CHAPTER 12

Landscapes: Forests, Parks, and Wilderness

A long line of trucks in Malaysia carrying logs from tropical rain forests. As land ownership changes in the United States, American corporations have purchased more and more forestland in less-developed parts of the world.

LEARNING OBJECTIVES

Forests and parks are among our most valued resources. Their conservation and management require that we understand landscapes—a larger view that includes populations, species, and groups of ecosystems connected together. After reading this chapter, you should understand . . .

- What ecological services are provided by landscapes of various kinds;
- The basic principles of forest management, including its historical context;
- The basic conflicts over forest ownership.
- The basic principles of park management;
- The roles that parks and nature preserves play in the conservation of wilderness.

CASE STUDY

Jamaica Bay National Wildlife Refuge: Nature and the Big City

The largest bird sanctuary in the northeastern United States is—surprise!—in New York City. It is the Jamaica Bay Wildlife Refuge, covering more than 9,000 acres—14 square miles of land, 20,000 acres in total, within view of Manhattan's Empire State Building (see Figure 12.1). Jamaica Bay is run by the National Park Service, and you can get there by city bus or subway.[1] More than 300 bird species have been seen there, including the glossy ibis, common farther south, and the curlew sandpiper, which breeds in northern Siberia. Clearly, this wildlife refuge, like the city itself, is a major transportation crossroads. In fact, it is one of the major stopovers on the Atlantic bird migration flyway.

We are not as likely to think of viewing nature near a big city as we are to think of taking a trip far away to wilderness, but as more and more of us become urban dwellers, parks and preserves within easy reach of cities are going to become more important. Also, cities like New York usually lie at important crossroads, not just for people but for wildlife, as illustrated by Jamaica Bay's many avian visitors.

In the 19th century, this bay was a rich source of shellfish, but these were fished out and their habitats destroyed by urban development of many kinds. And like so many other natural areas, parks, and preserves, Jamaica Bay Wildlife Refuge has troubles. The estuary that it is part of is today only half the size it was in colonial times, and the refuge's salt marshes are disappearing at a rate that alarms conservationists. Some of the wetlands have been filled, some shorelines bulkheaded to protect developments, and channels dredged. A lot of marshland disappeared with the building of Kennedy International Airport, just a few miles away. The salt marshes and brackish waters of the bay are also damaged by a large

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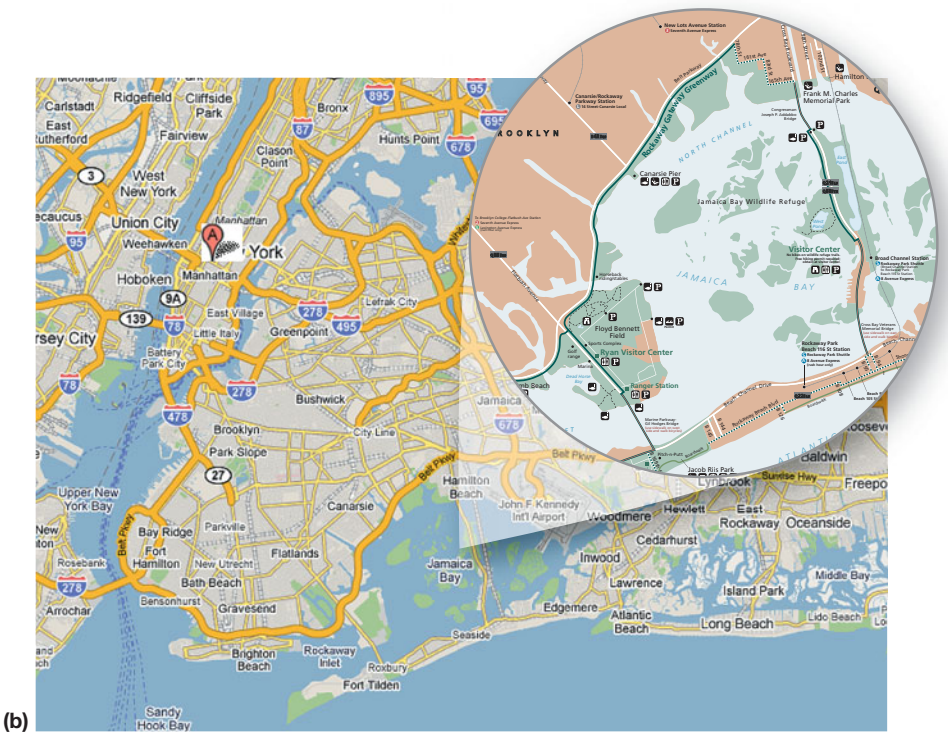


FIGURE 12.1 Jamaica Bay Wildlife Refuge, New York City. **(a)** The largest wildlife refuge in the northeastern United States is within view of New York City's Empire State Building. It's a surprisingly good place for birdwatching, since it is used by 325 species of birds. **(b) This map of the Jamaica Bay Wildlife Refuge shows how near the refuge is to Manhattan Island.**

flow of freshwater from treated sewage. Contrary to what you may think, the only difficulty with this water is that it is fresh, which is a problem to the bay's ecosystems.

Help may be on the way. A watershed protection plan has been written, and there is growing interest in this amazing refuge. The good news is that plentiful wildlife viewing is within a commuter's trip for more than 10 million people. Still, natural areas like the wetlands and bay near New York City and the forests and prairies throughout North America present a conflict. On the one hand, they have been valued for the profits to be made from developing the land for other uses. On the other hand, people value and want to preserve the wildlife and vegetation, the natural ecosystems, for all the reasons discussed in Chapter 7 on biological diversity.

In the 17th century, when the first Europeans arrived in what is now New York City and Long Island, they found a landscape already occupied by the Lenape Indians, who farmed, hunted, fished, and made trails that ran from Manhattan to Jamaica Bay.[2] Much of the land, especially land extending north along the Hudson River, was forested, and the forests, too, were occupied and used for their resources by the Lenape and other Indians. The dual uses of landscapes were already established: They were both harvested for many resources and appreciated for their beauty and variety.

Although since then the entire landscape has been heavily altered, those dual uses of the land are still with us and give rise to conflicts about which should dominate.

In this chapter we look at various kinds of landscapes: parks, nature preserves, and especially forests, a major kind of landscape that is harvested for commercial products but is also considered important for biological conservation. Which use to emphasize—harvest, or preservation and aesthetic appreciation—underlies all the environmental issues about landscapes. We will talk about these kinds of natural resources and how to conserve and manage them while benefiting from them in many ways.

12.1 Forests and Forestry

How People Have Viewed Forests

Forests have always been important to people; indeed, forests and civilization have always been closely linked. Since the earliest civilizations—in fact, since some of the earliest human cultures—wood has been one of the major building materials and the most readily available and widely

used fuel. Forests provided materials for the first boats and the first wagons. Even today, nearly half the people in the world depend on wood for cooking, and in many developing nations wood remains the primary heating fuel.[3]

At the same time, people have appreciated forests for spiritual and aesthetic reasons. There is a long history of sacred forest groves. When Julius Caesar was trying to conquer the Gauls in what is now southern France, he found the enemy difficult to defeat on the battlefield, so he burned the society's sacred groves to demoralize them—an early example of psychological warfare. In the Pacific Northwest, the great forests of Douglas fir provided the Indians with many practical necessities of life, from housing to boats, but they were also important to them spiritually.

Today, forests continue to benefit people and the environment indirectly through what we call *public-service functions*. Forests retard erosion and moderate the availability of water, improving the water supply from major watersheds to cities. Forests are habitats for endangered species and other wildlife. They are important for recreation, including hiking, hunting, and bird and wildlife viewing. At regional and global levels, forests may also be significant factors affecting the climate.

Forestry

Forestry has a long history as a profession. The professional growing of trees is called **silviculture** (from *silvus*, Latin for "forest," and *cultura*, for "cultivate"). People have long practiced silviculture, much as they have grown crops, but forestry developed into a science-based activity and into what we today consider a profession in the late 19th and early 20th centuries. The first modern U.S. professional forestry school was established at Yale University around the turn of the 20th century, spurred by growing concerns about the depletion of America's living resources. In the early days of the 20th century, the goal of silviculture was generally to maximize the yield in the harvest of a single resource. The ecosystem was a minor concern, as were nontarget, noncommercial species and associated wildlife.

In this chapter, we approach forestry as professionals who make careful use of science and whose goals are the conservation and preservation of forests and the sustainability of timber harvest and of forest ecosystems. Unfortunately, these goals sometimes conflict with the goals of others.

Modern Conflicts over Forestland and Forest Resources

What is the primary purpose of national forests? A national source of timber? The conservation of living resources? Recreation?

Who should own and manage our forests and their resources? The people? Corporations? Government agencies?

In the past decade a revolution has taken place as to who owns America's forests, and this has major implications for how, and how well, our forests will be managed, conserved, sustained, and used in the future. The state of Maine illustrates the change. About 80% of forestland owned by industrial forest companies was sold in that state between 1994 and 2000. Most of it (60%) was purchased by timber investment management organizations (TIMOs). The rest was sold to nongovernment entities, primarily conservation and environmental organizations.

Industrial forest companies, such as International Paper and Weyerhaeuser, owned the forestland, harvested the timber and planned how to do it, and made products from it. They employed professional foresters, and the assumption within the forest industry was that the profession of forestry and the science on which it was based played an important role in improving harvests and maintaining the land. Although timber companies' practices were often heavily criticized by environmental groups, both sides shared a belief in sound management of forests, and in the 1980s and 1990s the two sides made many attempts to work together to improve forest ecosystem sustainability.

In contrast, TIMOs are primarily financial investors who view forestland as an opportunity to profit by buying and selling timber. It is unclear how much sound forestry will be practiced on TIMO-owned land, but there is less emphasis on professional forestry and forest science,[4] and far fewer professional foresters have been employed. The danger is that forestland viewed only as a commercial commodity will be harvested and abandoned once the resource is used. If this happens, it will be the exact opposite of what most people involved in forestry, both in the industry and in conservation groups, hoped for and thought was possible throughout the 20th century.

Meanwhile, funding for forest research by the U.S. Forest Service has also been reduced. Our national forests, part of our national heritage, may also be less well managed and therefore less well conserved in the future.

How could this have come about? It is an ironic result of political and ideological activities. Ultimately, the conflict between industrial forestry and environmental conservation seems to have led timberland owners to decide it was less bothersome and less costly to just sell off forestland, buy wood from whomever owned it, and let them deal with the consequences of land use. Consistent with this rationale, much forest ownership by organizations in the United States has moved offshore, to places with fewer environmental constraints and fewer and less powerful environmental groups. This change should be all the more worrisome to those interested in environmental conservation because it has happened without much publicity and

FIGURE 12.2 The dual human uses of forests. This temperate rain forest on Vancouver Island illustrates the beauty of forests. Its tree species are also among those most desired for commercial timber production.

is relatively little known by the general public except where forestry is a major livelihood, as it is in the state of Maine.

In sum, then, modern conflicts about forests center on the following questions:

- Should a forest be used only as a resource to provide materials for people and civilization, or should a forest be used only to conserve natural ecosystems and biological diversity (see Figure 12.2), including specific endangered species?
- Can a forest serve some of both of these functions at the same time and in the same place?
- Can a forest be managed sustainably for either use? If so, how?
- What role do forests play in our global environment, such as climate?
- When are forests habitats for specific endangered species?
- When and where do we need to conserve forests for our water supply?

World Forest Area and Global Production and Consumption of Forest Resources

At the beginning of the 21st century, approximately 26% of Earth's surface was forested—about 3.8 billion hectares (15 million square miles) (Figure 12.3).[5] This works out to about 0.6 hectares (about 1 acre) per person. The forest area is up from 3.45 billion hectares (13.1 million square

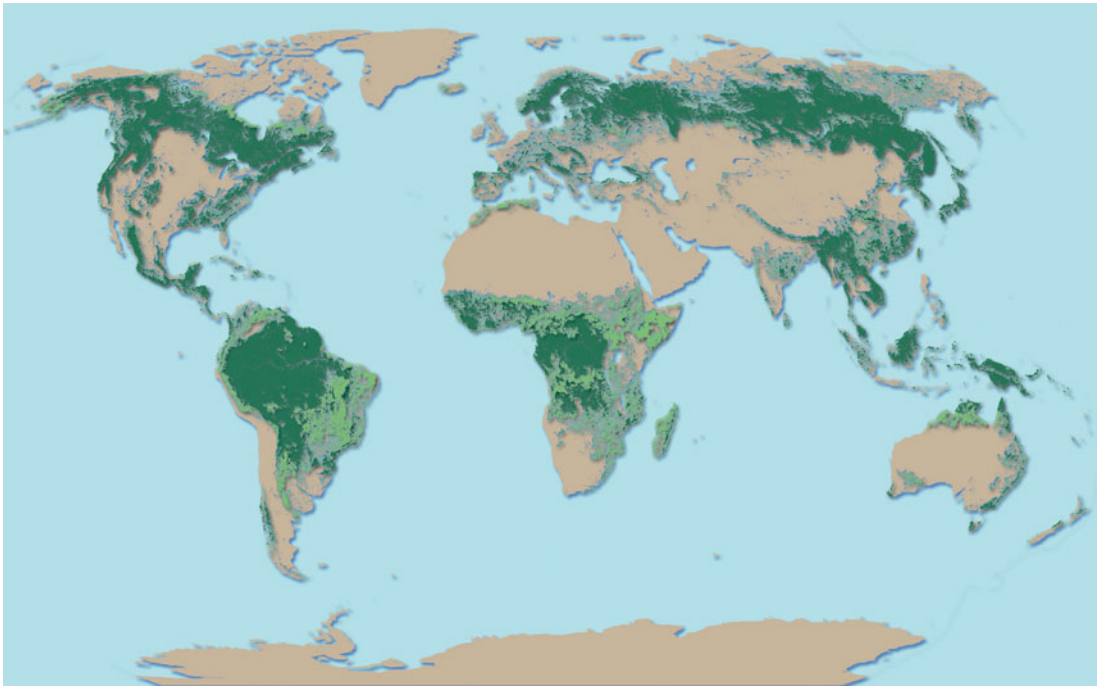


FIGURE 12.3 Forests of the world. (*Source:* Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, 00153 Rome, Italy.)

miles, or 23% of the land area) estimated in 1990, but down from 4 billion hectares (15.2 million square miles, or 27%) in 1980.

Countries differ greatly in their forest resources, depending on the suitability of their land and climate for tree growth and on their history of land use and deforestation. Ten nations have two-thirds of the world's forests. In descending order, these are the Russian Federation, Brazil, Canada, the United States, China, Australia, the Democratic Republic of the Congo, Indonesia, Angola, and Peru (Figure 12.4).

Developed countries account for 70% of the world's total production and consumption of industrial wood products; developing countries produce and consume about 90% of wood used as firewood. Timber for construction, pulp, and paper makes up approximately 90% of the world timber trade; the rest consists of hardwoods used for furniture, such as teak, mahogany, oak, and maple. North America is the world's dominant supplier. Total global production/consumption is about 1.5 billion m^3 annually. To think of this in terms easier to relate to, a cubic meter of timber is a block of wood 1 meter thick on each side. A billion cubic meters would be a block of wood 1 meter (39 inches) thick in a square 1,000 km (621 miles) long on each side. This is a distance greater than that between Washington, DC, and Atlanta, Georgia, and longer than the distance between San Diego and Sacramento, California. The great pyramid of Giza, Egypt, has a volume of more than 2.5 million cubic meters, so the amount of timber consumed in a year would fill 600 great pyramids of Egypt.

The United States has approximately 304 million hectares (751 million acres) of forests, of which 86 million hectares (212 million acres) are considered commercial-grade forest, defined as forest capable of producing at least 1.4 m^3/ha (20 ft^3/acre) of wood per year.[6] Commercial timberland occurs in many parts of the United States. Nearly 75% is in the eastern half of the country (about equally divided between the North and South); the rest is in the West (Oregon, Washington, California, Montana, Idaho, Colorado, and other Rocky Mountain states) and in Alaska.

In the United States, 56% of forestland is privately owned, 33% is federal land, 9% is state land, and 3% is on county and town land.[7] Publicly owned forests are primarily in the Rocky Mountain and Pacific Coast states on sites of poor quality and high elevation (Figure 12.5).[8] In contrast, worldwide most forestland (84%) is said to be publicly owned, although information is spotty.[9]

In the last several decades, world trade in timber does not appear to have grown much, if at all, based on the information reported by nations to the United Nations Food and Agriculture Organization. Thus, the amount traded annually (about 1.5 billion m^3, as mentioned earlier) is a reasonable estimate of the total present world demand for the 6.6 billion people on Earth, at their present standards of living. The fundamental questions are whether and how Earth's forests can continue to produce at least this amount of timber for an indefinite period, and whether and how they can produce even more as the world's human population continues to grow and as standards of living rise worldwide. Keep in mind, all of this has to happen while forests continue to perform their other functions, which include public-service functions, biological conservation functions, and functions involving the aesthetic and spiritual needs of people.

In terms of the themes of this book, the question is: How can forest production be sustainable while meeting the needs of people *and* nature? The answer involves science and values.

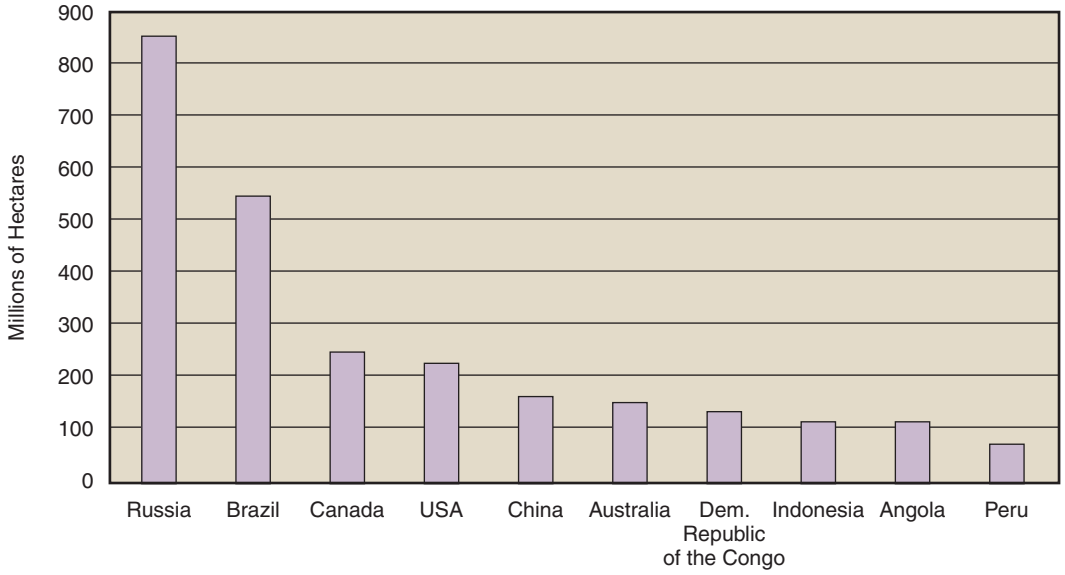


FIGURE 12.4 Countries with the largest forest areas. (*Source*: Data from www.mapsofworld.com)

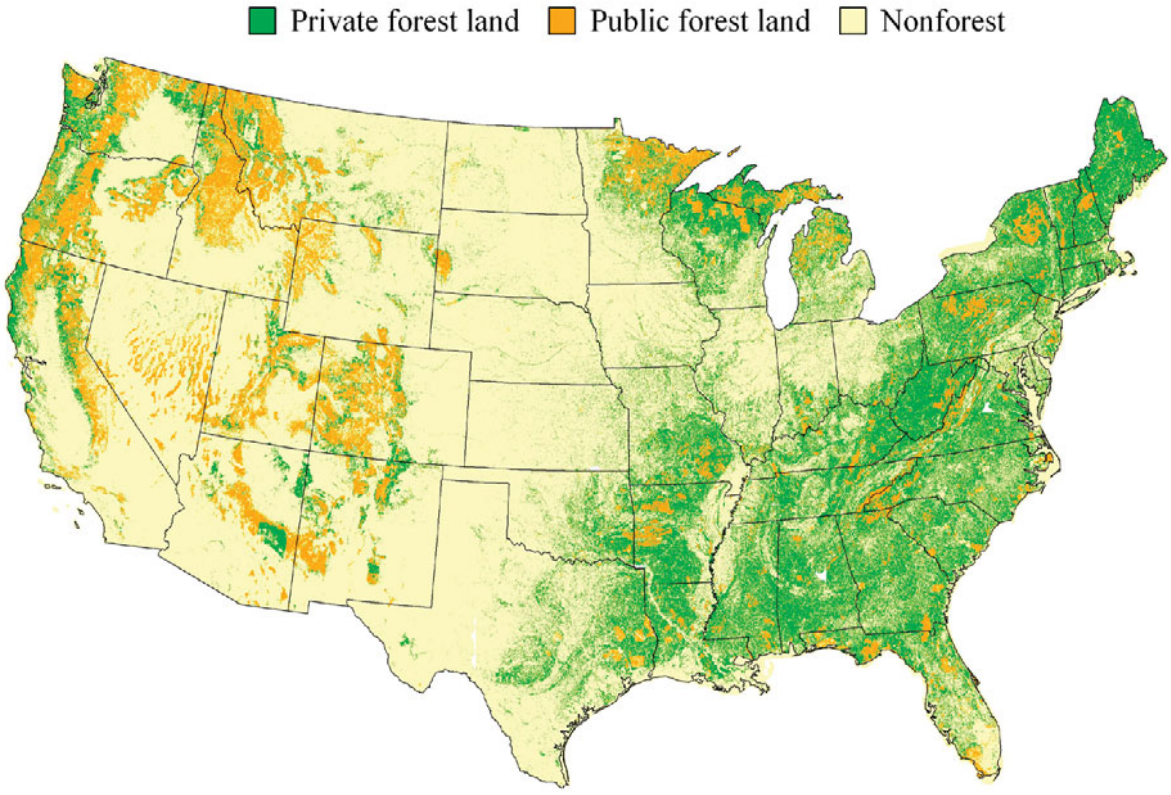


FIGURE 12.5 **Forest ownership in the lower 48 states of the United States in 2008.** (*Source:* U.S. Forest Service, Northern Research Station.)

As we mentioned, wood is a major energy source in many parts of the world. Some 63% of all wood produced in the world, or 2.1 million m^3, is used for firewood. Firewood provides 5% of the world's total energy use,[10] 2% of total commercial energy in developed countries, but 15% of the energy in developing countries, and is the major source of energy for most countries of sub-Saharan Africa, Central America, and continental Southeast Asia.[11]

As the human population grows, the use of firewood increases. In this situation, management is essential, including management of woodland stands (an informal term that foresters use to refer to groups of trees) to improve growth. However, well-planned management of firewood stands has been the exception rather than the rule.

How Forests Affect the Whole Earth

Trees affect the earth by evaporating water, slowing erosion, and providing habitat for wildlife (see Figure 12.6). Trees can also affect climate. Indeed, vegetation of any kind can affect the atmosphere in four ways, and since forests cover so much of the land, they can play an especially important role in the biosphere (Figure 12.7):

1. By changing the color of the surface and thus the amount of sunlight reflected and absorbed.
2. By increasing the amount of water transpired and evaporated from the surface to the atmosphere.
3. By changing the rate at which greenhouse gases are released from Earth's surface into the atmosphere.
4. By changing "surface roughness," which affects wind speed at the surface.

In general, vegetation warms the Earth by making the surface darker, so it absorbs more sunlight and reflects less. The contrast is especially strong between the dark needles of conifers and winter snow in northern forests and between the dark green of shrublands and the yellowish soils of many semiarid climates. Vegetation in general and forests in particular tend to evaporate more water than bare surfaces. This is because the total surface area of the many leaves is many times larger than the area of the soil surface.

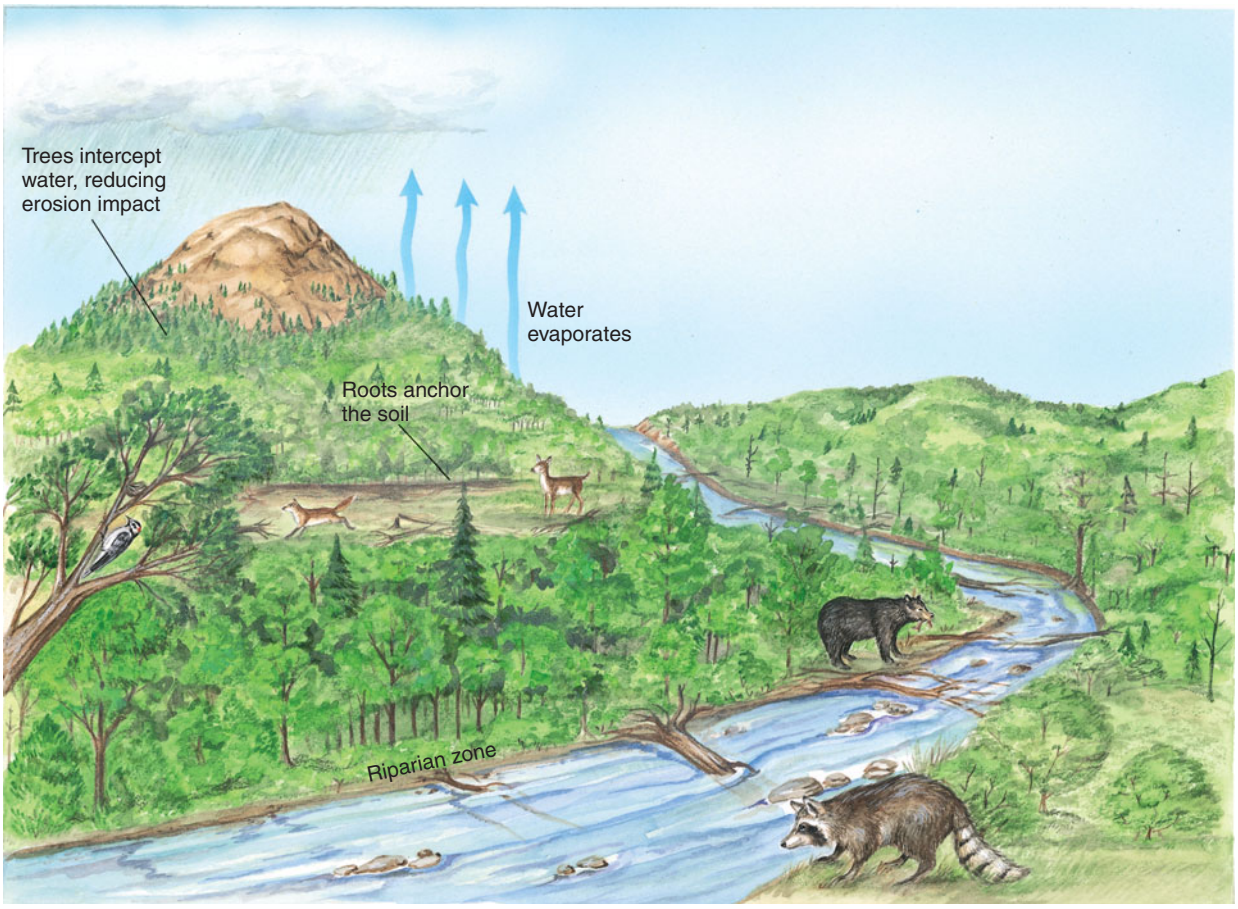


FIGURE 12.6 **A forested watershed,** showing the effects of trees in evaporating water, retarding erosion, and providing wildlife habitat.

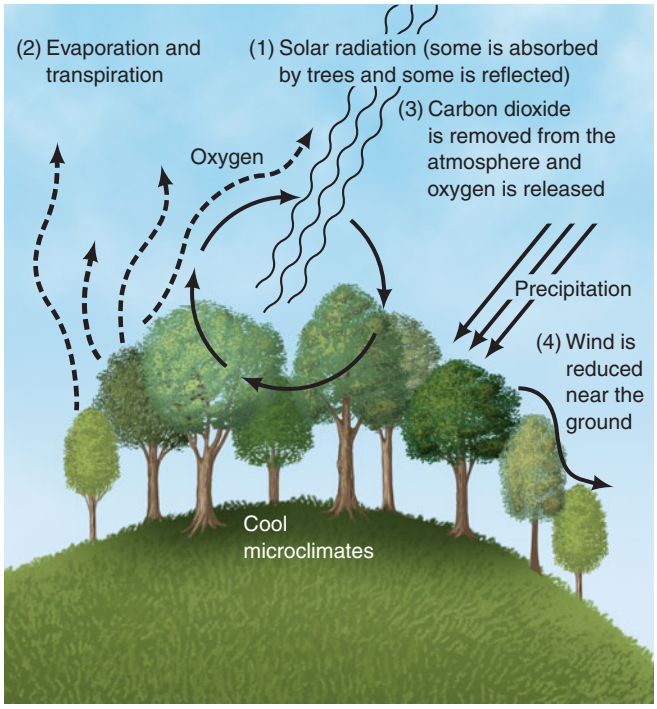


FIGURE 12.7 **Four ways that a forest (or a vegetated area) can affect the atmosphere:** (1) Some solar radiation is absorbed by vegetation and some is reflected, changing the local energy budget, compared to a nonforest environment; (2) evaporation and transpiration from plants, together called *evapotranspiration*, transfers water to the atmosphere; (3) photosynthesis by trees releases oxygen into the atmosphere and removes carbon dioxide, a greenhouse gas, cooling the temperature of the atmosphere; and (4) near-surface wind is reduced because the vegetation—especially trees—produces roughness near the ground that slows the wind.

Is this increased evaporation good or bad? That depends on one's goals. Increasing evaporation means that less water runs off the surface. This reduces erosion. Although increased evaporation also means that less water is available for our own water supply and for streams, in most situations the ecological and environmental benefits of increased evaporation outweigh the disadvantages.

The Ecology of Forests

Each species of tree has its own niche (see Chapter 5) and is thus adapted to specific environmental conditions. For example, in boreal forests, one of the determinants of a tree niche is the water content of the soil. White birch grows well in dry soils; balsam fir in well-watered sites; and northern white cedar in bogs (Figure 12.8).

Another determinant of a tree's niche is its tolerance of shade. Some trees, such as birch and cherry, can grow only in the bright sun of open areas and are therefore found in clearings and called "shade-intolerant." Other species, such as sugar maple and beech, can grow in deep shade and are called "shade-tolerant."

Most of the big trees of the western United States require open, bright conditions and certain kinds of disturbances in order to germinate and survive the early stages of their lives. These trees include coastal redwood, which wins in competition with other species only if both fires and floods occasionally occur; Douglas fir, which begins its growth in openings; and the giant sequoia, whose seeds will germinate only on bare, mineral soil—where there is a thick layer of organic mulch, the sequoia's seeds cannot reach the surface and will die before they can germinate. Some trees are adapted to early stages of succession, where sites are open and there is bright sunlight. Others are adapted to later stages of succession, where there is a high density of trees (see the discussion of ecological succession in Chapter 5).

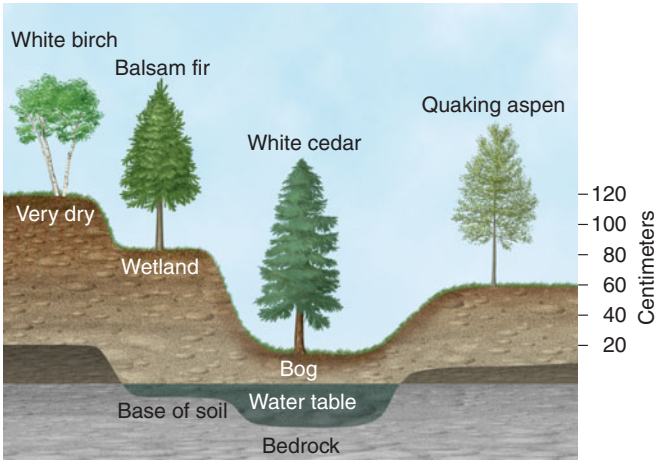


FIGURE 12.8 Some characteristics of tree niches. Tree species have evolved to be adapted to different kinds of environments. In northern boreal forests, white birch grows on dry sites (and early-successional sites); balsam fir grows in wetter soils, up to wetlands; and white cedar grows in even the wetter sites of northern bogs.

Understanding the niches of individual tree species helps us to determine where we might best plant them as a commercial crop, and where they might best contribute to biological conservation or to landscape beauty.

A CLOSER LOOK 12.1

The Life of a Tree

To solve the big issues about forestry, we need to understand how a tree grows, how an ecosystem works, and how foresters have managed forestland (Figure 12.9). Leaves of a tree take up carbon dioxide from the air and absorb sunlight. These, in combination with water transported up from the roots, provide the energy and chemical elements for leaves to carry out *photosynthesis*. Through photosynthesis, the leaves convert carbon dioxide and water into a simple sugar and molecular oxygen. This simple sugar is then combined with other chemical elements to provide all the compounds that the tree uses.

Tree roots take up water, along with chemical elements dissolved in the water and small inorganic compounds, such as the nitrate or ammonia necessary to make proteins. Often the process of extracting minerals and compounds from the soil is aided by symbiotic relationships between the tree

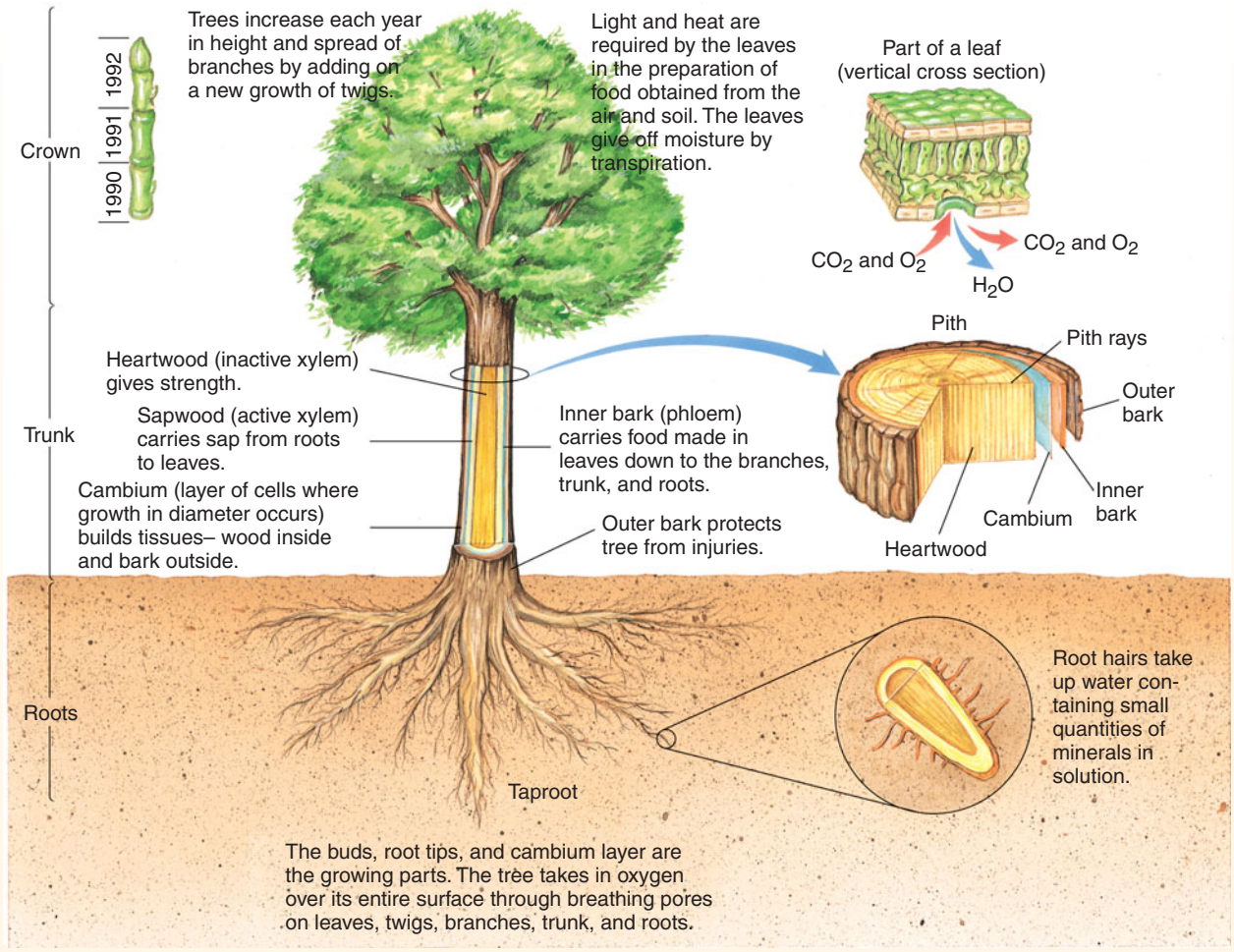


FIGURE 12.9 **How a tree grows.** (*Source*: C.H. Stoddard, *Essentials of Forestry Practice*, 3rd ed. [New York: Wiley, 1978].)

roots and fungi. Tree roots release sugars and other compounds that are food for the fungi, and the fungi benefit the tree as well.

Leaves and roots are connected by two transportation systems. Phloem, on the inside of the living part of the bark, transports sugars and other organic compounds down to stems and roots. Xylem, farther inside (Figure 12.9), transports water and inorganic molecules upward to the leaves. Water is transported upward by a sun-powered pump—that is, sunlight provides energy to pump the water up the tree by heating leaves so they evaporate water. Water from below is then pulled upward to replace water that evaporated.

Forest Management

A Forester's View of a Forest

Traditionally, foresters have managed trees locally in stands. Trees in a **stand** are usually of the same species or group of species and often at the same successional stage. Stands can be small (half a hectare) to medium size (several hundred hectares) and are classified by foresters on the basis of tree composition. The two major kinds of commercial stands are *even-aged stands*, where all live trees began growth from seeds and roots germinating the same year, and *uneven-aged stands*, which have at least three distinct age classes. In even-aged stands, trees are approximately the same height but differ in girth and vigor.

A forest that has never been cut is called a *virgin forest* or sometimes an **old-growth forest**. A forest that has been cut and has regrown is called a **second-growth forest**. Although the term old-growth forest has gained popularity in several well-publicized disputes about forests, it is not a scientific term and does not yet have an agreed-on, precise meaning. Another important management term is **rotation time**, the time between cuts of a stand.

Foresters and forest ecologists group the trees in a forest into the **dominants** (the tallest, most common, and most vigorous), **codominants** (fairly common, sharing the canopy or top part of the forest), **intermediate** (forming a layer of growth below dominants), and **suppressed** (growing in the understory). The productivity of a forest varies according to soil fertility, water supply, and local climate. Foresters classify sites by **site quality**, which is the maximum timber crop the site can produce in a given time. Site quality can decline with poor management.

Although forests are complex and difficult to manage, one advantage they have over many other ecosystems is that trees provide easily obtained information that can be a great help to us. For example, the age and growth rate of trees can be measured from tree rings. In temperate and boreal forests, trees produce one growth ring per year.

Harvesting Trees

Managing forests that will be harvested can involve removing poorly formed and unproductive trees (or selected other trees) to permit larger trees to grow faster, planting genetically controlled seedlings, controlling pests and diseases, and fertilizing the soil. Forest geneticists breed new strains of trees just as agricultural geneticists breed new strains of crops. There has been relatively little success in controlling forest diseases, which are primarily fungal.

Harvesting can be done in several ways. **Clear-cutting** (Figure 12.10) is the cutting of all trees in a stand at the same time. Alternatives to clear-cutting are selective cutting, strip-cutting, shelterwood cutting, and seed-tree cutting.

In **selective cutting**, individual trees are marked and cut. Sometimes smaller, poorly formed trees are selectively removed, a practice called **thinning**. At other times, trees of specific species and sizes are removed. For example, some forestry companies in Costa Rica cut only some of the largest mahogany trees, leaving less valuable trees to help maintain the ecosystem and permitting some of the large mahogany trees to continue to provide seeds for future generations.

FIGURE 12.10 **A clear-cut forest in western Washington.**

In **strip-cutting**, narrow rows of forest are cut, leaving wooded corridors whose trees provide seeds. Strip-cutting offers several advantages, such as protection against erosion.

Shelterwood cutting is the practice of cutting dead and less desirable trees first, and later cutting mature trees. As a result, there are always young trees left in the forest.

Seed-tree cutting removes all but a few seed trees (mature trees with good genetic characteristics and high seed production) to promote regeneration of the forest.

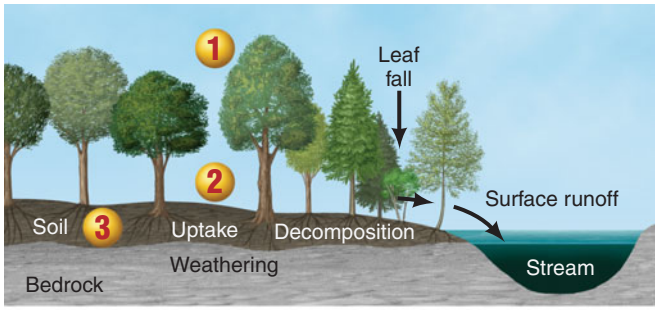
Scientists have tested the effects of clear-cutting, which is one of the most controversial forest practices.[12, 13, 14] For example, in the U.S. Forest Service Hubbard Brook experimental forest in New Hampshire, an entire watershed was clear-cut, and herbicides were applied to prevent regrowth for two years.[14] The results were dramatic. Erosion increased, and the pattern of water runoff changed substantially. The exposed soil decayed more rapidly, and the concentrations of nitrates in the stream water exceeded public-health standards. In another experiment, at the U.S. Forest Service H.J. Andrews experimental forest in Oregon, a forest where rainfall is high (about 240 cm, or 94 in., annually), clear-cutting greatly increased the frequency of landslides, as did the construction of logging roads.[15]

Clear-cutting also changes chemical cycling in forests and can open the way for the soil to lose chemical elements necessary for life. Exposed to sun and rain, the ground becomes warmer. This accelerates the process of decay, with chemical elements, such as nitrogen, converted more rapidly to forms that are water-soluble and thus readily lost in runoff during rains (Figure 12.11).[16]

The Forest Service experiments show that clear-cutting can be a poor practice on steep slopes in areas of moderate to heavy rainfall. The worst effects of clear-cutting resulted from the logging of vast areas of North America during the 19th and early 20th centuries. Clear-cutting on such a large scale is neither necessary nor desirable for the best timber production. However, where the ground is level or slightly sloped, where rainfall is moderate, and where the desirable species require open areas for growth, clear-cutting on an appropriate spatial scale may be a useful way to regenerate desirable species. The key here is that clear-cutting is neither all good nor all bad for timber production or forest ecosystems. Its use must be evaluated on a case-by-case basis, taking into account the size of cuts, the environment, and the available species of trees.

Plantations

Sometimes foresters grow trees in a **plantation**, which is a stand of a single species, typically planted in straight rows (Figure 12.12). Usually plantations are fertilized, sometimes by helicopter, and modern machines harvest rapidly—some remove the entire tree, root and all.



1 Trees shade ground.

2 In cool shade, decay is slow.

3 Trees take up nutrients from soil.

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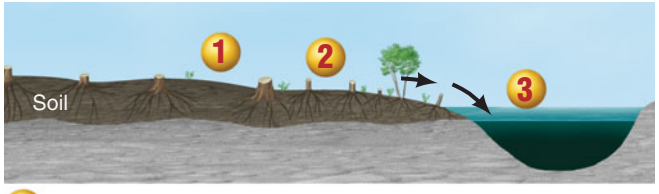
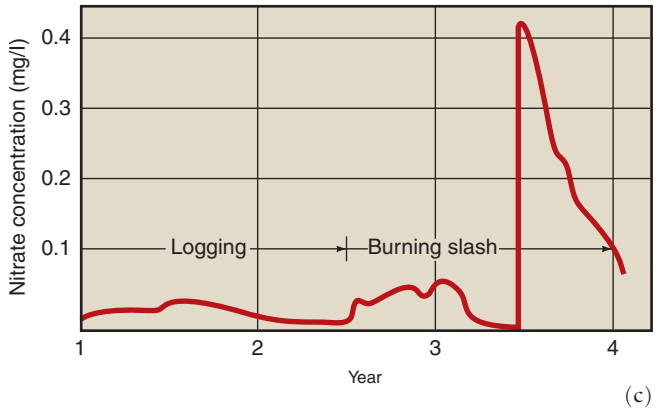


1 Branches and so on decay rapidly in open, warm areas.

2 Soil is more easily eroded without tree roots.

3 Runoff is greater without evaporation by trees.

(b)



(c)

FIGURE 12.11 Effects of clear-cutting on forest chemical cycling. Chemical cycling **(a)** in an old-growth forest and **(b)** after clear-cutting. **(c)** Increased nitrate concentration in streams after logging and the burning of slash (leaves, branches, and other tree debris). (*Source*: adapted from R.L. Fredriksen, "Comparative Chemical Water Quality—Natural and Disturbed Streams Following Logging and Slash Burning," in *Forest Land Use and Stream Environment* [Corvallis: Oregon State University, 1971], pp. 125–137.)

In short, plantation forestry is a lot like modern agriculture. Intensive management like this is common in Europe and parts of the northwestern United States and offers an important alternative solution to the pressure on natural forests. If plantations were used where forest production was high, then a comparatively small percentage of the world's forestland could provide all the world's

FIGURE 12.12 A modern forest plantation in Queensland, Australia. Note that the trees are evenly spaced and similar, if not identical, in size.

timber. For example, high-yield forests produce 15–20 m^3/ha/yr. According to one estimate, if plantations were put on timberland that could produce at least 10 m^3/ha/yr, then 10% of the world's forestland could provide enough timber for the world's timber trade.[17] This could reduce pressure on old-growth forests, on forests important for biological conservation, and on forestlands important for recreation.

Can We Achieve Sustainable Forestry?

There are two basic kinds of ecological sustainability: (1) sustainability of the harvest of a specific resource that grows within an ecosystem; and (2) sustainability of the entire ecosystem—and therefore of many species, habitats, and environmental conditions. For forests, this translates into sustainability of the harvest of timber and sustainability of the forest as an ecosystem. Although sustainability has long been discussed in forestry, we don't have enough scientific data to show that sustainability of either kind has been achieved in forests in more than a few unusual cases.

Certification of Forest Practices

If the data do not indicate whether a particular set of practices has led to sustainable forestry, what can be done? The general approach today is to compare the actual practices of specific corporations or government agencies with practices that are believed to be consistent with sustainability. This has become a formal process called **certification of forestry**, and there are organizations whose main function is to certify forest practices. The catch here is that nobody actually knows whether the beliefs are correct and therefore whether the prac-

tices will turn out to be sustainable. Since trees take a long time to grow, and a series of harvests is necessary to prove sustainability, the proof lies in the future. Despite this limitation, certification of forestry is becoming common. As practiced today, it is as much an art or a craft as it is a science.

Worldwide concern about the need for forest sustainability has led to international programs for certifying forest practices, as well as to attempts to ban imports of wood produced from purportedly unsustainable forest practices. Some European nations have banned the import of certain tropical woods, and some environmental organizations have led demonstrations in support of such bans. However, there is a gradual movement away from calling certified forest practices "sustainable," instead referring to "well-managed forests" or "improved management."[19, 20] And some scientists have begun to call for a new forestry that includes a variety of practices that they believe increase the likelihood of sustainability.

Most basic is accepting the dynamic characteristics of forests—that to remain sustainable over the long term, a forest may have to change in the short term. Some of the broader, science-based concerns are spoken of as a group—the need for ecosystem management and a landscape context. Scientists point out that any application of a certification program creates an experiment and should be treated accordingly. Therefore, any new programs that claim to provide sustainable practices must include, for comparison, control areas where no cutting is done and must also include adequate scientific monitoring of the status of the forest ecosystem.

Deforestation

Deforestation is believed to have increased erosion and caused the loss of an estimated 562 million hectares (1.4 billion acres) of soil worldwide, with an estimated annual loss of 5–6 million hectares.[21] Cutting forests in one country affects other countries. For example, Nepal, one of the most mountainous countries in the world, lost more than half its forest cover between 1950 and 1980. This destabilized soil, increasing the frequency of landslides, amount of runoff, and sediment load in streams. Many Nepalese streams feed rivers that flow into India (Figure 12.13). Heavy flooding in India's Ganges Valley has caused about a billion dollars' worth of property damage a year and is blamed on the loss of large forested watersheds in Nepal and other countries.[20] Nepal continues to lose forest cover at a rate of about 100,000 hectares (247,000 acres) per year. Reforestation efforts replace less than 15,000 hectares (37,050 acres) per year. If present trends continue, little forestland will remain in Nepal, thus permanently exacerbating India's flood problems.[19, 20]

Because forests cover large, often remote areas that are little visited or studied, information is lacking on which to determine whether the world's forestlands are expanding or shrinking, and precisely how fast and how much. Some experts argue that there is a worldwide net increase in forests because large areas in the temperate zone, such as the eastern and midwestern United States, were cleared in the 19th and early 20th centuries and are now regenerating. Only recently have programs begun to obtain accurate estimates of the distribution and abundance of forests, and these suggest that past assessments overestimated forest biomass by 100 to 400%.[22]

On balance, we believe that the best estimates are those suggesting that the rate of deforestation in the 21st century is 7.3 million hectares a year—an annual loss equal to the size of Panama. The good news is that this is 18% less than the average annual loss of 8.9 million hectares in the 1990s.[23]

(a)

(b)

FIGURE 12.13 **(a) Planting pine trees on the steep slopes in Nepal to replace entire forests that were cut.** The dark green in the background is yet-uncut forest, and the contrast between foreground and background suggests the intensity of clearing that is taking place. **(b) The Indus River in northern India carries a heavy load of sediment**, as shown by the sediments deposited within and along the flowing water and by the color of the water itself. This scene, near the headwaters, shows that erosion takes place at the higher reaches of the river.

(a) (b)

FIGURE 12.14 **(a)** A satellite image showing clearings in the tropical rain forests in the Amazon in Brazil. The image is in false infrared. Rivers appear black, and the bright red is the leaves of the living rain forest. The straight lines of other colors, mostly light blue to gray, are of deforestation by people extending from roads. Much of the clearing is for agriculture. The distance across the image is about 100 km (63 mi). **(b)** An intact South American rain forest with its lush vegetation of many species and a complex vertical structure. This one is in Peru.

History of Deforestation

Forests were cut in the Near East, Greece, and the Roman Empire before the modern era. Removal of forests continued northward in Europe as civilization advanced. Fossil records suggest that prehistoric farmers in Denmark cleared forests so extensively that early-successional weeds occupied large areas. In medieval times, Great Britain's forests were cut, and many forested areas were eliminated. With colonization of the New World, much of North America was cleared.[24]

The greatest losses in the present century have taken place in South America, where 4.3 million acres have been lost on average per year since 2000 (Figure 12.14). Many of these forests are in the tropics, mountain regions, or high latitudes, places difficult to exploit before the advent of modern transportation and machines. The problem is especially severe in the tropics because of rapid human population growth. Satellite images provide a new way to detect deforestation (Figure 12.14a).

Causes of Deforestation

Historically, the two most common reasons people cut forests are to clear land for agriculture and settlement and to use or sell timber for lumber, paper products, or fuel. Logging by large timber companies and local cutting by villagers are both major causes of deforestation. Agriculture is a principal cause of deforestation in Nepal and Brazil and was one of the major reasons for clearing forests in New England during the first settlement by Europeans. A more subtle cause of the loss of forests is indirect deforestation—the death of trees from pollution or disease.

If global warming occurs as projected by global climate models, indirect forest damage might occur over large regions, with major die-offs in many areas and major shifts in the areas of potential growth for each species of tree due to altered combinations of temperature and rainfall.[25] The extent of this effect is controversial. Some suggest that global warming would merely change the location of forests, not their total area or production. However, even if a climate conducive to forest growth were to move to new locations, trees would have to reach these areas. This would take time because changes in the geographic distribution of trees depend primarily on seeds blown by the wind or carried by animals. In addition, for production to remain as high as it is now, climates that meet the needs of forest trees would have to occur where the soils also meet these needs. This combination of climate and soils occurs widely now but might become scarcer with large-scale climate change.

12.2 Parks, Nature Preserves, and Wilderness

As suggested by this chapter's opening case study about Jamaica Bay Wildlife Refuge, governments often protect landscapes from harvest and other potentially destructive uses by establishing parks, nature preserves, and legally designated wilderness areas. So do private organizations, such as the Nature Conservancy, the Southwest Florida Nature Conservancy, and the Land

Trust of California, which purchase lands and maintain them as nature preserves. Whether government or private conservation areas succeed better in reaching the goals listed in Table 12.1 is a matter of considerable controversy.

Parks, natural areas, and wilderness provide benefits within their boundaries and can also serve as migratory corridors between other natural areas. Originally, parks were established for specific purposes related to the land within the park boundaries (discussed later in this chapter). In the future, the design of large landscapes to serve a combination of land uses—including parks, preserves, and wilderness—needs to become more important and a greater focus of discussion.

What's the Difference between a Park and a Nature Preserve?

A park is an area set aside for use by people. A nature preserve, although it may be used by people, has as its primary purpose the conservation of some resource, typically a biological one. Every park or preserve is an ecological island of one kind of landscape surrounded by a different kind of landscape, or several different kinds. Ecological and physical islands have special ecological qualities, and concepts of island biogeography are used in the design and management of parks. Specifically, the size of the park and the diversity of habitats determine the number of species that can be maintained there. Also, the farther the park is from other parks or sources of species, the fewer species are found. Even the shape of a park can determine what species can survive within it.

One of the important differences between a park and a truly natural wilderness area is that a park has definite boundaries. These boundaries are usually arbitrary from an ecological viewpoint and have been established for political, economic, or historical reasons unrelated to the natural ecosystem. In fact, many parks have been developed on areas that would have been considered wastelands, useless for any other purpose. Even where parks or preserves have been set aside for the conservation of some species, the boundaries are usually arbitrary, and this has caused problems.

For example, Lake Manyara National Park in Tanzania, famous for its elephants, was originally established with boundaries that conflicted with elephant habits. Before this park was established, elephants spent part of the year feeding along a steep incline above the lake. At other times of the year, they would migrate down to the valley floor, depending on the availability of food and water. These annual migrations were necessary for the elephants to obtain food of sufficient nutritional quality throughout the year. However, when the park was established, farms that were laid out along its northern border crossed the traditional pathways of the elephants. This had two negative effects. First, elephants came into direct conflict with farmers. Elephants crashed through farm fences, eating corn and other crops and causing general disruption. Second, whenever the farmers succeeded in keeping elephants out, the animals were cut off from reaching their feeding ground near the lake.

When it became clear that the park boundaries were arbitrary and inappropriate, the boundaries were adjusted to include the traditional migratory routes. This eased the conflicts between elephants and farmers.

Table 12.1 GOALS OF PARKS, NATURE PRESERVES, AND WILDERNESS AREAS

Parks are as old as civilization. The goals of park and nature-preserve management can be summarized as follows:

1. Preservation of unique geological and scenic wonders of nature, such as Niagara Falls and the Grand Canyon
2. Preservation of nature without human interference (preserving wilderness for its own sake)
3. Preservation of nature in a condition thought to be representative of some prior time (e.g., the United States prior to European settlement)
4. Wildlife conservation, including conservation of the required habitat and ecosystem of the wildlife
5. Conservation of specific endangered species and habitats
6. Conservation of the total biological diversity of a region
7. Maintenance of wildlife for hunting
8. Maintenance of uniquely or unusually beautiful landscapes for aesthetic reasons
9. Maintenance of representative natural areas for an entire country
10. Maintenance for outdoor recreation, including a range of activities from viewing scenery to wilderness recreation (hiking, cross-country skiing, rock climbing) and tourism (car and bus tours, swimming, downhill skiing, camping)
11. Maintenance of areas set aside for scientific research, both as a basis for park management and for the pursuit of answers to fundamental scientific questions
12. Provision of corridors and connections between separated natural areas

A CLOSER LOOK 12.2

A Brief History of Parks Explains Why Parks Have Been Established

The French word *parc* once referred to an enclosed area for keeping wildlife to be hunted. Such areas were set aside for the nobility and excluded the public. An example is Coto Doñana National Park on the southern coast of Spain. Originally a country home of nobles, today it is one of Europe's most important natural areas, used by 80% of birds migrating between Europe and Africa (Figure 12.16).

The first major *public* park of the modern era was Victoria Park in Great Britain, authorized in 1842. The concept of a *national* park, whose purposes would include protection of nature as well as public access, originated in North America in the 19th century.[26] The world's first national park was Yosemite National Park in California (Figure 12.15), made a park by an act signed by President Lincoln in 1864. The term *national park*, however, was not used until the establishment of Yellowstone in 1872.

The purpose of the earliest national parks in the United States was to preserve the nation's unique, awesome landscapes—a purpose that Alfred Runte, a historian of national parks, refers to as "monumentalism." In the 19th century, Americans considered their national parks a contribution to civilization equivalent to the architectural treasures of the Old World and sought to preserve them as a matter of national pride.[27]

In the second half of the 20th century, the emphasis of park management became more ecological, with parks established both to conduct scientific research and to maintain examples of representative natural areas. For instance, Zimbabwe established Sengwa National Park (now called Matusadona National Park) solely for scientific research. It has no tourist areas, and tourists are not generally allowed; its purpose is the study of natural ecosystems with as little human interference as possible so that the principles of wildlife and wilderness management can be better formulated and understood. Other national parks in the countries of eastern and southern Africa—including those of Kenya, Uganda, Tanzania, Zimbabwe, and South Africa—have been established primarily for viewing wildlife and for biological conservation.

In recent years, the number of national parks throughout the world has increased rapidly. The law establishing national parks in France was first enacted in 1960. Taiwan had no national parks prior to 1980 but now has six. In the United States, the area in national and state parks has expanded from less than 12 million hectares (30 million acres) in 1950 to nearly 83.6 million acres today, with much of the increase due to the establishment of parks in Alaska.[28]

FIGURE 12.15 **The famous main valley of Yosemite National Park.**

(a)

(b)

FIGURE 12.16 **(a) Flamingos are among the many birds that use Coto Doñana National Park,** a major stopover on the Europe-to-Africa flyway. **(b)** Map of Coto Doñana National Park, Spain (*Source*: Colours of Spain. World Heritage Sites http://www.coloursofspain.com/travelguidedetail/17/andalucia_andalusia/world_heritage_sites_donana_national_park/)

Conserving representative natural areas of a country is an increasingly common goal of national parks. For example, the goal of New Zealand's national park planning is to include at least one area representative of each major ecosystem of the nation, from seacoast to mountain peak. In some cases, such as Spain's Coto Doñana National Park, national parks are among the primary resting grounds of major bird flyways (Figure 12.16) or play other crucial roles in conservation of biodiversity.

Conflicts Relating to Parks

Size, Access, and Types of Activities

Major conflicts over parks generally have to do with their size and what kinds and levels of access and activities will be available. The idea of a national, state, county, or city park is well accepted in North America, but conflicts arise over what kinds of activities and what intensity of activities should be allowed in parks. Often, biological conservation and the needs of individual species require limited human access, but, especially in beautiful areas desirable for recreation, people want to go there. As a recent example, travel into Yellowstone National Park by snowmobile in the winter has become popular, but this has led to noise and air pollution and has marred the experience of the park's beauty for many visitors. In 2003 a federal court determined that snowmobile use should be phased out in this park.

Alfred Runte explained the heart of the conflict. "This struggle was not against Americans who like their snowmobiles, but rather against the notion that anything goes in the national parks," he said. "The courts have reminded us that we have a different, higher standard for our national parks. Our history proves that no one loses when beauty wins. We will find room for snowmobiles, but just as important, room without them, which is the enduring greatness of the national parks."[29]

Many of the recent conflicts relating to national parks have concerned the use of motor vehicles. Voyageurs National Park in northern Minnesota, established in 1974—fairly recently compared with many other national parks—occupies land that was once used by a variety of recreational vehicles and provided livelihoods for hunting and fishing guides and other tourism businesses. These people felt that restricting motor-vehicle use would destroy their livelihoods. Voyageurs National Park has 100 miles of snowmobile trails and is open to a greater variety of motor-vehicle recreation than Yellowstone.[30]

Interactions Between People and Wildlife

While many people like to visit parks to see wildlife, some wildlife, such as grizzly bears in Yellowstone National Park, can be dangerous. There has been conflict in the past between conserving the grizzly and making the park as open as possible for recreation.

How Much Land Should Be in Parks?

Another important controversy in managing parks is what percentage of a landscape should be in parks or nature preserves, especially with regard to the goals of biological diversity. Because parks isolate populations genetically, they may provide too small a habitat for maintaining a minimum safe population size. If parks are to function as biological preserves, they must be adequate in size and habitat diversity to maintain a population large enough to avoid the serious genetic difficulties that can develop in small populations. An alternative, if necessary, is for a park manager to move individuals of one species—say, lions in African preserves—from one park to another to maintain genetic diversity. But park size is a source of conflicts, with conservationists typically wanting to make parks bigger and commercial interests typically wanting to keep them smaller. Proponents of the Wildlands Projects, for example, argue that large areas are necessary to conserve ecosystems, so even America's large parks, such as Yellowstone, need to be connected by conservation corridors.

Nations differ widely in the percentage of their total area set aside as national parks. Costa Rica, a small country with high biological diversity, has more than 12% of its land in national parks.[31] Kenya, a larger nation that also has numerous biological resources, has 7.6% of its land in national parks.[32] In France, an industrialized nation in which civilization has altered the landscape for several thousand years, only 0.7% of the land is in the nation's six national parks. However, France has 38 regional parks that encompass 11% (5.9 million hectares) of the nation's area.

The total amount of protected natural area in the United States is more than 104 million hectares (about 240 million acres), approximately 11.2% of the total U.S. land area.[33] However, the states differ greatly in the percentage of land set aside for parks, preserves, and other conservation areas. The western states have vast parks, whereas the six Great Lakes states (Michigan, Minnesota, Illinois, Indiana, Ohio, and Wisconsin), covering an area approaching that of France and Germany combined, allocate less than 0.5% of their land to parks and less than 1% to designated wilderness.[34]

12.3 Conserving Wilderness

What It Is, and Why It Is of Growing Importance

As a modern legal concept, **wilderness** is an area undisturbed by people. The only people in a wilderness are visitors, who do not remain. The conservation of wilderness is a new idea introduced in the second half of the 20th century. It is one that is likely to become more important as the human population increases and the effects of civilization become more pervasive throughout the world.

The U.S. Wilderness Act of 1964 was landmark legislation, marking the first time anywhere that wilderness was recognized by national law as a national treasure to be preserved. Under this law, wilderness includes "an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions." Such lands are those in which (1) the imprint of human work is unnoticeable, (2) there are opportunities for solitude and for primitive and unconfined recreation, and (3) there are at least 5,000 acres. The law also recognizes that these areas are valuable for ecological processes, geology, education, scenery, and history. The Wilderness Act required certain maps and descriptions of wilderness areas, resulting in the U.S. Forest Service's Roadless Area Review and Evaluation (RARE I and RARE II), which evaluated lands for inclusion as legally designated wilderness.

Where You'll Find It and Where You Won't

Countries with a significant amount of wilderness include New Zealand, Canada, Sweden, Norway, Finland, Russia, and Australia; some countries of eastern and southern Africa; many countries of South America, including parts of the Brazilian and Peruvian Amazon basin; the mountainous high-altitude areas of Chile and Argentina; some of the remaining interior tropical forests of Southeast Asia; and the Pacific Rim countries (parts of Borneo, the Philippines, Papua New Guinea, and Indonesia). In addition, wilderness can be found in the polar regions, including Antarctica, Greenland, and Iceland.

Many countries have no wilderness left to preserve. In the Danish language, the word for wilderness has even disappeared, although that word was important in the ancestral languages of the Danes.[32] Switzerland is a country in which wilderness is not a part of preservation. For example, a national park in Switzerland lies in view of the Alps—scenery that inspired the English romantic poets of the early 19th century to praise what they saw as wilderness and to attach the adjective *awesome* to what they saw. But the park is in an area that has been heavily exploited for such activities as mining and foundries since the Middle Ages. All the forests are planted.[32]

The Wilderness Experience: Natural vs. Naturalistic

In a perhaps deeper sense, wilderness is an idea and an ideal that can be experienced in many places, such as Japanese gardens, which might occupy no more than a few hundred square meters. Henry David Thoreau distinguished between "wilderness" and "wildness." He thought of wilderness as a physical place and wildness as a state of mind. During his travels through the Maine woods in the 1840s, he concluded that wilderness was an interesting place to visit but not to live in. He preferred long walks through the woods and near swamps around his home in Concord, Massachusetts, where he was able to experience a *feeling* of wildness. Thus,

Thoreau raised a fundamental question: Can one experience true wildness only in a huge area set aside as a wilderness and untouched by human actions, or can wildness be experienced in small, heavily modified and, though not entirely natural, *naturalistic* landscapes, such as those around Concord in the 19th century?[31]

As Thoreau suggests, small, local, naturalistic parks may have more value than some of the more traditional wilderness areas as places of solitude and beauty. In Japan, for instance, there are roadless recreation areas, but they are filled with people. One two-day hiking circuit leads to a high-altitude marsh where people can stay in small cabins. Trash is removed from the area by helicopter. People taking this hike experience a sense of wildness.

In some ways, the answer to the question raised by Thoreau is highly personal. We must discover for ourselves what kind of natural or naturalistic place meets our spiritual, aesthetic, and emotional needs. This is yet another area in which one of our key themes, science and values, is evident.

Conflicts in Managing Wilderness

The legal definition of *wilderness* has given rise to several controversies. The wilderness system in the United States began in 1964 with 3.7 million hectares (9.2 million acres) under U.S. Forest Service control. Today, the United States has 633 legally designated wilderness areas, covering 44 million hectares (106 million acres)—more than 4% of the nation. Another 200 million acres meet the legal requirements and could be protected by the Wilderness Act. Half of this area is in Alaska, including the largest single area, Wrangell–St. Elias (Figure 12.17), covering 3.7 million hectares (9 million acres).[33, 35]

Those interested in developing the natural resources of an area, including mineral ores and timber, have argued that the rules are unnecessarily stringent, protecting too much land from exploitation when there is plenty of wilderness elsewhere. Those who wish to conserve additional wild areas have argued that the interpretation of the U.S. Wilderness Act is too lenient and that mining and logging are inconsistent with the wording of the Act. These disagreements are illustrated by the argument over drilling in the Arctic National Wildlife Refuge, a dispute that reemerged with the rising price of petroleum.

FIGURE 12.17 **Wrangell–St. Elias Wilderness Area, Alaska**, designated in 1980 and now covering 9,078,675 acres. As the photograph suggests, this vast area gives a visitor a sense of wilderness as a place where a person is only a visitor and human beings seem to have no impact.

The notion of managing wilderness may seem paradoxical—is it still wilderness if we meddle with it? In fact, though, with the great numbers of people in the world today, even wilderness must be defined, legally set aside, and controlled. We can view the goal of managing wilderness in two ways: in terms of the wilderness itself and in terms of people. In the first instance, the goal is to preserve nature undisturbed by people. In the second, the purpose is to provide people with a wilderness experience.

Legally designated wilderness can be seen as one extreme in a spectrum of environments to manage. The spectrum ranges from wilderness rarely disturbed by anyone to preserves in which some human activities are allowed to be visible—parks designed for outdoor recreation, forests for timber production and various kinds of recreation, hunting preserves, and urban parks—and finally, at the other extreme, open-pit mines. You can think of many stages in between on this spectrum.

Wilderness management should involve as little direct action as possible, so as to minimize human influence. This also means, ironically, that one of the necessities is to control human access so that a visitor has little, if any, sense that other people are present.

Consider, for example, the Desolation Wilderness Area in California, consisting of more than 24,200 hectares (60,000 acres), which in one year had more than 250,000 visitors. Could each visitor really have a wilderness experience there, or was the human carrying capacity of the wilderness exceeded? This is a subjective judgment. If, on one hand, all visitors saw only their own companions and believed they were alone, then the actual number of visitors did not matter for each visitor's wilderness experience. On the other hand, if every visitor found the solitude ruined by strangers, then the management failed, no matter how few people visited.

Wilderness designation and management must also take into account adjacent land uses. A wilderness next to a garbage dump or a power plant spewing smoke is a contradiction in terms. Whether a wilderness can be adjacent to a high-intensity campground or near a city is a more subtle question that must be resolved by citizens.

Today, those involved in wilderness management recognize that wild areas change over time and that these changes should be allowed to occur as long as they are natural. This is different from earlier views that nature undisturbed was unchanging and should be managed so that it did not change. In addition, it is generally argued now that in choosing what activities can be allowed in a wilderness, we should emphasize activities that depend on wilderness

(the experience of solitude or the observation of shy and elusive wildlife) rather than activities that can be enjoyed elsewhere (such as downhill skiing).

Another source of conflict is that wilderness areas frequently contain economically important resources, including timber, fossil fuels, and mineral ores. There has been heated debate about whether wilderness areas should be open to the extraction of these.

Still another controversy involves the need to study wilderness versus the desire to leave wilderness undisturbed. Those in favor of scientific research in the wilderness argue that it is necessary for the conservation of wilderness. Those opposed argue that scientific research contradicts the purpose of a designated wilderness as an area undisturbed by people. One solution is to establish separate research preserves.

CRITICAL THINKING ISSUE

Can Tropical Forests Survive in Bits and Pieces?

Although tropical rain forests occupy only about 7% of the world's land area, they provide habitat for at least half of the world's species of plants and animals. Approximately 100 million people live in rain forests or depend on them for their livelihood. Tropical plants provide products such as chocolate, nuts, fruits, gums, coffee, wood, rubber, pesticides, fibers, and dyes. Drugs for treating high blood pressure, Hodgkin's disease, leukemia, multiple sclerosis, and Parkinson's disease have been made from tropical plants, and medical scientists believe many more are yet to be discovered.

In the United States, most of the interest in tropical rain forests has focused on Brazil, whose forests are believed to have more species than any other geogaphic area. Estimates of destruction in the Brazilian rain forest range from 6 to 12%, but numerous studies have shown that deforested area alone does not adequately measure habitat destruction because surrounding habitats are also affected (refer back to Figure 12.14a). For example, the more fragmented a forest is, the more edges there are, and the greater the impact on the living organisms. Such edge effects vary depending on the species, the characteristics of the land surrounding the forest fragment, and the distance between fragments. For example, a forest surrounded by farmland is more deeply affected than one surrounded by abandoned land in which secondary growth presents a more gradual transition between forest and deforested areas. Some insects, small mammals, and many birds find only 80 m (262.5 ft) to be a barrier to movement from one fragment to another, whereas one small marsupial has been found to cross distances of 250 m (820.2 ft). Corridors between forested areas also help to offset the negative effects of deforestation on plants and animals of the forest.

Critical Thinking Questions

1. Look again at Figure 12.14a, the satellite image of part of the Brazilian rain forest. You are asked to make a plan that will allow 50% of the area to be cut, and the rest established as a national park. Make a design for how you think this would best be done, taking into account conservation of biological diversity, the difficulty of travel in tropical rain forests, and the needs of local people to make a living. In your plan, the areas to be harvested will not change over time once the design is in place.
2. You are asked to create a park like the one in question 1, taking into account that the forested areas cut for timber will be allowed to regenerate and during that time, until actual harvest, could be used for recreation. Modify your design to take that into account.
3. The forest fragments left uncut in Figure 12.14 are sometimes compared with islands. What are some ways in which this is an appropriate comparison? Some ways in which it is not?

SUMMARY

- In the past, land management for harvesting resources and conserving nature was mostly local, with each parcel of land considered independently.
- Today, a landscape perspective has developed, and lands used for harvesting resources are seen as part of a matrix that includes lands set aside for the conservation of biological diversity and for landscape beauty.
- Forests are among civilization's most important renewable resources. Forest management seeks a sustainable harvest and sustainable ecosystems. Because examples of success-

ful sustainable forestry are rare, "certification of sustainable forestry" has developed to determine which methods appear most consistent with sustainability and then compare the management of a specific forest with those standards.

- Given their rapid population growth, continued use of firewood as an important fuel in developing nations is a major threat to forests. It is doubtful that these nations can implement successful management programs in time to prevent serious damage to their forests and severe effects on their people.
- Clear-cutting is a major source of controversy in forestry. Some tree species require clearing to reproduce and grow, but the scope and method of cutting must be examined carefully in terms of the needs of the species and the type of forest ecosystem.
- Properly managed plantations can relieve pressure on forests.
- Managing parks for biological conservation is a relatively new idea that began in the 19th century. The manager of a park must be concerned with its shape and size. Parks that are too small or the wrong shape may have too small a population of the species for which the park was established and thus may not be able to sustain the species.
- A special extreme in conservation of natural areas is the management of wilderness. In the United States, the 1964 Wilderness Act provided a legal basis for such conservation. Managing wilderness seems a contradiction—trying to make sure it will be undisturbed by people requires interference to limit user access and to maintain the natural state, so an area that is not supposed to be influenced by people actually is.
- Parks, nature preserves, wilderness areas, and actively harvested forests affect one another. The geographic pattern of these areas on a landscape, including corridors and connections among different types, is part of the modern approach to biological conservation and the harvest of forest resources.

REEXAMINING THEMES AND ISSUES

Human Population

Forests provide essential resources for civilization. As the human population grows, there will be greater and greater demand for these resources. Because forest plantations can be highly productive, we are likely to place increasing emphasis on them as a source of timber. This would free more forestland for other uses.

Sustainability

Sustainability is the key to conservation and management of wild living resources. However, sustainable harvests have rarely been achieved for timber production, and sustained ecosystems in harvested forests are even rarer. Sustainability must be the central focus for forest resources in the future.

Global Perspective

Forests are global resources. A decline in the availability of forest products in one region affects the rate of harvest and economic value of these products in other regions. Biological diversity is also a global resource. As the human population grows, the conservation of biological diversity is likely to depend more and more on legally established parks, nature preserves, and wilderness areas.

Urban World

We tend to think of cities as separated from living resources, but urban parks are important in making cities pleasant and livable; if properly designed, they can also help to conserve wild living resources.

People and Nature

Forests have provided essential resources, and often people have viewed them as perhaps sacred but also dark and scary. Today, we value wilderness and forests, but we rarely harvest forests sustainably. Thus, the challenge for the future is to reconcile our dual and somewhat opposing views so that we can enjoy both the deep meaningfulness of forests and their important resources.

Science and Values

Many conflicts over parks, nature preserves, and legally designated wilderness areas also involve science and values. Science tells us what is possible and what is required in order to conserve both a specific species and total biological diversity. But what society desires for such areas is, in the end, a matter of values and experience, influenced by scientific knowledge.

KEY TERMS

certification of forestry **246**
clear-cutting **245**
codominants **245**
dominants **245**
intermediate **245**
old-growth forest **244**
plantation **245**
rotation time **244**
second-growth forest **244**
seed-tree cutting **245**
selective cutting **245**
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STUDY QUESTIONS

1. What environmental conflicts might arise when a forest is managed for the multiple uses of (a) commercial timber, (b) wildlife conservation, and (c) a watershed for a reservoir? In what ways could management for one use benefit another?
2. What arguments could you offer for and against the statement "Clear-cutting is natural and necessary for forest management"?
3. Can a wilderness park be managed to supply water to a city? Explain your answer.
4. A park is being planned in rugged mountains with high rainfall. What are the environmental considerations if the purpose of the park is to preserve a rare species of deer? If the purpose is recreation, including hiking and hunting?
5. What are the environmental effects of decreasing the rotation time (accelerating the rate of cutting) in forests from an average of 60 years to 10 years? Compare these effects for (a) a woodland in a dry climate on a sandy soil and (b) a rain forest.
6. In a small but heavily forested nation, two plans are put forward for forest harvests. In Plan A, all the forests to be harvested are in the eastern part of the nation, while all the forests of the West are set aside as wilderness areas, parks, and nature preserves. In Plan B, small areas of forests to be harvested are distributed throughout the country, in many cases adjacent to parks, preserves, and wilderness areas. Which plan would you choose? Note that in Plan B, wilderness areas would be smaller than in Plan A.
7. The smallest legally designated wilderness in the United States is Pelican Island, Florida (Figure 12.18), covering 5 acres. Do you think this can meet the meaning of *wilderness* and the intent of the Wilderness Act?

FURTHER READING

Botkin, D.B., ***No Man's Garden: Thoreau and a New Vision for Civilization and Nature*** (Washington, DC: Island Press, 2001).

Hendee, J.C., ***Wilderness Management: Stewardship and Protection of Resources and Values*** (Golden, CO: Fulcrum Publishing, 2002). Considered the classic work on this subject.

Kimmins, J.P., ***Forest Ecology*****, 3rd ed.** (Upper Saddle River, NJ: Prentice Hall, 2003). A textbook that applies recent developments in ecology to the practical problems of managing forests.

Runte, A., ***National Parks: The American Experience*** (Lincoln: Bison Books of the University of Nebraska, 1997). The classic book about the history of national parks in America and the reasons for their development.