Managing Our Natural Resources

6TH EDITION

William G. Camp | Betty Heath-Camp

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Managing Our Natural Resources, 6th Edition

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WCN: 02-200-202

Library of Congress Control Number: 2014946317

ISBN-13: 978-1-285-83507-5

Cengage Learning
200 First Stamford Place, 4th Floor
Stamford, CT 06902
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Printed in the United States of America
Print Number: 01 Print Year: 2014

This book is dedicated to the children of the next and future generations. It is for them that we advocate the wise management of our natural resources.

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PREFACE

Managing Our Natural Resources is designed for high school and postsecondary students enrolled in an agriculture program with a natural resources, conservation, forestry management, environmental science, or wildlife management course.

It is the purpose of this book to present a balanced viewpoint of the place of humans in the world as long-term residents. We discuss soil formation, erosion, reclamation, and conservation; water use and improvement; and air quality. We examine endangered species of wildlife; hunting game animals; fishing; and safety in boating, hiking, and other forms of outdoor recreation. We study conservation farming; land-use planning; construction practices that minimize the impact of exploitation on the environment; energy resources use, abuse, conservation, and alternatives; mineral use and recycling; and career opportunities in each of those diverse fields.

For this sixth edition, we worked to present the most current and relevant events, statistics, and topics. Our intention is that readers become informed of the natural resource management issues of today.

Managing natural resources itself is a very broad topic, and a book that attempts to deal with it cannot go into great depth in any of the areas considered. Therefore, this book should be used as a survey of many broad areas rather than as a definitive treatment of any one area of study.

Why We Wrote This Book

Managing Our Natural Resources was written because we perceived a need for a book that takes a broad look at the whole panorama of preservation, exploitation, and conservation of natural resources from a balanced perspective. There are many books on soils, for instance, but such books do not treat soil management as it relates to other disciplines, such as wildlife management and fisheries development. We have attempted to take just such an approach in this book. We hope it will lead students into at least one area of study that will pique their appetite to learn more and that will lead them to conduct their own research and further study in that area.

New to This Edition

The sixth edition was thoroughly revised to reflect the changing landscape of natural resource management:

- Statistics throughout the book were updated and checked for accuracy.
- Changes in technology and the economy and how they have affected the energy production sector in drastic ways are discussed.
- The emergence of the widespread use of hydraulic fracturing (fracking) is described.
- Recent events, such as the nuclear accident in Fukushima, Japan, and Superstorm Sandy along the East coast of the United States are discussed.
- United Nations population growth forecasts, indicating a leveling off of the human population over the next several centuries, are reviewed.
- Web sites in Appendix A and safety certification programs in Appendix B were updated and checked for accuracy.

Supplement to This Book

A set of resources to facilitate the teaching and learning experience are available for the sixth edition of *Managing Our Natural Resources*.

Instructor's Manual

The printed Instructor's Manual includes Lesson Plans with PowerPoint® correlations for each chapter and Answers to the Review and Discussion Questions in the book and the questions in the accompanying workbook, to ensure that the instructor is prepared for classroom instruction and evaluation.

Classmaster CD-ROM

The Classmaster CD-ROM is an integrated tool that contains many useful resources for the instructor:

- Instructor's Manual – an electronic version of the printed Instructor's Manual, including Lesson Plans with PowerPoint® correlations for each chapter, and the Answers to the Review and Discussion Questions in the book and workbook, is available for reference.
- PowerPoint® presentations – visually-robust with photos and illustrations, each presentation maps out the key points contained within a chapter and correlates to the Lesson Plans that are included in the Instructor's Manual.
- A link to new flexible online testing system powered by Cognero provides instructors with the ability to:
  - author, edit, and manage test bank content from multiple resources
  - create multiple test versions in an instant
  - deliver tests from instructor/institution-specific LMS or classrooms

The link will direct you to CengageBrain.com at http://login.cengagage.com. Follow the prompts for obtaining access to this secure site.

Also Available on the CD are versions of the same tests that appear online in a Microsoft Word® format. This option is for instructors who prefer to use the questions as provided, while still having the flexibility to edit or print the tests.

- An Image Gallery, containing all the images from the book, enables instructors to enhance classroom presentations or review key concepts and information.

New! Companion Site

Instructor resources on the ClassMaster CD-ROM are also available online, including the new flexible online testing system powered by Cognero. Please visit CengageBrain.com at http://login.cengagage.com and follow the prompts for obtaining access to this secure site.

Student Workbook

Newly revised to reflect the sixth edition, the student workbook includes activities, questions and job exercises for each chapter and unit in the book.

New! Coursemate

Another new online option for the fourth edition, this course is designed for students and combines the *Managing Our Natural Resources, 6th Edition* ebook with additional features to enhance learning for the student. It includes the PowerPoint® presentations, additional quizzing, glossary, interactive games and activities and other helpful resources related to the lessons in the book. Also featured is an Engagement Tracker that allows instructors to monitor time on task for each individual student.

ACKNOWLEDGMENTS

Acknowledgments are due to a number of people who assisted in the development of this book.

Cengage Learning

First, we would like to express our special thanks to the editorial staff of Cengage Learning.

- A special "thank you" goes to:
    - Laura Stewart, senior content developer
    - Jennifer Starr, senior content developer
    - Nicole Sgueglia, associate product manager
    - Scott Royael, product assistant
    - Betsy Hough, senior content project manager
    - Dave Arsenault, art director

Without all of your guidance, encouragement, and help, this revision would have been impossible.

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- Carla A. Kirts, PhD, Dean of Student Services Emerita and Associate Professor Emerita, University of Alaska, provided input to the first edition.
- Susan Wilder (formerly Aksamit) wrote sections of the fourth edition.
- Andrea Kavleski wrote the case studies on zebra mussels and Asian long-horned beetles.
- Heidi Martin, agriculture teacher in Virginia, contributed to several case studies in the fourth edition and wrote the case study on genetic modification.

HOW TO USE THIS TEXT

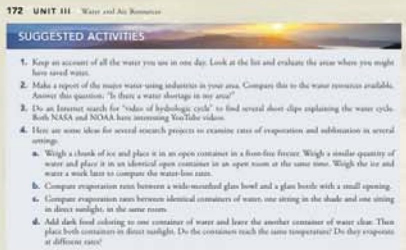
How This Book Is Organized

This book provides an overview of a wide range of topics in natural resources management. The book is organized into eight major units to help students logically progress through each of the subject areas. Each unit includes one or more chapters as well as a concluding case study that represents a current issue that is relevant to the chapters included within that unit. In addition, six of the eight units include chapters that enable students to explore careers relevant to the topic of the unit.

Features

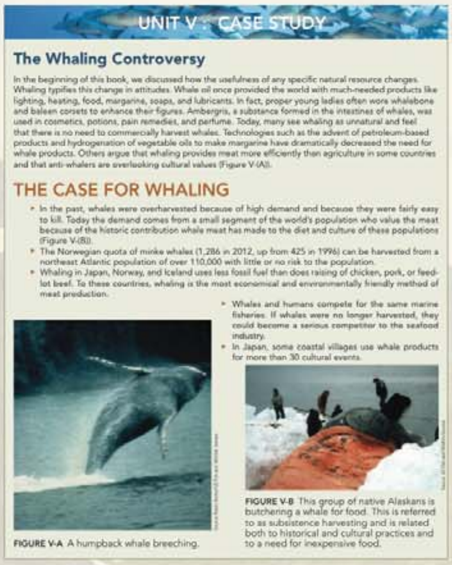
Each chapter is organized to help guide students along a learning path:

- **Objectives** can help students organize thoughts as they read the chapter—they tell the student what to expect.
- **Terms to Know** are highlighted in the chapter to help define key points. All the terms are also defined in the **Glossary** at the end of the book.
- **Review Questions** help students determine if they are able to recall basic facts of the chapter.
- **Discussion questions** encourage students to reflect more deeply and think about what they have learned in the chapter
- **Suggested activities** are intended to go beyond the content of the chapter and give you a chance to apply the content of the chapter to your own life



Units II through VI end with chapters on careers relevant to the unit content. Each unit also concludes with a case study:

- Unit 1 – *Eyes in the Night: The Debate over Wolf Reintroduction in North America* examines the precarious status of the wolf and their reintroduction into the United States.
- Unit 2 – *Let's Go to the Beach* discusses the pros and cons of coastal development.
- Unit 3 – *The Tale of the Pesky Mollusk* describes the invasion of the zebra mussel, brought on by human activity, in the waters of North America.
- Unit 4 – *Hey! Don't Eat My Trees!* describes the introduction of another pesky invader, the Asian long-horned beetle, into the United States, an event brought on by shipping and trade with other countries.
- Unit 5 – *The Whaling Controversy* examines the history and current attitudes on whaling and how values, economics and cultural beliefs can factor into the debate.
- Unit 6 – *Forest and Foes* investigates the two philosophies behind forest management—the perspectives of the preservationist and the conservationist.
- Unit 7 – *To Regulate or Not to Regulate—That Is the Question* examines the controversy over federal government involvement within the energy sector.



UNIT V : CASE STUDY

The Whaling Controversy

In the beginning of this book, we discussed how the usefulness of any specific natural resource changes. Whaling typifies this change in attitudes. Whale oil once provided the world with much-needed products like lighting, heating, food, margarine, soaps, and lubricants. In fact, proper young ladies often wore whalebone and baleen corsets to enhance their figures. Ambergris, a substance formed in the intestines of whales, was used in cosmetics, potions, pain remedies, and perfume. Today, many see whaling as unnatural and feel that there is no need to commercially harvest whales. Technologies such as the advent of petroleum-based products and hydrogenation of vegetable oils to make margarine have dramatically decreased the need for whale products. Others argue that whaling provides meat more efficiently than agriculture in some countries and that anti-whalers are overlooking cultural values (Figure V-(A)).

THE CASE FOR WHALING

- In the past, whales were overharvested because of high demand and because they were fairly easy to kill. Today the demand comes from a small segment of the world's population who value the meat because of the historic contribution whale meat has made to the diet and culture of these populations (Figure V-(B)).
- The Norwegian quota of minke whales (1,286 in 2012, up from 425 in 1996) can be harvested from a northeast Atlantic population of over 110,000 with little or no risk to the population.
- Whaling in Japan, Norway, and Iceland uses less fossil fuel than does raising of chicken, pork, or feed-lot beef. To these countries, whaling is the most economical and environmentally friendly method of meat production.
- Whales and humans compete for the same marine fisheries. If whales were no longer harvested, they could become a serious competitor to the seafood industry.
- In Japan, some coastal villages use whale products for more than 30 cultural events.

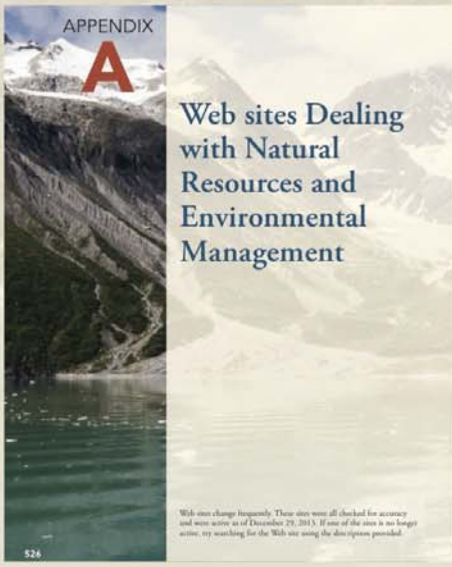
FIGURE V-A A humpback whale breeching.

FIGURE V-B This group of native Alaskans is butchering a whale for food. This is referred to as subsistence harvesting and is related both to historical and cultural practices and to a need for inexpensive food.

- Unit 8 – *GMOS and the Environment: Where Do We Draw the Line?* investigates the pros and cons of genetic engineering.

In addition, the **Appendices** included at the back of the book provide a wealth of information for further study:

- **Appendix A** provides a list of links to authoritative Web sites that can be trusted to provide accurate information.
- **Appendix B** describes several Safety Certification programs that may be of interest: Hunter Safety, Boating Safety, and others.
- **Appendix C** provides a method for improving the safety of your school laboratory or workplace.
- **Appendix D** offers suggested Supervised Agricultural Experience Programs that might be valuable to you.
- **Appendix E** includes several additional case studies in addition to those at the ends of the units.



APPENDIX A

Web sites Dealing with Natural Resources and Environmental Management

Web sites change frequently. These sites were all checked for accuracy and were active as of December 29, 2013. If one of the sites is no longer active, try searching for the Web site using the descriptions provided.

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INTRODUCTION

There are many different ways to look at the management of our natural resources. Three different perspectives that must be considered are those of the preservationist, the exploiter, and the conservationist.

If we view the world as preservationists, nature is something that should be left intact as much as possible. From that perspective, humankind is a great destroyer and pillager, and we have no right to destroy the land or tear the earth apart. To a preservationist, managing nature is a foreign concept because nature is something to be left alone and not managed. The preservationist would stop the construction of a pipeline needed by our economy to move Alaskan or Canadian oil because he or she believes it will make the landscape ugly and endanger the migratory habits of wildlife. From that perspective, almost all development is inherently bad. A preservationist would protect a rare 150-year-old tree simply because it is a 150-year-old tree.

If we take the viewpoint of the exploiter, natural resources are merely a source of wealth and power. They represent something that is there for the taking and for our own use. From that perspective, nature is something to be reshaped for our economic benefit, with little regard for other creatures in the ecosystem. The exploiter would build a dam to supply electricity even if, by doing so, the habitat of a small, rare fish would be destroyed. The exploiter would harvest a rare 150-year-old tree because the wood could be used to make expensive furniture.

The conservationist viewpoint is somewhere between those two. From that perspective, nature provides resources that should be used sustainably for our collective economic benefit. The conservationist would encourage the harvesting of forests to produce wood and paper as long as the trees are replaced by other trees having economic value, but not necessarily the same kind of tree harvested originally. The conservationist would allow the strip mining of coal as long as the land is restored to a balanced, natural state when the mining is completed and as long as no meaningful collateral environmental damage occurred during the process. The conservationist would consider whether to harvest the rare 150-year-old tree in light of the impact on the area. If he or she decided to harvest the tree, several tree seedlings compatible with that location would be planted to replace it.

Which viewpoint is right, and which is wrong? There is no simple answer to such a question. If there were a right answer, there would not be such divergent viewpoints. Consensus among the different factions would be possible. What we can say for certain is that the world is not a very large place, and there are many people. As the number of people on earth continues to increase, the pressure applied by humans to the environment also increases. It is clear that we cannot follow the exploiter's approach forever, but by the same token, a world human population of over 7 billion cannot exist without affecting the shape and condition of the environment.

It is not the purpose of this book to convince you that any one of these three divergent perspectives is the right one. We will try to make the preservationist argument that such creatures as the bald eagle and the sea turtle have legitimate rights to exist on earth. At the same time, it is difficult to argue convincingly that the people of a village in India should be forced to live in constant danger of being killed and eaten by tigers to safeguard the tiger population. We believe also that without the exploiters, our nation would never have grown into the powerful and rich society it is today but that sometimes exploitation of nature can go too far. We believe that our natural resources should be conserved by wise use in a sustainable way. Yet it was conservationists who gave us kudzu (a vine imported from China) to prevent road-bank erosion, and now much of the South is overgrown with the rapidly spreading plant. It is obvious that members of all three groups are both right and wrong in many ways.

As noted earlier, it is our goal to present a balanced viewpoint of the place of humans in the world as long-term residents. Where do you stand? What do you believe? *You* decide.

UNIT

I

Introduction

CHAPTER 1

Our Natural Resources

OBJECTIVES

After reading this chapter, you should be able to

- define and discuss the concept of natural resources
- list and describe the major categories of natural resources in the United States
- explain what makes something a natural resource

TERMS TO KNOW

natural resource
topsoil
usable water
vertebrate
noncommercial forest
mature forest
minerals
recreational resources

In earlier times, people did not have the technology to see beyond the horizon. As a result, distant places were more mysterious to people than they are today and many feared to go beyond the boundaries of the land that they knew. The apparently limitless nature of the world led people to believe that our natural resources were endless, boundless, and inexhaustible. In reality, when there were fewer people and when our technology was limited to human and animal power, we had very limited ability to use the natural resources that were available. When our technology did not allow us to change the face of the earth so dramatically, nature actually did provide resources almost beyond the capacity of humans to use them. But now our machines allow one person to do things that armies of workers could not in ancient times.

More importantly, the world population of humans has surged in the past couple of centuries. According to the U.S. Census Bureau, the human population first reached 1 billion in 1804. Reaching the first billion mark took many thousands of years of human history. A total population of two billion was reached in 1927. That second billion took only 127 years. According to the United Nations, the world's population exceeded 6 billion on about October 12, 1999. That figure was estimated at just over 7.1 billion on November 30, 2013—just 14 years after the 6 billion mark was reached. According to United Nations estimates, the world population should exceed 8 billion by 2025 and then grow more slowly to about 9 billion by 2100 and begin to level after that. See Chapter 3 for a more detailed discussion on human population. Everything has changed in the past couple of centuries. Yet, many people continue to treat nature's gifts as endless, boundless, and inexhaustible. This cannot continue. It is to help you appreciate that dilemma that this book was written.

Special Features to Look for in This Book

To guide you along the learning path, each chapter begins with a list of **objectives** and **terms to know** and ends with **review questions**, **discussion questions**, and **suggested activities**. Each unit ends with a **Case Study** intended to help you dig deeper into some part of the unit.

The Appendices also can be very helpful:

- Appendix A provides links to authoritative web sites.
- Appendix B describes Hunter Safety, Boating Safety, and other safety programs.
- Appendix C outlines a safety program for school laboratories and SAE work sites.
- Appendix D offers ideas for Supervised Agricultural Experience (SAE) Programs.
- Appendix E includes several additional case studies.

WHAT IS A NATURAL RESOURCE?

One authority defines a natural resource as any form of energy that can be used by humans. Others would tell us that natural resources are objects people use. In an ecological sense, anything that was not produced by humans and that is or can be useful in our lives is a natural resource.

For the purposes of this book, we will use the ecological approach. Natural resources can be defined as all those things that have not been created by humans with which people come into contact and that can be used to perform any useful function. This includes all energy forms that can be harnessed by human ingenuity. It includes objects, creatures, and materials that can be moved, shaped, built upon, built with, or manipulated for any useful purpose. It includes those things that inspire, relax, or strengthen humans as individuals or groups.

Clearly, this approach covers too many areas for any single book to deal with in detail, so we must limit our discussion. We will look at only those natural resources used on a large scale and in an organized way. These include our soil, water, fish and wildlife, forests, metals and minerals, fossil fuels, other major energy sources, and recreational resources.

This leads us to a working definition of natural resources: **Natural resources** are objects, materials (including soil, water, and air), creatures, or energy that are found in nature and that can be used by humans.

Usefulness Changes

This is a difficult concept, but the potential of an item to "be used by humans" is not constant. Usefulness changes over time and from one place or society to another. Many factors affect our definition of usefulness. Religion affects Hindu attitudes toward cattle, for instance. Custom affects most Western attitudes toward dogs as a food source. Technology and science affect our use of outer space as a communication medium.

In particular, the usefulness of many resources changes over time as our science and technology improve. For instance, the natural resources humans have used to provide light have changed many times. For thousands of years, humans burned wood to provide light at night. Later, people learned that wood torches could be dipped into animal fat and made to burn longer, and so fat from animals became a source of light. Still later, people learned that whale oil could be used to burn in lamps, and whales became a natural resource used to produce light.

Over a century ago, we learned that petroleum could be refined to produce products that could be burned to produce light, and a new natural resource was born. We learned to capture natural gas and use that to generate light. In the twentieth century, falling water and nuclear energy (among other things) were harnessed to produce electricity to provide light. None of these resources was new. Animal fat, whale oil, petroleum, natural gas, falling water, and nuclear energy have existed all along, but their usefulness has changed because developments in our technology have meant that we could use resources that have existed all along in new ways.

Many of the things we consider to be resources today were not resources at all in earlier times. Nuclear energy, gasoline, most metal alloys, electricity from falling water, deep groundwater—these and many more—were not natural resources when the first Native Americans settled in this land, or even later when the first permanent European settlers came to America. They were not natural resources because they were not useful to humans.

Our situation changed too. When the first permanent English settlement in America was established in 1607 on the James River in what is now Virginia, the settlers faced many problems. One of the most serious was the number of trees. Certainly, a few trees were needed for building and to be used as fuel for heating and cooking, but once those needs were met, forests were a liability to settlers. The forests seemed to be dark and endless. In that sense, forests were a hindrance rather than a natural resource. The same situation remained true for the many years that followed, during which European settlers made their way across the continent (Figure 1-1).

United States Army

FIGURE 1-1 A reconstruction of Fort Clatsop is located in the Lewis and Clark National Historical Park near Astoria, Oregon. Dense forest had to be cleared to make way for the safety of a log fort.

With this working definition of natural resources as useful to humans in mind, let's continue. The remainder of this chapter will briefly examine the major categories of natural resources.

SOIL RESOURCES

Land Area

The United States has a total land area of 3,675,545 square miles in its 50 states. That equates to 2.26 billion acres. The surface of our country ranges from 282 feet below sea level in Death Valley to 20,320 feet above sea level on Mt. McKinley. This vast area is covered by rocks, sand, water, organic matter, parent material, subsoil, and soil as well as man-made structures. It is from the **topsoil**, the uppermost layer of soil, that we must get almost all of our food and natural fibers; it is also where we, for the most part, live, work, and play. Someone has said that *"Man, despite his artistic pretensions, his sophistication and many accomplishments, owes the fact of his existence to a six-inch layer of topsoil and the fact that it rains."*

Of the land in this country in 1607, there seemed to be no practical limit. There was more land than it seemed possible to use. Even 100 years later, there was more land than we could settle. Today, that is no longer true.

In the early twenty-first century, almost one-third of our land area is not suitable for farming. Another 8 percent is covered by cities, factories, homes, highways, and other artificial structures. The remaining 60 percent is useful for food and fiber production. Of that, only about 385 million acres, or 17 percent of the total, is usable for crop production. An even smaller percentage is prime farmland, and much of that is of only marginal value because of its location.

The soil's major enemy has been erosion. In the years since our nation began, we have lost one-third of our topsoil to erosion. Only one-fourth of our cropland remains undamaged by this menace. Another problem we are beginning to face is

FIGURE 1-2 Land is being converted into a large housing development near Bluffton, South Carolina.

the conversion of agricultural land to urban or other uses. Once an acre of prime corn-belt land is covered by concrete or asphalt, it is, to say the least, hard to grow corn there (Figure 1-2).

Urban expansion, industrialization, highway construction, and other alternative uses for our land surface are becoming increasingly important. This is not necessarily bad. Land is an important natural resource for many purposes—food and fiber production is only one purpose. Unfortunately, this expansion tends too often to occur on our best land for farm production. Land-use planning is more important now than ever. We must, as a nation, establish our priorities for land use. We must then allocate our land and soil resources based on those priorities. It would seem that, with the world population explosion, food production must rank very high in those priorities. Nevertheless, manufacture of other products, transportation, processing, and distribution are also critical to our way of life.

Managing our soil and land resources is a complex problem. Hard decisions need to be made, both now and in the future.

WATER RESOURCES

"Water, water, everywhere" was the wail of the old sailor in *The Rime of the Ancient Mariner* by Samuel Taylor Coleridge. Indeed, this resource is abundant. Why worry about managing our water resources when 70 percent of the earth's surface is covered by it?

However, the ancient mariner continued his lament with, *"nor any drop to drink."* There is a great difference between water and **usable water**. Remember our definition of natural resource: Water is a natural resource only when it can be put to use by humans. The oceans provide us with marine products and a medium in which ships can travel. They contain minerals and metals, and tide flows can be harnessed for electrical generation. The ocean floors contain vast deposits of oil and minerals (Figure 1-3).

FIGURE 1-3 Padre Island National Seashore, Texas. "Water, water, everywhere, nor any drop to drink." Over 70 percent of the earth's surface is covered by water, yet drinking water is one of the most precious resources on the planet.

Most of our usable water is always on its way back to the sea. We can increase its usefulness by slowing its journey. We can contain it for other uses and take its energy for our own purposes. We can drink, wash, clean, cool, grow our food, and manufacture with it. To do these things, we must manage the water.

Water was an early source of power in this country. Running water carried logs, floated boats, and turned waterwheels. By 1900, less than 4 percent of America's power still came from this source. Still, water is needed in even greater quantities today. Every day, Americans use 300 billion gallons of water annually. Of this, about 60 billion gallons are temporarily removed from the water cycle. Most of the remaining 240 billion gallons are returned directly to the hydrologic cycle (discussed in Chapter 13), but much of that is either heated or damaged by pollutants. Almost none of that water is permanently removed from the water cycle. Some water used in hydraulic fracturing, or "fracking" (see chapter 32) is injected deep into the earth and is effectively removed from the water cycle. Unfortunately, reliable estimates of the actual amount of water permanently removed are not available.

Another facet of our water resource management problem is the control of excess runoff. At least 37 states have average annual runoffs of 10 inches or more, yet much of this area has low annual rainfall totals—as little as 20 inches in several of the states. Thus, much of the water that falls on the land simply flows directly into streams and then back to the sea—it remains part of the hydrologic cycle without being put to use by people. This is a potential natural resource we may be able to access with effective water management.

There is no shortage of water in this country. We have plenty of freshwater, but try telling that to a deep-well farmer in Arizona! Yes, there is plenty of water, but most of it is not located where people need it. Moreover, it may not be of a usable quality even when it is located where it is needed. The problems are control, quality, and distribution, and those problems are real and becoming more intense.

FISH AND WILDLIFE RESOURCES

Wildlife is the natural resource that resembles humans most. Although not considered a resource by many, wildlife species definitely play an important role in our lives. In the conservationist sense, fish and wildlife are defined as non-domesticated animals, either game or nongame. Broadly interpreted, however, the term can also embrace uncultivated plant life. The key ingredient is "wildness."

A renewable natural resource is one that can reproduce itself. Fish and animal wildlife are considered renewable, but this is only true while a species is alive and reproducing. Since colonial times, 117 **vertebrate** species have become extinct in our nation. Another 403 species of mammals, birds, reptiles, amphibians, and fishes were regarded as threatened or endangered by the U.S. Department of Fish and Wildlife as of late 2013. Thus, in one sense, wildlife species are not always renewable, and they certainly are not inexhaustible.

Although wildlife is not as important for food as it was when the country was young, it still is of value to us. The pleasure that wild animals, fish, and birds afford us, the meat still produced from them, and their instinctive insect-destroying ability (valued at over $1 billion per year) are all assets that they contribute. According to the U.S. Fish and Wildlife Service, more than $1.2 billion in state revenue was generated in 2003 through the purchase of hunting and fishing licenses, permits, stamps, and tags in the United States. That is a very small amount of money compared to the expenditures hunters and sports fishers made on hunting and fishing gear.

Until recently, the structure of wildlife conservation has dictated a program especially for hunters and sports fishers. However, lately, a new aspect of fish and wildlife management has begun to emerge in the form of ecotourism. This aspect deals with satisfying the demands of the non-hunting and non-fishing public for the pleasure afforded by observing wild creatures in nature. Thus, parks and preserves are becoming more dedicated to this idea. They are concentrating on the return of "nature" to such recreation areas. Aesthetic values encourage the preservation of ecosystems in their natural states (Figure 1-4).

As long as the population of a species of fish or wildlife remains fairly stable, there is little concern for its long-term survival. For such species, hunting and fishing are acceptable forms of management. When the population of a species starts to fall too low, it may become "threatened." Threatened species are those that appear to be declining in numbers toward the point that the species' survival may be in danger. If the population continues to fall, it may be declared "endangered" or "rare." When that happens, exceptional efforts are often required to help the species recover. More in-depth discussions of rare, endangered, and extinct species will be provided in a later chapter.

Source: Vernon Byrd/US Fish and Wildlife Service

FIGURE 1-4 Tourists traveled to the Alaska Maritime Wildlife Refuge for a chance to see these walrus.

FOREST RESOURCES

In 1607, at least half of our land area was forested. This amounted to over a billion acres. Almost 70 percent of that area is still in forest. Of the 738 million acres of forest in the United States today, about one-third is **noncommercial forest**. This means it is generally not usable for forest production. The other two-thirds is usable for commercial forestry.

Of the 30 percent of our original forest that is now gone, almost all would have been considered commercially usable. As in nonfarm uses of farmland, this non-forest use of forestland is not necessarily bad. Our society could not function without the highways we have built over some good farmland. By the same token, people cannot be fed without clearing the forests for farming and construction.

Since colonial times, U.S. forests have produced about 2,700 billion board feet of timber. Each decade, we take more wood from our forests than the decade before, yet each year the trees in our forests grow more wood than we harvest. Our 760 million acres produce more wood each year than what our over 1 billion acres did in 1607. Forest management works!

Source: US National Park Service

FIGURE 1-5 A mature forest, such as this redwood forest in California, is beautiful and peaceful, but it produces no usable wood and little wildlife. Still, it is useful in other ways. What is usefulness?

Mature Forests

When you think of the term *forest*, what do you think of? Is it a pine plantation with rows of trees all of the same height, or do you think of a dark, cool place with tall, beautiful trees? Most people would think of the latter.

When a forest tree begins to grow, it starts slowly. It may gain a foot a year in height, but even after a few years the tree does not have much wood. As it gets older, its crown increases in size and it produces wood much faster. As it becomes even older, its growth slows, and it gains less in height each year. Like people, a tree grows slowly, then faster, and then matures and does not grow very quickly after that. Eventually, the tree dies (Figure 1-5).

When a forest is left alone for centuries, it becomes a **mature forest**. This means that its canopy is dominated by mature, slow-growing trees. (Canopy refers to the upper portions, or crowns, of the trees, including the limbs and branches with leaves.) A mature forest is beautiful, dark, and cool, but it produces very little wood and provides a home for relatively few birds and animals. When we need to produce wood, we need a growing forest—a young forest. When we want to encourage wildlife populations we need a growing forest—a young forest. When this country was settled, the colonists found mostly mature forests. Today, we have fewer mature forests in our commercially usable forestland.

Forest management techniques and improved varieties of trees have helped greatly. In general, do not feel sad to see trees being cut. After all, they are not a natural resource until they become useful. More importantly, by good management, trees are renewable. This means we can cut a million trees and still have more than before.

OTHER RESOURCES

Energy Sources

Most of our energy comes either directly or indirectly from the sun, the earth's most vital natural resource. Capturing the energy that originates in the sun has always been our greatest challenge.

Over the centuries we have used the force of moving air, i.e., wind, to transport our goods and to pull water from the earth. Windmills once dotted the American landscape. Sailing ships crossed the oceans and the great lakes of the world. We cannot compare the quantity of wind in the past to that today. Nor can we conserve or waste wind. We can only use it whenever possible and try to avoid polluting it. During the energy crisis of the 1970s, there was a growing interest in the use of wind power. Then a temporary energy "glut" in the 1980s diminished the interest in wind power for several decades. Interest in wind power is on the rise again, and huge wind farms can be seen in many parts of the country today.

Another major energy source is coal. It is probably the most widely distributed storehouse of the sun's energy. Coal was first discovered in America in 1673, in what is now Illinois. In 1824, about 81,000 tons of coal was mined in this country. By 1950, the annual production had grown to 516 million tons. United States coal production in 2011 was estimated at 1.1 billion tons. Thus, a total of about 78 billion tons of coal was produced in the United States between 1890 and 2011.[i] Yet that represents only 1 to 2 percent of the total available. Authorities estimate reserves of 2.75 billion tons in U.S. coal. Coal is a one-time resource—but it is very plentiful. That means we have been finding coal much faster than we have been using it. There is no doubt that our known coal deposits could last for centuries. Moreover, there is little doubt that we have enough coal still undiscovered to last through the next thousand years. As we have already seen, usefulness changes over time. It seems likely that the earth's supply of coal will last long after coal as a source of heat energy has been replaced by less expensive and cleaner natural resources that we may not even know about yet.

Another sun-charged energy resource is oil. A science textbook for high school students in the late 1950s said that the world's reserve of oil would only last about 14 years at the rate of use then in effect. Today we use much more oil each year, but we have a greater store of known oil than we did 50 years ago. Because of improved oil discovery and recovery techniques, the world's known oil reserves have grown steadily over the years. Yet oil is also a one-time resource, so it must be carefully conserved.

A barrel of oil is about 36 gallons, or 159 liters. In 1960, world production of crude oil totaled 20.96 million barrels per day. By 1989, that had increased to 59.46 million barrels per day. Known world crude oil reserves totaled almost 135 billion metric tons in 1990. In 2009, the known crude oil reserves, in the Middle East countries alone, totaled over 745 billion barrels. In contrast, the known crude oil reserves in the United States in 2009 were only 21.3 billion barrels. In 2012, the worldwide proven oil reserve had grown to 1.5 trillion barrels, of which 26.5 billion barrels were in the United States.[ii]

It is important to understand that in addition to traditional crude oil reserves, a massive amount of petroleum is stored in oil sand and oil shale deposits. These have been too expensive to extract in the past, but increasing crude oil prices are making that source of oil feasible today. Oil sands and shale will be discussed in some detail in Chapter 32. In addition, with the advent of hydraulic fracturing (more commonly known as "fracking") technologies in the past several decades, the recoverable volume of oil has grown drastically. That trend will also be discussed in Chapter 32.

Until the early 1900s, natural gas was considered a waste product from oil fields. Now, however, it has been recognized for what it is—a clean, efficient fuel. Proven worldwide natural gas reserves totaled over 6,845 trillion (that is 6,845,000,000,000) cubic feet in 2012. That is an almost 10 percent increase in world reserves, up from 6,262 trillion cubic feet just three years earlier in 2009. The 2012 U.S. reserve of natural gas had expanded to 334 trillion cubic feet, up from 237 trillion cubic feet as recently as 2009. Obviously, natural gas is being discovered much faster than it is being used.[iii]

Minerals

Minerals are yet another type of natural resource. The most widely used are the metals, such as iron, copper, aluminum, magnesium, lead, zinc, tin, and several others. These metals, although not as vital as some of our other resources, are still important and need conservation. Improved mining and processing methods are doing a great deal to help conservation. To get some idea of the known reserves of some minerals, see Table 1-1.

Geologists generally agree that our undiscovered mineral reserves far exceed what we have already found, and the possibilities for further discovery are tremendous. These estimates do not take into consideration future technological advances or possibilities of mining lower-grade ore.

TABLE 1-1 Known World Reserves[iv] of Selected Metals[1]

Mineral	Years of Proven Reserve[2]
Aluminum	222
Copper	37[3]
Iron	145
Lead	42
Mercury	68
Nickel	49
Tin	20
Zinc	21

[1]Estimates are based on current proven reserves in recoverable mining sites, current mining rates, existing technology, and current prices as of 2012. Estimates do not consider recycling, which, in the case of lead, for instance, provides about half of all of the metal consumed.

[2]Years are calculated primarily from U.S. Geologic Survey data on latest world production and estimated reserves.

[3]The actual amount of copper in the earth's crust would last millions of years at current usage rates. Only a very small portion is in deposits that are economically feasible to extract at today's prices.

Recreational Resources

Certainly, as America has become richer, our people have found more time for recreation. We have moved from an agrarian to an industrial to a technological world. These changes place pressures on our time and on our mental capacities. People need to relax, to enjoy life, to enjoy nature.

Popular **recreational resources** in this country include forests, lakes, beaches, mountains, parks, game animals, and fish. As the United States moves further into its third century, we must closely guard the quality of our ecosystem. We are not alone on this planet, and we do not own exclusive rights to live here. Beyond this philosophical reason for carefully managing our environment, we need the relaxing and inspirational values we gain from unspoiled nature. We need clean water in which to swim. We need unlittered trails to hike. We need clean parks in which to picnic and camp.

SUMMARY

Our natural resources can be defined as objects, materials, creatures, or energy found in nature that can be put to use by humankind. Some of these resources are in fairly short supply. Others, such as coal, are plentiful. Some, such as clean drinking water, can be easily spoiled. And some, like oil, can be used only once and then are gone.

The most important characteristic of a natural resource is its usefulness. Those things that are useful to us today may no longer be useful in the future. Things in our past that had no usefulness can be very valuable resources today. Custom and technology greatly affect the usefulness of a natural resource.

The United States is a vast country rich in natural resources. However, many of our important resources are available in only limited quantities. Managing those natural resources for the long-range benefit of our people is the challenge facing all of us.

NOTES

[i]U.S. Department of Energy, (http://www.eia.gov/coal/annual/)
[ii]Central Intelligence Agency World Factbook, https://www.cia.gov/library/publications/the-world-factbook/geos/sa.html
[iii]Central Intelligence Agency World Factbook, https://www.cia.gov/library/publications/the-world-factbook/geos/sa.html
[iv]Central Intelligence Agency World Factbook, https://www.cia.gov/library/publications/the-world-factbook/geos/sa.html

REVIEW QUESTIONS

1. When did the world population reach 1 billion? Six billion?
2. What is the total land area of the United States in acres? Square miles?
3. How much water do Americans use each day?
4. Of that water use, how much is actually "used up"?
5. Wild deer can be a traffic hazard. Are they also considered a natural resource?
6. True or false? The United States has more land in forests today than in the 1600s.
7. True or false? More wood is produced in U.S. forests today than in the 1600s.
8. True or false? The ultimate source of most of the energy we use is the sun.
9. True or false? Estimates of U.S. natural gas reserves have dropped in the past 50 years as we have used up the supply.
10. Are our minerals considered an exhaustible or an inexhaustible resource?

DISCUSSION QUESTIONS

1. Nature's resources once seemed limitless. Explain why this is no longer true.
2. What is a natural resource?
3. How does the usefulness of a natural resource change over time? What factors affect usefulness most?
4. Please explain why so much of the land in the United States is not suitable for farming. Describe how much of the land in the United States is suitable for farming and how much is suitable for crop production.
5. Describe how many species of wild animals, birds, and fish have become extinct in this country since colonial times. Explain what factors most commonly lead to extinction.
6. What was the forested area in this country 300 years ago? What is it today? Explain how it can be that our smaller forest area produces more wood today.
7. Describe some of our key mineral resources and what our known reserves are today.
8. Discuss two very good arguments given in the chapter for carefully maintaining our natural resources for recreation.

SUGGESTED ACTIVITIES

1. Make a list of the natural resources in your community. Include soil resources; water resources; forest resources; fish and wildlife resources; metals, minerals, and energy resources; and outdoor recreation resources. Remember, a natural resource is something that occurs in nature and that is useful to people. Also remember that there are many kinds of usefulness.
2. Prepare a report for discussion in class on any one type of natural resource. Each class member should select a different natural resource to discuss.
3. Do an Internet search to make a list of agencies that manage U.S. natural resources.

CHAPTER 2

A History of Conservation in the United States

OBJECTIVES

After reading this chapter, you should be able to

- contrast exploitation, conservation, and preservation as they relate to natural resources management
- outline the history of conservation in the United States
- describe the role of the federal government in conservation

TERMS TO KNOW

exploitation
conservation
New York Sporting Club
market hunter
migratory waterfowl
"duck" stamp
CCC
NRCS
soil conservation district
ASCS

The history of this country has been one of **exploitation**, or using up, of our natural resources. Our industrial greatness was built upon our forests, water, iron, coal, oil, and other natural resources. Our agricultural greatness was built on our soil and water resources. When people were few and resources were seemingly without limit, there appeared to be no need to conserve. As a result, little thought was given to the future, but that was another time and another century. The future is here.

As we will see in Chapter 3, some natural resources are exploited and some are changed without being used up (developed). When we exploit or develop our natural resources carefully so that they will last as long as possible we are practicing conservation. **Conservation**, as we use the term in this book, refers to the careful use of our natural resources to provide as much usefulness as possible to people both now and in the future. That is often referred to as sustainable use.

In the fields of forestry, fish and wildlife management, soil and water management, energy, and mineral resources management, we have begun to turn the tide. Wise management of our natural resources is beginning to replace shortsighted exploitation. We cannot afford to let our progress in the last third of the twentieth century give us a false sense of security as we move further into the twenty-first century.

The challenges facing us in the future are greater than ever before. With a world population that is now adding a billion people every few decades, we must continue and even accelerate our country's recent progress in natural resources management.

With that in mind, let's look into the past. This chapter briefly discusses the history of the conservation movement in this country. The areas of forest management, soil and water conservation, and wildlife management are examined. We will not look at the energy or mineral areas. Large-scale conservation efforts in those fields have been fairly recent developments.

WILDLIFE MANAGEMENT

The Early Years

Early accounts of America's wildlife discuss it in awed tones. The settlers in the Virginia colony and the Pilgrims further north wrote of deer, hares, and fowl "in incredible numbers." At least one writer estimated the number of passenger pigeons as "millions of millions." There is no reason to doubt that America was one of the world's greatest storehouses of wildlife. Yet, these early settlers probably badly overestimated the true picture in the eastern part of the country. Of course, they had no way of knowing about the vast game herds in the Great Plains at the time.

When the European settlers came, the colonies were covered largely by mature forests. These forests were broken only by streams, marshes, natural meadows, and clearings created by Native Americans, beavers, or lightning-caused fires.

Virgin forests and grasslands could support vast flocks of passenger pigeons. The streams could support millions of beaver. The marshes could support great flocks of waterfowl.

Deer, turkey, quail, rabbits, and many other important game animals need access to clearings in the forests to exist in large numbers. The animals were plentiful along the coasts and streams and around the great marshes, but they could not have been plentiful in the great inland mature forests. The early settlers, by choice, also lived near the coasts and along the streams. Thus, they misperceived the true populations of most important game animals (Figure 2-1).

This mistaken impression may help explain the rapid depletion of early game populations. Hunters could depopulate deer herds along the coast. When they went further inland looking for more deer, they found the hunting to be less successful.

Because deer herds preferred certain types of land, they were easy to find. And because deer were good sources of meat and hides, they were hunted mercilessly. By 1639, regulations on deer hunting were imposed by the town charter of Newport, Rhode Island. Such minor attempts at conservation grew until 1698 when two colonies, Connecticut and Massachusetts, imposed limits on the deer hunt. By then, the deer herds were almost gone in those areas.

In 1844, the **New York Sporting Club** was formed. A few years later, it became the New York State Game Protective Society. This group was made up of a group of men who hunted primarily for sport. It sought to promote restrictions against market hunters. The first state-administered game and fish commission was created in Massachusetts in 1865. Soon, all the states had similar agencies. These early fish and wildlife commissions were instrumental in getting laws passed for the conservation of game species.

Source: USDA, Agricultural Research Service, photo by Scott Bauer

FIGURE 2-1 Whitetail deer like this 8-point buck would have provided meat, hide, and other valuable resources for native Americans or European settlers.

Market Hunters

When there were only about a million Native Americans in what is now the United States, there was no problem in terms of wild game populations. Native Americans hunted for food and hides and took game and fish as they needed them. There was no motivation for wholesale slaughter. When the settlers came, the situation changed. Europeans prized beaver hides and bird feathers. Colonists needed meat from game animals and birds. Native Americans found they could live better, with less uncertainty, by selling furs and meat to colonial traders. The traders saw the opportunity to sell furs back East and in Europe as a source of wealth for themselves. Hunting and trapping fur and meat animals became big business overnight, and many colonists turned from other kinds of work to hunting and trapping to earn a living. People who killed birds and animals to sell their feathers, furs, and meat became known as **market hunters**.

Market hunters found that their quarry could be taken all year long. Passenger pigeons could be killed most easily during nesting season. Migratory waterfowl could be found most easily on their breeding grounds. Such shortsighted slaughter led to the extinction of the passenger pigeon. The same thing almost happened to the buffalo (actually, the American bison) further west. By 1890, only an estimated 500,000 deer remained in North America, and most of those were hidden in dense swamps along the southern coastlines.

Habitat Change

We should be able to agree that such practices were distasteful and shortsighted. In most cases, however, the market hunters caused less actual damage than their critics claimed.

The ox, the plow, herds of livestock, and fire drastically changed the face of America. It is certain that market hunters needlessly damaged our wildlife resources. Passenger pigeons were slaughtered to extinction. Bison were slaughtered first for their hides. Later bison were slaughtered to deprive Native Americans of a traditional source of food and hides. At the same time, it is certain that our clearing of the land for farming changed the wildlife habitat in extreme ways.

FIGURE 2-2 The American bison is often called the buffalo. Market hunters killed so many bison in the 1800s that the "buffalo" almost became extinct in the wild.

Westward expansion and settlement also meant land had to be cleared for homes, town, roads, and railroads. All of these things meant wholesale changes in the habitat available for preexisting wildlife.

The Road Back

After the beginning of the twentieth century, the first federal act dealing with wildlife was passed. The Lacey Act of 1900 made the interstate transportation of game taken against state law a federal crime. This legislation spelled the doom of large-scale market hunting. It also went a long way toward saving a number of fish and wildlife species from destruction (Figure 2-2).

In 1916, the United States and Great Britain signed the Migratory Bird Treaty, and in 1918, the federal Migratory Bird Treaty Act was passed, making the treaty effective. This was the first effective legislation for the protection of **migratory waterfowl**, in this case waterfowl that breed in Canada and fly across the United States each year.

Changing patterns of land use also came to the aid of America's disappearing game animals and birds. In the early 1900s, farm acreages began to decline all across the eastern half of the country. This meant that many pastures and fields were no longer being farmed. On such land, scrub growth and new forests began to spring up, creating an ideal habitat for wildlife. By 1900, there were practically no deer in most of the eastern states. But by the 1920s, deer populations had returned to all those states. This dramatic recovery can be attributed both to federal regulations and to the conversion of farmland back into scrubland and forests.

In 1933, Aldo Leopold, a professor of game management at the University of Wisconsin, published a book titled *Game Management*. This landmark book still forms the basis for much of our work in wildlife management today. In 1934, the Duck Stamp Act was passed, requiring waterfowl hunters to purchase a $1 stamp. The resulting sale of **"duck" stamps** produced $600,000 in its first year. With an increase to $3, duck stamps have since raised up to $6 million a year. The money generated by this act has been used to finance numerous projects to protect and expand North American waterfowl populations.

The United States Fish and Wildlife Service of the Department of Interior was established on June 30, 1940. Today, every state operates its own fish and wildlife agency, although their names vary from state to state. The sale of hunting and fishing permits generates many millions of dollars annually.

Today, partly as a result of better game management laws and enforcement, deer populations in the United States are at their highest in history. That is also true of many other game animals. Wolves and coyotes are reappearing in parts of the United States where they had all but vanished. In fact, they are becoming so plentiful that they are a problem in many parts of the country. Alligators are becoming so abundant that they have become a nuisance in parts of Florida and other southeastern states. You need only drive along the highways of the country to see evidence of this change in the form of animals killed in ever-increasing numbers in traffic accidents.

Without serious argument, all must agree that the large and healthy game animal, bird, and fish populations in the United States today are a result of conservationist efforts. And most of those efforts have been led and funded over the last century by hunters and sports fishers. It is ironic, but nevertheless true, that hunters and sports fishers have made possible much of America's abundance in wildlife.

FOREST MANAGEMENT

Probably the earliest recorded timber shortage occurred in China about 5,000 years ago. The Egyptians experienced a shortage of timber about 4,000 years ago. The Romans had to import wood from their conquered lands before the birth of Christ. By AD 1000, central Europeans were running out of wood, and strict regulations were needed to preserve timber.

In 1626, Plymouth Colony passed America's first ordinance controlling the sale of timber. By 1650, several of the colonies had passed laws against burning of the forests. These attempts, however, were the exception and not the rule in our early history. More often than not, our forests were seen as endless, as a gift from God for us to exploit.

In the late 1700s and early 1800s, the U.S. forest preservation effort centered on saving live oaks for use in building ships. In fact, the efforts were for military purposes and not for forest conservation. With the advent of ironclad ships during the Civil War, that interest ended. Even though a tree species was being protected, forest conservation was not the motive. It had been merely an attempt to prevent the live oaks from being cut for nonmilitary uses.

The forests of the United States produced about a billion board feet of lumber in 1840. That grew to 35 billion board feet in 1869 and 46 billion board feet in 1906. During the period of settlement of this country, land grants were made to individuals and companies. Forests were harvested to pay for other enterprises, or they were simply cleared and burned to make way for farming. Forest use for developing our nation was essential, but such wasteful exploitation was certainly a great tragedy.

The American Forestry Association was organized in 1875 to promote timber culture and forestry. A year later, a forestry agent was appointed to the United States Department of Agriculture (USDA). The forestry office became the Division of Forestry of the USDA in 1881.

A decade later, in 1891, Congress authorized the creation of forest reserves from public-owned land. By 1900, 33 million acres of forest reserves had been set aside in the western states. These areas were controlled under the Department of the Interior.

Gifford Pinchot became head of the USDA's Forestry Division in 1898. Under his leadership, and with President Theodore Roosevelt's backing, the Division of Forestry was upgraded to bureau status and became the United States Forest Service in 1905. Also in 1905, the forest reserves were transferred from the Department of Interior to Pinchot's control in the Forest Service. The reserves were renamed national forests at that time. Pinchot is generally considered one of the leading influences in the development of our system of national forests. Together, Pinchot and Roosevelt greatly expanded the national forest system. The United States Forest Service's national forest system covered 182 million acres in 1983. During the administration of President Ronald Reagan, large parcels of national forestland were sold to private landowners. In 2006 and again in 2007, President George W. Bush proposed selling over 300,000 acres of national forest. Extreme pressure from environmental groups prevented most of the sales.

The Weeks Law of 1911 gave the president authority to purchase forestlands for river watershed protection. This officially linked forestry with soil and water conservation as well as navigable waterway transportation and flood control. Certainly, this connection was far-reaching in its effects. Also under this legislation, forest fire prevention and control measures were authorized.

FIGURE 2-3 A log cabin and split rail fence at the Abraham Lincoln Birthplace National Park near Hodgenville, Kentucky.

World War I brought an expanded federal role in the forestry business. Timber was needed for the war, and many thousands of soldiers were used to harvest, process, and ship it.

Another great impetus to the federal role in forestry came with the Great Depression. Much of the famous Civilian Conservation Corps (CCC) was involved in forestry work. As a result of these involvements during the war and the depression, many people, who would later remain in the field, were trained and gained experience in forestry. In addition, much work of immediate as well as long-range value was done in our national forests under this and other programs (Figure 2-3).

World War II brought another expansion in the need for timber. Following the war, expansion in the housing industry still further increased America's need for wood.

One significant trend in recent years has been the upsurge of private forestry. The giant forest and forest products industry has recognized now that the cut-and-move methods of the past are no longer adequate. Intensive forest management has replaced the wasteful earlier methods. Chapters 19 and 20 deal with this topic in some detail.

Early in our history, Americans cut and burned or cut and used forests with no regard for the future. At the time, that approach seemed to make sense, but it was a wasteful, short-sighted attitude. Today, we waste very little of our forest resources. In general, it is safe to say that today we produce more wood in this country each year than we use. It is also safe to say that our forests produce more wood each year today than when the European settlers arrived in America. Our forests are our greatest renewable resource. Yet, we are not safe for the future. Removal of forestlands for farm, highway, residential, and industrial uses poses a great threat to our forest industry. Careful management is the key to the future in forestry.

SOIL CONSERVATION

In the beginning of this country, the majority of workers were either full- or part-time farmers. Educated and foresighted farmers from earliest colonial times saw the effects of erosion. They watched clean rainfall become muddy runoff. They saw the hillsides become sterile and the valleys become either rich with topsoil washed down from the hillsides or clogged with debris.

Jared Eliot (1685–1763) was one of the first to experiment with and write about soil erosion and drainage in America. He and other early colonists recognized the developing problem. Yet, in general, farmers failed to heed their warnings.

This mentality of farming for today and leaving tomorrow to take care of itself came about for a reason. After all, America was the land of plenty. It stretched to the mountains and beyond. It stretched so far and was so extensive that our ancestors thought of it as without practical limit. Thus, it was easier to clear new land and abandon "worn-out" farms than to take care of the land (Figure 2-4).

In general, the three centuries after the settlement of Jamestown saw this pattern of soil abuse continue. Wherever the land was tillable, it was cleared. The cleared land was used for agricultural production without regard to its productive potential. Hillsides in Georgia and Pennsylvania were row cropped. Grasslands in the southwest were overgrazed.

FIGURE 2-4 Severely eroded farm site in the 1930s.

Scattered attempts at soil conservation were made. Hillside "ditching" campaigns were tried, and individual farmers established good farming practices on their own land. These attempts were the exception, not the rule. Between 1607 and the mid-1800s, first tobacco, then corn, and then cotton were our main farm crops. All of these crops can be very hard on the soil. Since the 1600s, we have lost at least one-third of our precious topsoil to erosion.

In general, early attempts at soil conservation in this country were quite limited. For a long time, soil conservation merely meant the prevention of the most obvious erosion. Soil surveys conducted by the Bureau of Soils of the United States Department of Agriculture began to show the results of erosion by the early 1900s. (Soil surveys will be explained in Chapter 4.)

Dr. Hugh H. Bennett was an early advocate of soil conservation. His work in soil surveys in Virginia, North Carolina, and South Carolina convinced him that something must be done. In 1928, he and W. R. Chapline published the United States Department of Agriculture's (USDA) first soil conservation bulletin, *Soil Erosion—A National Menace.*

As a result of Bennett's efforts, Congress established a series of soil erosion research stations under his supervision. Bennett later concluded that enough soil was being washed away from American fields to load a string of freight trains that would stretch around the earth 18 times at the equator! Congress and the American people were convinced.

In 1933, the Soil Erosion Service (SES) was established in the Department of the Interior. Tied in with the economic recovery from the Great Depression, the SES directed much of its effort toward erosion control. In 1935, the Soil Erosion Service was moved to the Department of Agriculture. In that same year, it became the Soil Conservation Service (SCS). Today, this agency is known as the Natural Resources Conservation Service (**NRCS**).

Experience showed that farmers were more likely to accept conservation practices if they were directly involved in planning and decision making. This gave rise to the concept of the soil conservation association. In 1937, the Secretary of Agriculture mandated that all SCS work on private land be done only through such associations. In that way, the farmers themselves would be responsible for

FIGURE 2-5 A planning meeting of the Hidalgo County, Texas, Soil and Water Conservation District.

group planning and decisions. SCS personnel would serve as advisors and technicians. In 1937, President Franklin D. Roosevelt proposed that the states enact laws to establish **soil conservation districts**. Each district would consist of an association of local farmers, businesspersons, and others interested in the conservation of local soil and water resources (Figure 2-5).

Also in 1936, the federal government instituted a program of grants to farmers. These grants, or incentive payments, were to assist in the cost of soil conservation and soil-building practices—some of which could be very expensive. Construction of terraces, drainage systems, waterways, and farm ponds were very greatly expanded by this effort. Such measures help control erosion by reducing the speed with which water moves across the soil surface during rainstorms. These, along with other programs, now fall under the USDA's Agricultural Stabilization and Conservation Service (**ASCS**). In effect, the NRCS helps the farmer develop a plan for soil and water conservation. The ASCS helps in financing the practices.

As a result of these successes, other federal agencies began to enter the field of soil and water conservation: the Bureau of Indian Affairs, the Department of Defense, the Bureau of Land Reclamation, and the Bureau of Land Management. Americans' involvement in this field led to the establishment of the National Association of Soil and Water Conservation Districts and the Soil Conservation Society of America. Those two organizations are now known as the National Association of Conservation Districts and the Soil and Water Conservation Society of America to reflect their broader missions.

Much has been done since Bennett conducted a soil survey in Louisa County, Virginia, in 1905. Yet, much more remains to be done. Two-thirds of U.S. cropland needs additional soil conservation practices. Three-fourths of our pasture and rangeland is in need of improvements. Over half of our forestland needs better practices. Even on those areas where soil and water management is good, efforts must be continuous.

Nature does not provide us with thousand-acre cornfields or with quarter-acre gardens. Humans must change the natural world to make those benefits happen.

Whenever we change the surface of the land for our own purposes, we must be prepared to deal with undesirable side effects. Soil erosion is one of the main side effects of food and fiber production. Soil Conservation is a continuous process. After all, our soil is our most important nonrenewable resource.

WATER MANAGEMENT

Transportation and Flood Control

In the early years of our country, water was the factor determining where people would live, work, and play. Settlers built homes only where there was adequate water from lakes, rivers, streams, springs, or wells. To a lesser extent, rainwater, captured and stored in cisterns, met some of this need. Cities could be built only where water could be supplied. Water was used also as a means of waste disposal in many areas. When a city built a sewage system, it typically emptied directly into the river or stream. Imagine living downstream from a town that simply dumped its raw sewage into the river!

Early interest in water management in this country came out of the forestry movement rather than as a genuine concern over water itself. Forest conservationists emphasized the benefits of forests in regulating stream flow, preventing silting of waterways, and preventing flooding. In 1882, the Commonwealth of Massachusetts authorized its cities to purchase "municipal forests" to protect their watersheds. The American Association for the Advancement of Science made a general effort to advocate conservation of resources during the 1890s. Among its interests were stream flow, water supplies, and watershed maintenance.

Federal legislation dealing with forest management used water management as part of its justification. Unfortunately, authorities could not agree on the effects forests had on the hydrologic (water) cycle (see Chapter 13) even as late as the 1920s.

In 1879, the Mississippi River Commission was set up to help the states improve the river as a waterway. The Rivers and Harbors Acts of 1917 and 1927 expanded the federal role in establishing and maintaining navigable waterways in this country. A century prior to that, the famous Erie Canal had been completed. This connected the Great Lakes with the Hudson River in 1825.

Thus, early emphasis in this country was not on water conservation as such. It was on water as a channel for transportation and water as a by-product of forestry. By the late 1920s, the federal government began to assume some responsibility for flood control. The second major concern in water management arose—prevention of flooding.

It became clear that flooding was a function of two other problems. Loss of good forest cover led to greater runoff and thus more flooding. Soil erosion led to clogging of waterways and silt deposits on streets, residences, and highways. It also caused the filling in of lakes, rivers, and streams. This, in turn, led to more flooding. Thus, the main emphasis on water management still came from foresters and soil conservationists.

The Flood Control Act of 1936 authorized the SCS to develop and implement plans for upstream soil and water conservation in order to reduce sedimentation and flooding. This and following work led to the 1954 Watershed Protection1 and Flood Prevention Act, which transferred responsibility of decision making to state and local organizations. In general, most watershed management projects today are handled through the local soil and water conservation districts described earlier in this chapter.

The deadliest flooding event in U.S. history took place in the Galveston, Texas, area in 1900. In that disaster, over 8,000 people were killed according

Source: National Oceanic and Atmospheric Administration/Department of Commerce

FIGURE 2-6 The deadliest storm in American history struck Galveston, Texas, in 1900.

to federal estimates. That flooding came as a result of a hurricane (Figure 2-6). Throughout the 1990s and 2000s, a number of record-setting weather events have resulted in increased emphasis on the need for flood-control efforts in this country and worldwide. Massive rains in the Midwest in 1993 resulted in the most severe flooding in at least a century in the Mississippi Valley. Entire towns simply ceased to exist as a result of that flooding episode. Major floods occurred in 2010 in Tennessee, Southern New England, Minnesota, Wisconsin, and the Mississippi River. In September 2011, tropical storm Lee produced major flooding in the Northeast.

In late 1999, a series of hurricanes followed one after the other in eastern North Carolina and Virginia. The heavy rains caused the ground to become saturated. Then in September, yet another hurricane, Floyd, came ashore along the Eastern Seaboard, dumping as much as 2 feet of rain in a single day in some places. The floods resulting from Hurricane Floyd were the worst in the history of that part of the country. Then, in the early 2000s, even more destructive hurricanes repeatedly struck the states along the Gulf Coast. Hurricane Katrina was the most destructive storm in U.S. history in terms of costs, resulting in a large number of deaths. Initial estimated deaths resulting from Katrina were up to 20,000. Fortunately, that number turned out to be an overestimate. As of October, 2005, the National Oceanic and Atmospheric Administration estimated 1,833 deaths (Figure 2-7) from Katrina—far fewer than initial estimates but still a great tragedy.

Subsequently, in October, 2012, the second costliest storm in U.S. history, commonly known as Superstorm Sandy, passed over Jamaica, and then Cuba, before making landfall in New Jersey on October 29 (Figure 2-8). Before it was over, Sandy had destroyed at least 650,000 homes and 250,500 insured vehicles, damaged over 300,000 businesses, and killed 159 people, according to the National Oceanic and Atmospheric Administration (NOAA).

Over the last 50 years, the emphasis on water management has greatly broadened. Prior to 1930, our efforts focused on water transportation and flood prevention. With expanding population, industry, and irrigation farming,

Source: Federal Emergency Management Administration/Photograph by Jocelyn Augustino

FIGURE 2-7 New Orleans, Louisiana. August 30, 2005: Air-to-air photograph of an army rescue helicopter searching for victims in New Orleans. The city is being evacuated as a result of floods from Hurricane Katrina.

the quantity of water used by Americans has grown drastically. Significantly, with a growing concern for the quality of life in this country, Americans have demanded cleaner water. Advances in our understanding of the human body and of medicine have shown the importance of cleaner water supplies. As a result, wastewater that once was dumped directly into rivers is now treated and disinfected before reintroduction into the water cycle. Federal legislation in the 1960s and 1970s emphasized these health concerns.

Another problem that is becoming critical is the distribution of our water supply. Lowered water tables in the western states have resulted largely from deep-well irrigation. This is a problem that must be addressed immediately.

SUMMARY

What appeared to be limitless bounty in this country resulted in open exploitation of our natural resources that produced damage and waste and led to other problems. Recognition of problems sparked concern for the future. That, in turn, encouraged study, research, planning, and action. The result has been the conservation movement in this country.

The original theme of conservation was to prevent damage. Today, the natural resources management efforts in this country look not only to the wise use of our resources but also to the goal of redressing the damage our thoughtless exploitations of the past have caused. The concept of sustainability has come to the center of our national awareness. Sustainability will be discussed in some detail in Chapter 3.

Our quality of life is improving today as a result of the conservation movement. We should never forget the contributions of great American conservationists like Gifford Pinchot, Aldo Leopold, and Hugh Bennett. They, and thousands like them, have guided us in the right direction; but their work—indeed, all of our past efforts—is not adequate for the future. Our nation and our world must write an even greater history of conservation as we embark upon the twenty-first century.

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FIGURE 2-8 The Casino Pier Star Jet roller coaster washed out into the Atlantic off Seaside Heights, New Jersey, during Super Storm Sandy. Photo was taken January 13, 2013, 75 days after the storm.

REVIEW QUESTIONS

1. True or false? Early colonists seemed to believe that the supply of wild game in this country was nearly limitless.
2. The first state commission for the management of wild game was established when and in what state?
3. What term was used to describe people who hunted animals and birds to sell the meat, furs, and feathers?
4. Water fowl that migrate between the United States and Canada were first protected by what treaty? When was it established?
5. Aldo Leopold wrote perhaps the most important book on wildlife ever written. The book is still available today, both in print and electronic forms. What is the title, and when was it first published?
6. The earliest recorded timber shortage was in what country, and when did it occur?
7. Who is credited with being the early leader in the establishment of the U.S. system of national forests?
8. What president is credited with establishing the U.S. Forest Service?
9. The Soil Erosion Service was originally established in what U.S. department, and when did that happen?
10. What is the former Soil Erosion Service known as today? In what department is it located?

DISCUSSION QUESTIONS

1. Explain why Americans have such wasteful practices in using our natural resources in the past.
2. In what ways were they right? How were they wrong?
3. Define market hunters and explain why were they so unpopular among American sports fishers and hunters.
4. If sports hunters and fishers had not fought market hunters, what would have happened to our fish and game animal populations?
5. Who pays for most wildlife conservation in this country?
6. Describe the Weeks Law of 1911, and explain why it is important.
7. Define and explain how a soil and water conservation district works.
8. Explain how the federal government has helped local farmers and other landowners work to solve their soil and water conservation problems.
9. Explain why soil and water conservation is a federal concern.
10. Early water management efforts in America centered on three needs. Describe these three needs.

SUGGESTED ACTIVITIES

1. If you live in a suburban or rural area, interview several persons who have lived in your community for at least 60 years. How have the hunting and fishing changed over the last 50 years? Are there more or fewer forested areas? What have been the worst floods? Have they seen any severe erosion or sedimentation problems develop?
2. If you live in a large city, interview a relative or friend who is at least 60 years old and who was raised in a rural area. Ask him or her the same questions about the area where he or she grew up.
3. Try to find some old (pre-1920) books or articles on conservation in your library or on the Internet and read them. Try to determine how our perspectives on conservation have changed. Have the goals of conservationists changed?
4. Find and view videos on the Internet dealing with some topic discussed in this chapter. Use them to lead to a class discussion on how conservation efforts in the US have changed in the past 250 years.

CHAPTER

3

Concepts in Natural Resources Management

OBJECTIVES

After reading this chapter, you should be able to

- explain the differences between nonexhaustible, renewable, and exhaustible natural resources
- discuss the concept of balance in natural ecosystems
- describe the role of food chains in maintaining balanced ecosystems
- discuss the role of ecology in human efforts at natural resources management

TERMS TO KNOW

environment
nonexhaustible
renewable
exhaustible
ecology
ecosystem
environmentalist
amoral
producer
consumer (primary, secondary, and tertiary)
decomposer
biome
biogeography
food chain
food web
apex predator
population level
invasive species
carrying capacity
preservation
multiple use
sustainability

People have always lived in an **environment**. Our environment consists of everything around us: soil, water, plants, animals, energy, minerals, atmosphere, sunlight, and more. Our environment has provided everything for our survival. If any part of our requirements had not been met, then humans would not exist. At one time, our natural resources could be used without regard for the future. There were fewer people, and our technology did not allow for rapid and massive use of natural resources. Trees were cut by stone axes, then later by metal saws and axes, and coal was harvested by hand. Those days are gone now.

People still live in a finite environment, but now we have the ability to use our resources on unbelievably large scales. We can take water from an aquifer hundreds or even thousands of feet underground, and with the aid of modern technology we can quickly level mountains, change the flow of rivers, and take energy from the atom. All of that sounds impressive but, taken together, our advancing technology and our growing population present a problem. We find that we must, in the future, live in the same environment—our "spaceship earth." And it is not getting appreciably larger. We know now that many of nature's resources are not going to last forever.

Wise use of our natural resources is not a new idea; but today, more than ever, it must become a common goal. Managing our natural resources for the future as well as the present must become a priority for all of us. This chapter explains a number of important ideas in natural resources conservation and management.

THE NATURE OF RESOURCES

In a very real sense, everything in our environment could be considered a natural resource. Rocks can be used as gravel for our roads, facings for our buildings, or material for our statues. Wind, falling water, still air, resting water, minerals, insects—virtually everything around us can be considered a potential resource. When someone takes an object and uses it to perform work or change other parts of the environment, that object has become a resource. Even before its use, the potential for use makes the object a natural resource.

Those things that have become, or show promise of becoming, important to us are the natural resources we are concerned about in this book. Those natural resources may take many forms. More importantly, some resources are capable of going on forever. On the other hand, others are very limited. They may be usable over and over, or they may be gone forever with a single use. Let's look at both of these categories a little closer.

Nonexhaustible Resources

Natural resources that can last forever regardless of human activities are **nonexhaustible**. They renew themselves continuously. This does not mean that such resources are not limited—they very well might be available in limited quantities at any given time. It also does not mean that human misuse cannot damage such resources—it certainly can.

A good example of a nonexhaustible resource is surface water. If you take a gallon of water from a river, another gallon will replace it from rain. If you dam a stream, the water will simply go elsewhere. If we damage a watershed so that its rainfall does not soak into the ground, the rainfall will simply go elsewhere.

FIGURE 3-1 Taughannock Falls (pronounced tuh-GAN-uck) is located near Ithaca, New York. At 215 feet, Taughannock is taller than Niagara Falls and the tallest free-falling waterfall in the northeastern United States.

Little that we do will affect the total amount of water that comes to earth in the form of precipitation.

On the other hand, water supplies may be very limited in certain locations. Chapter 13 deals with our water supply and its users. At the beginning of that chapter the hydrologic cycle is explained. It is because of this cycle that water is a nonexhaustible resource. Chapter 14 points out the problems we face in damaging our water supply by pollution. Nevertheless, our water supply is nonexhaustible, for all practical purposes (Figure 3-1).

Another example of a nonexhaustible resource is air. We use air to breathe, to grow plants, to fly airplanes, to power windmills, and to dry food and clothes. We can damage the air with pollution. We could even make it unusable, as many environmentalists would argue, but we cannot "use it up," given our current technology. It is nonexhaustible, for all practical purposes.

Renewable Resources

Natural resources that reproduce themselves or that can be reproduced by human efforts are considered **renewable**. Simply because a resource is renewable does not mean it will never be used up. On the other hand, it is possible to use such resources and yet have as much left afterward as before that use.

Consider forests. (Chapter 19 discusses forests and forest products.) We use more wood today than ever before, and still we produce more wood each year than we use in this country. The types of wood have changed; we no longer harvest as many large hardwoods as we once did. Yet we have no foreseeable shortage of wood or wood products in the United States. This is true because of the advances made in forestry, both in woodland management and in genetics. And it is true because trees are a renewable natural resource.

Another example of renewable resources is our fish and wildlife population. In our nation's past, there have been times of great waste. Like all wildlife, passenger pigeons were renewable—but they were exhaustible. Millions of passenger pigeons were killed, and the popular food bird became extinct. Great herds of

FIGURE 3-2 A commercial fishing boat hauls in a net brimming with fish destined for U.S. tables.

bison, or buffalo, were killed for their hides and meat, and this great American natural resource neared extinction. Yet, with techniques of game management such as those discussed in Chapter 25, their numbers rebounded. Fish populations, too, respond readily to fishery management techniques (Figure 3-2). For more on this topic, see Chapters 26 and 27. At the same time, mismanagement and over fishing can easily lead to population collapses or even extinction of some species.

Exhaustible Resources

Many of our natural resources exist in fixed quantities. Those limited resources that cannot be replaced or reproduced are known as nonrenewable or **exhaustible**. We cannot manage exhaustible resources for renewal. They do not renew themselves, and we cannot renew them. Once they are gone, they are gone forever. We can conserve our exhaustible resources. We can learn how to use less. We may try to find more of the resources. We may even be able to recycle some of them. But once a given resource is gone, we simply have to do without it or find a replacement.

Even though an exhaustible resource exists in a finite (limited) supply, that does not mean it is necessarily a limited resource. Many exhaustible resources exist in such huge amounts that for all practical purposes, they are nonexhaustible. For instance, there is so much coal on the planet that, although it is exhaustible, there is no practical limit to coal. There is so much iron ore that, although iron is an exhaustible resource, there is no practical limit to the metal.

One vital exhaustible resource is the crude oil that is used to produce petroleum products. We constantly hear of the "energy crisis." There is only so much oil in the ground, and when we have removed all we can find, it is gone. We will just have to develop other sources of energy. As you will see in Chapter 32, we can use newer technologies to find more oil. We can find new ways to extract limited resources so the effective amount available for use can be greatly increased. Nevertheless, even with improved technologies, like hydraulic fracturing (fracking), limited resources such as oil and gas will eventually run out if we continue to use them without limit. Fracking involves the injection of liquid under high pressure into rock layers deep underground to aid in the extraction of oil and gas. For a more detailed discussion of fracking, see Chapter 32.

Another example is our mineral resources. We use lead, cobalt, zinc, and other minerals to make our goods. We depend on these mineral resources for our way of life. We must manage those resources to make them last as long as possible.

Soil can also fit into this category. Chapter 4 explains that soil is constantly being formed by nature. We can improve existing soil, make it more fertile, move water to it, and supply missing minerals. We can even make soil substitutes in small quantities, but we cannot really make soil in any practical sense. Only nature does that. Why, then, is soil not a nonexhaustible resource? It is exhaustible because nature makes soil so slowly. True, a soil destroyed by improper use will probably be replaced—in 500,000 years. As far as we are concerned, that is not renewal in a sense that is useful to us. Thus, soil is a nonrenewable or exhaustible resource.

AN ECOLOGICAL OUTLOOK

Humans, trees, water, animals, fish, grasses, sunlight—all these and more fit into an overall environment. This system, with all its interactions and interdependencies, is our ecosystem.

Ecology is the branch of science dealing with the complex relationships among living things and their environment. An ecological system, or **ecosystem**, is any partially self-contained environmental and living system. A lake might be thought of as an ecosystem. A forest, a large valley, or a desert might be considered an ecosystem.

In a very real sense, we exist in an ecosystem. We depend on our environment for life itself. For many thousands of years, that was no problem, but today, our numbers are increasing. Our technology is becoming tremendously powerful. In ancient times, our use of natural resources had little effect on our ecosystem, but in the past few centuries, we have had an ever-increasing impact on that ecosystem.

Perceptions in Ecology

It is important to note that ecology is a science. It can be defined as the study of the interactions of organisms and their environment. Environmentalism, which is simply a strong concern for the environment, is not the same thing at all. Environmentalism is based on emotion, values, beliefs, and politics. An **environmentalist** is a political activist with a special interest in some aspect of the environment. Environmentalists concern themselves with right and wrong as they perceive it; with good and bad, again as they perceive it; and with morality, as they perceive it.

As a science, ecology is based on observation and objective interpretation of data. An ecologist is a scientist. In their role as scientists, ecologists do not attempt to make decisions based on moral interpretations (value judgments). We say that science is **amoral**, meaning outside the scope of morality. When we use this word, we are simply communicating the idea that value judgments about what is good and what is bad should not be a part of science. Scientists are interested in learning how things work, not in deciding what is good or bad (moral or immoral) from a human perspective (Figure 3-3).

To illustrate the distinction, consider this situation: A person in a fishing boat catches a large shark just off a beach used by swimmers. Should he or she release the shark because the fish has a right to live? Should the person kill the shark out of concern for the human swimmers? That sort of judgment is one of values. It is a moral question, not a question for science. An ecologist (while acting as a scientist) would simply look at the shark as a large predator and an important part of the food web. To the ecologist, the question of killing the shark or releasing it should focus on the shark's place in the ecosystem. The role of science in this situation would be amoral. The scientist would be interested in the facts of the situation rather than in making value judgments about right and wrong or about good and bad.

This does not mean a scientist cannot also be an environmentalist. When a scientist stops doing science and starts advocating environmentalist positions on political issues, he or she is not talking as a scientist but as an environmentalist, although perhaps as a very well-informed environmentalist.

Source: National Oceanic and Atmospheric Administration/Photographer G. De Metrio

FIGURE 3-3 Scientist displaying a pop-off electronic tag. This tag is inserted into the body of a fish. It releases at a preset time, floats to the surface, and transmits a signal to an ARGOS satellite. The devices are used to radio-track large pelagic fish species, such as tuna.

The Science of Ecosystems

An ecosystem is a given set of organisms, organic residues, physical and chemical components, and conditions (i.e., light, temperature, etc.) that interact and transform energy and matter in form and location (Figure 3-4). Ecosystems consist of biotic (living) subsystems as well as abiotic (nonliving) subsystems. An example of a biotic subsystem is the relationships among the plants and animals that live in a particular location. An example of an abiotic system is the water of a lake and the chemicals that dissolve from the atmosphere and land that affect the water's acidity level (Figure 3-4).

FIGURE 3-4 Removing the debris from the spillway of this water impoundment will drastically affect the ecosystem.

In its most basic sense, an ecosystem is an energy system. Every part of an ecosystem interacts with the other parts of the system and depends on them. Fish in a lake use oxygen from the atmosphere that is dissolved in the water. The plants in the lake use light from the sun and minerals from the lake water and the land below the lake to grow. All the processes in an ecosystem depend on energy. In fact, we can say accurately that nothing happens in an ecosystem without the flow of energy.

To have a complete ecosystem, there must be three kinds of organisms present. There must be **producers**, usually green plants that produce new food (sugar) by means of photosynthesis. There must be **consumers** that can take that primary source of food, incorporate other chemicals and energy forms, and change it into more complex organic compounds, foods, and tissue. Finally, there must be **decomposers** that break the organic materials back down into their constituents for reuse in the ecosystem. One organism can be a member of more than one of the components. For instance, a green plant can be both producer and consumer. A fungus can be both consumer and decomposer, as are animals. We will see how these relate to each other in the section on food webs later in this chapter.

An ecosystem can be defined in many different ways. In one sense, a terrarium in your classroom is an ecosystem. In another sense, your classroom makes up an ecosystem, and the terrarium is simply a part of that ecosystem. In yet another sense, your school campus is part of an ecosystem that could be defined in geographic terms.

That brings us to what could be called the "Ultimate Concept in Ecology." Everything on earth is part of one or more ecosystems. In each system, if you do something to one part, it affects some or all the other parts of the system. The effects are often unpredictable and may be very extreme.

Ecological Succession

At any given time in a particular ecosystem, there is probably a wide variety of living things. No ecosystem is ever completely and permanently stable. For that reason, there is no real "balance of nature." All ecosystems are dynamic, that is, constantly changing. One species of plant or animal is replaced by another as conditions change and as the ecosystem matures. The replacement of one species by another in a maturing ecosystem is ecological succession (Figure 3-5).

Perhaps an example would make this clear. Consider a pond that has been constructed by a landowner living in a region characterized by forests. Initially, algae will be the only plant in that pond. Later, water lilies and cattails will appear. After many years, the pond will fill up with sediment and become dry land again. Then the algae and water plants will be replaced by grasses and small shrubs. After a few more years, cedars and small trees will dominate the area. Later still, those will be replaced by taller trees until; eventually, the area will become forested, perhaps with tall hardwood trees.

The term *climax species* implies eventual stability in ecosystems. If an ecosystem were to become completely stable, as in the example just given, the species of plants that would dominate the system would be known as the climax species. Of course, as we have seen, there is no permanent climax species because no ecosystem is ever truly stable forever. In the example of the pond that fills in and becomes a hardwood forest, there will someday be a fire, a disease, a logger, an ice age, or something else that changes the conditions of the ecosystem, and the whole process will start over.

An important concept in ecology is that of the **biome**. A biome can be thought of as the biotic subsystem (living organisms) in an extensive ecosystem. When we speak of biomes, we describe them in terms of their geography and of their climax vegetation (Climax vegetation refers to the species of plants that eventually becomes dominant in a given location if there are no major disturbances). The major biomes are the Arctic, the Antarctic, tundra, deserts, coniferous forests, deciduous forests, grasslands, the freshwater biome, and the marine biome. The study of the distribution and residents of the world's biomes is called **biogeography**.

Source: US National Park Service

FIGURE 3-5 This is a mature forest in the the Flint Ridge section of California's Coastal Train. The ecosystem is relatively stable, i.e. "balanced" for now. Disease or fire could change that at any time.

Balance of Nature

We have all read or heard about the balance of nature, but is nature really balanced? If nature were perfectly balanced, there would be little change. As a gallon of water flowed to the ocean, another gallon would evaporate and enter the hydrologic cycle. As one rabbit died, another would be born. Rivers would not change their courses. Ice ages would never occur. Clearly these situations are not the case.

The forces of nature are constantly counteracting each other. The result is a constant change of nature. Change is different from balance because balance implies no change. The reality is that change in the environment is both continuous and natural. What is important is that the changes in nature be gradual to allow time for organisms such as humans to adapt to the changes. Gradual change is what we are really talking about when we refer to a balance of nature. Please hold that idea in mind whenever the term *balance of nature* is used in this book (Figure 3-6).

Source: US Fish and Wildlife Service

FIGURE 3-6 This prescribed burn in the Bayou Sauvage National Wildlife Refuge in Louisiana is changing the ecosystem drastically. If the ecosystem is left alone for a natural succession, grasses will return first, then shrubs, then eventually trees.