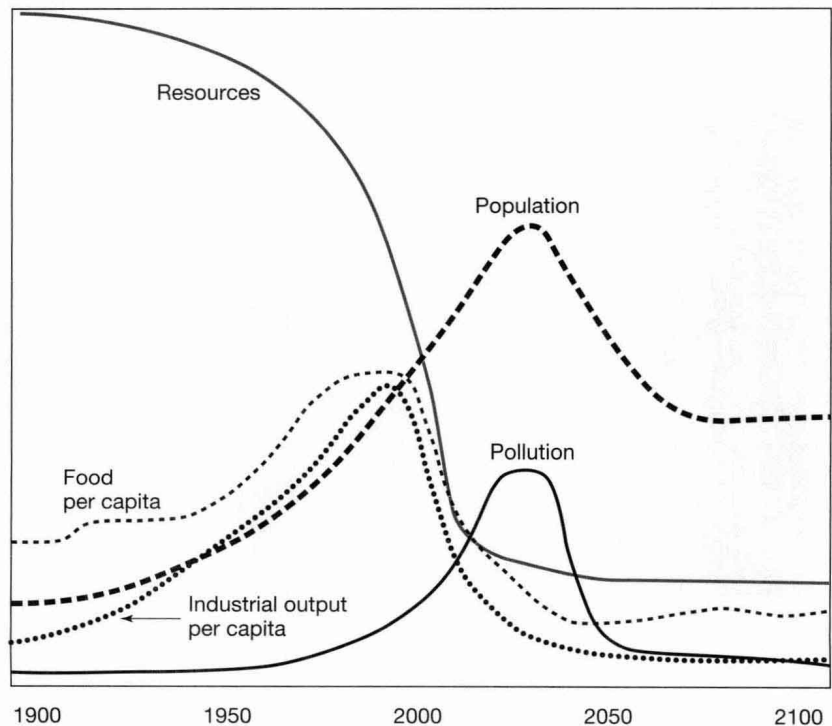


FIGURE 1.5 The Limits to Growth study. Researchers used the computer to predict the fate of human society if current trends continue. This graph shows that if the population continues to grow, resources will decline dramatically. Pollution levels will increase. The combined effect is a decline in human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