CHAPTER 22

Urban Environments

New Orleans suffering right after Hurricane Katrina.

LEARNING OBJECTIVES

Because the world is becoming increasingly urbanized, it is important to learn how to improve urban environments—to make cities more pleasant and healthier places to live, and reduce undesirable effects on the environment. After reading this chapter, you should understand . . .

- How to view a city from an ecosystem perspective;
- How location and site conditions determine the success, importance, and longevity of a city;
- How cities have changed with changes in technology and in ideas about city planning;
- How a city changes its own environment and affects the environment of surrounding areas, and how we can plan cities to minimize some of these effects;
- How trees and other vegetation not only beautify cities but also provide habitats for animals, and how we can alter the urban environment to encourage wildlife and discourage pests;
- How cities can be designed to promote biological conservation and become pleasant environments for people;
- The fundamental choices we face in deciding what kind of future we want and what the role of cities will be in that future.

CASE STUDY

New York's High Line Park in the Sky

From the late 19th century to the 1930s, trains ran on street level in New York City, carrying goods such as meat to the meatpacking district near the Hudson River. This was dangerous and caused accidents. In the 1930s, a public–private project built an elevated railroad 30 feet above the streets, making the streets safer, if darker and less attractive.

By the 1980s the economy had changed, and the trains were no longer needed and so stopped running. The elevated rail line that had served Manhattan's meatpacking district near the Hudson River was just another urban eyesore. Although the narrow, rusty steel stairs that led up to them were closed off and hard to find, a few New Yorkers did manage to climb up and discovered that nature was taking over—the open ground between and along the tracks was undergoing secondary succession, with trees, shrubs, tall grasses, and flowering plants growing wild. Following the rails above the city streets, you could get a secret taste of what Henry David Thoreau would have called "wildness"—the feeling of nature—even within one of the world's largest cities.

Some people proposed tearing down the useless rail line to let more light reach the streets beneath, but another group of citizens had a different idea: to turn it into a park. They formed "Friends of the High Line" in 1999 and got city approval. In 2009 the eagerly anticipated first section of the High Line Park opened, carefully planned by professional landscape designers who strove to keep the natural, uncultivated look by using many of the same plant species that had been growing wild on their own.

Although New York City has many parks, including the very large Central Park, its millions of residents need more places to relax, stroll, sit, and enjoy nature. The park will ultimately be a mile and a half long, and as soon as the first section opened, it was filled with people (Figure 22.1), strolling, enjoying the views of the city on one side and the river on the other, relaxing on wheeled wooden lounges mounted on the tracks. A lot of imagination had helped bring nature to the city, and city people to nature.[1]

(a)

(c)

(b)

FIGURE 22.1 A portion of the newly opened first section of New York City's High Line **(a)** as originally designed for use as an elevated freight railway within Manhattan and **(b)** as it is today, an urban park, ultimately a mile and a half long when completed, planted with many of the species that grew wild after the railway was abandoned **(c)** the HighLine as an elevated with Field.

22.1 City Life

In the past, the emphasis of environmental action has most often been on wilderness, wildlife, endangered species, and the impact of pollution on natural landscapes outside cities. Now it is time to turn more of our attention to city environments. In the development of the modern environmental movement in the 1960s and 1970s, it was fashionable to consider everything about cities bad and everything about wilderness good. Cities were viewed as polluted, dirty, lacking in wildlife and native plants, and artificial—therefore bad. Wilderness was viewed as unpolluted, clean, teeming with wildlife and native plants, and natural—therefore good.

Although it was fashionable to disdain cities, many people live in urban environments and have suffered directly from their decline. According to the United Nations Environment Program, in 1950 fewer than a third of the people of the world lived in a town or city, while today almost half of the world's population is urban, and the forecasts are that in just 20 years—by 2030—almost two-thirds of the people will live in cities and towns.[2] (See Chapter 4.)

In the United States, about 75% of the population live in urban areas and about 25% in rural areas. Perhaps even more striking, half of all Americans live in one of the 39 cities with populations over 1 million.[3] However, in the past decade more people have moved out of the largest cities in the United States than have moved into them. The New York, Los Angeles, Chicago, and San Francisco/Oakland metropolitan areas each averaged a net loss of more than 60,000 people a year. Chicago's Cook County lost a half million people between 2000 and 2004.[4, 5, 6, 7] Today approximately 45% of the world's population live in cities, and it is projected that 62% of the population will live in cities by the year 2025.[6] Economic development leads to urbanization; 75% of people in developed countries live in cities, but only 38% of people in the poorest of the developing countries are city dwellers.[7]

Megacities—huge metropolitan areas with more than 8 million residents—are cropping up more and more. In 1950 the world had only two: the New York City and nearby urban New Jersey metropolitan area (12.2 million residents altogether) and greater London (12.4 million). By 1975, Mexico City, Los Angeles, Tokyo, Shanghai, and São Paulo, Brazil, had joined this list. By 2002, the most recent date for which data are available, 30 urban areas had more than 8 million people.[5]

Yet comparatively little public concern has focused on urban ecology. Many urban people see environmental issues as outside their realm, but the reality is just the opposite: City dwellers are at the center of some of the most important environmental issues. People are realizing that city and wilderness are inextricably connected. We cannot fiddle in the wilderness while our Romes burn from sulfur dioxide and nitrogen oxide pollution. Fortunately, we are experiencing a rebirth of interest in urban environments and urban ecology. The National Science Foundation has added two urban areas, Baltimore and Phoenix, to its Long-Term Ecological Research Program, a program that supports research on, and long-term monitoring of, specific ecosystems and regions.

In the future, most people will live in cities. In most nations, most urban residents will live in the country's single largest city. For most people, living in an environment of good quality will mean living in a city that is managed carefully to maintain that environmental quality.

22.2 The City as a System

We need to analyze a city as the ecological system that it is—but of a special kind. Like any other life-supporting system, a city must maintain a flow of energy, provide necessary material resources, and have ways of removing wastes. These ecosystem functions are maintained in a city by transportation and communication with outlying areas. A city is not a self-contained ecosystem; it depends on other cities and rural areas. A city takes in raw materials from the surrounding countryside: food, water, wood, energy, mineral ores—everything that a human society uses. In turn, the city produces and exports material goods and, if it is a truly great city, also exports ideas, innovations, inventions, arts, and the spirit of civilization. A city cannot exist without a countryside to support it. As was said half a century ago, city and country, urban and rural, are one thing—one connected system of energy and material flows—not two things (see Figure 22.2).

As a consequence, if the environment of a city declines, almost certainly the environment of its surroundings will also decline. The reverse is also true: If the environment around a city declines, the city itself will be threatened. Some people suggest, for example, that the ancient Native American settlement in Chaco Canyon, Arizona, declined after the environment surrounding it either lost soil fertility from poor farming practices or suffered a decline in rainfall.

Cities also export waste products to the countryside, including polluted water, air, and solids. The average city resident in an industrial nation annually uses (directly or indirectly) about 208,000 kg (229 tons) of water, 660 kg (0.8 ton) of food, and 3,146 kg (3.5 tons) of fossil fuels and produces 1,660,000 kg (1,826 tons) of sewage, 660 kg (0.8 ton) of solid wastes, and 200 kg (440 lb) of air pollutants. If these are exported without care, they pollute the countryside, reducing its ability to provide necessary resources for the city and making life in the surroundings less healthy and less pleasant.

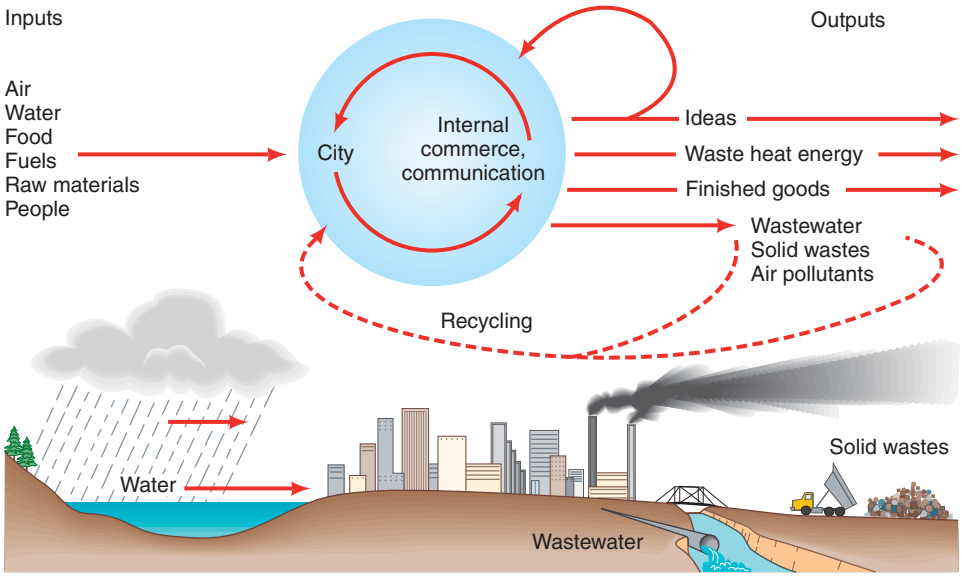


FIGURE 22.2 The city as a system with flows of energy and materials. A city must function as part of a city–countryside ecosystem, with an input of energy and materials, internal cycling, and an output of waste heat energy and material wastes. As in any natural ecosystem, recycling of materials can reduce the need for input and the net output of wastes.

Given such dependencies and interactions between city and surroundings, it's no wonder that relationships between people in cities and in the countryside have often been strained. Why, country dwellers want to know, should they have to deal with the wastes of those in the city? The answer is that many of our serious environmental problems occur at the interface between urban and rural areas. People who live outside but near a city have a vested interest in maintaining both a good environment for that city and maintaining a good system for managing the city's resources. The more concentrated the human population, the more land is available for other uses, including wilderness, recreation, conservation of biological diversity, and production of renewable resources. So cities benefit wilderness, rural areas, and so forth.

With the growing human population, we can imagine two futures. In one, cities are pleasing and livable, use resources from outside the city in a sustainable way, minimize pollution of the surrounding countryside, and allow room for wilderness, agriculture, and forestry. In the other future, cities continue to be seen as environmental negatives and are allowed to decay from the inside. People flee to grander and more expansive suburbs that occupy much land, and the poor who remain in the city live in an unhealthy and unpleasant environment. Without care for the city, its technological structure declines and it pollutes even more than in the past. Trends in both directions appear to be occurring.

In light of all these concerns, this chapter describes how a city can fit within, use, and avoid destroying the ecological systems on which it depends, and how the city itself can serve human needs and desires as well as environmental functions. With this information, you will have the foundation for making decisions, based on science and on what you value, about what kind of urban-rural landscape you believe will provide the most benefits for people and nature.

22.3 The Location of Cities: Site and Situation

Here is an idea that our modern life, with its rapid transportation and its many electronic tools, obscures: Cities are not located at random but develop mainly because of local conditions and regional benefits. In most cases they grow up at crucial transportation locations—an aspect of what is called the city's situation—and at a good site, one that can be readily defended, with good building locations, water supplies, and access to resources. The primary exceptions are cities that have been located primarily for political reasons. Washington, DC, for example, was located to be near the geographic center of the area of the original 13 states; but the site was primarily swampland, and nearby Baltimore provided the major harbor of the region.

The Importance of Site and Situation

The location of a city is influenced primarily by the **site**, which is the summation of all the environmental features of that location; and the **situation**, which is the placement of the city with respect to other areas. A good site includes a geologic substrate suitable for buildings, such as a firm rock base and well-drained soils that are above the water table; nearby supplies of drinkable water; nearby lands suitable for agriculture; and forests. Sometimes,

however, other factors—such as the importance of creating a port city—can compensate for a poor geological site, as long as people are able to build an artificial foundation for the city and maintain that foundation despite nature's attempts to overwhelm it.

Cities influence and are influenced by their environment. The environment of a city affects its growth, success, and importance—and can also provide the seeds of its destruction. All cities are so influenced, and those who plan, manage, and live in cities must be aware of all aspects of the urban environment.

The environmental situation is especially important with respect to transportation and defense. Waterways, for example, are important for transportation. Before railroads, automobiles, and airplanes, cities depended on water for transportation, so most early cities—including all the important cities of the Roman Empire—were on or near waterways. Waterways continue to influence the locations of cities; most major cities of the eastern United States are situated either at major ocean harbors, like New Orleans (see A Closer Look 22.1), or at the fall line on major rivers.

A **fall line** on a river occurs where there is an abrupt drop in elevation of the land, creating waterfalls (Figure 22.3), typically where streams pass from harder, more erosion-resistant rocks to softer rocks. In eastern North America the major fall line occurs at the transition from the granitic and metamorphic bedrock that forms the Appalachian Mountains to the softer, more easily eroded and more recent sedimentary rocks. In general, the transition from major mountain range bedrock to another bedrock forms the primary fall line on continents.

Cities have frequently been established at fall lines, especially the major continental fall lines, for a number

FIGURE 22.3 **The fall line**. Most major cities of the eastern and southern United States lie either at the sites of harbors or along a fall line (shown by the dashed line in the figure), which marks locations of waterfalls and rapids on major rivers. This is one way the location of cities is influenced by the characteristics of the environment. (*Source*: C.B. Hunt, *Natural Regions of the United States and Canada* [San Francisco: Freeman, 1974]. Copyright 1974 by W.H. Freeman & Co.)

of reasons. Fall lines provide waterpower, an important source of energy in the 18th and 19th centuries, when the major eastern cities of the United States were established or rose to importance. At that time, the fall line was the farthest inland that larger ships could navigate; and just above the fall line was the farthest downstream that the river could be easily bridged. Not until the development of steel bridges in the late 19th century did it become practical to span the wider regions of a river below the fall line. The proximity of a city to a river has another advantage: River valleys have rich, water-deposited soils that are good for agriculture. In early times, rivers also provided an important means of waste disposal, which today has become a serious problem.

Cities also are often founded at other kinds of crucial locations, growing up around a market, a river crossing, or a fort. Newcastle, England, and Budapest, Hungary, are located at the lowest bridging points on their rivers. Other cities, such as Geneva, are located where a river enters or leaves a major lake. Some well-known cities are at the confluence of major rivers: Saint Louis lies at the confluence of the Missouri and Mississippi rivers; Manaus (Brazil), Pittsburgh (Pennsylvania), Koblenz (Germany), and Khartoum (Sudan) are at the confluence of several rivers. Many famous cities are at crucial defensive locations, such as on or adjacent to easily defended rock outcrops. Examples include Edinburgh, Athens, and Salzburg. Other cities and municipalities are situated on peninsulas—for example, Istanbul and Monaco. Cities also frequently arise close to a mineral resource, such as salt (Salzburg, Austria), metals (Kalgoorlie, Australia), or medicated waters and thermal springs (Spa, Belgium; Bath, Great Britain; Vichy, France; and Saratoga Springs, New York).

When a successful city grows and spreads over surrounding terrain, its original purpose may be obscured. Its original market or fort may have evolved into a square or a historical curiosity. In most cases, though, cities originated where the situation provided a natural meeting point for people.

An ideal location for a city has both a good site and a good situation, but such a place is difficult to find. Paris is perhaps one of the best examples of a perfect location for a city—one with both a good site and a good situation. Paris began on an island more than 2,000 years ago, the situation providing a natural moat for defense and waterways for transportation. Surrounding countryside, a fertile lowland called the Paris basin, affords good

(a)

(b)

FIGURE 22.4 **(a)** Geologic, topographic, and hydrologic conditions greatly influence how successful the city can be. If these conditions, known collectively as the city's site, are poor, much time and effort are necessary to create a livable environment. New Orleans has a poor site but an important situation. **(b)** In contrast, New York City's Manhattan is a bedrock island rising above the surrounding waters, providing a strong base for buildings and a soil that is sufficiently above the water table so that flooding and mosquitoes are much less of a problem.

A CLOSER LOOK 22.1

Should We Try to Restore New Orleans?

On August 29, 2005, Hurricane Katrina roared, slammed, and battered its way into New Orleans with 192 km/hr (120 mph) winds. Its massive storm surges breached the levees that had protected many of the city's residents from the Gulf Coast's waters, flooding 80% of the city and an estimated 40% of the houses (opening photo). With so many people suddenly homeless and such major damage (Figure 22.5), the New Orleans mayor, Ray Nagin, ordered a first-time-ever complete evacuation of the city, an evacuation that became its own disaster. Some estimates claimed that 80% of the 1.3 million residents of the greater New Orleans metropolitan area evacuated.

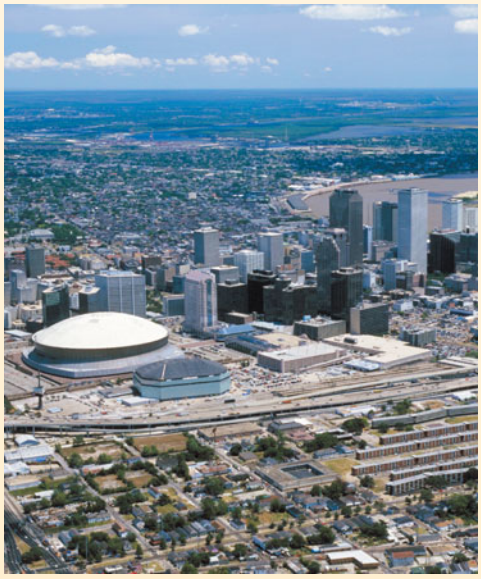
By the time it was over, Katrina was the most costly hurricane in the history of the United States—between $75 billion and $100 billion, in addition to an estimated $200 billion in lost business revenue. A year after the hurricane, much of the damage remained, and even today much of New Orleans is not yet restored. Citizens remain frustrated by the lack of progress on many fronts.[8] An estimated 50,000 homes will have to be demolished. Many former residents are still living elsewhere, scattered across the nation. The storm affected the casino and entertainment industry, as many of the Gulf Coast's casinos were destroyed or sustained considerable damage. New Orleans also was home to roughly 115,000 small businesses, many of which will likely never reopen.

The problem with New Orleans is that it is built in the wetlands at the mouth of the Mississippi River, and much of it is below sea level (Figure 22.6). Although a port at the mouth of the Mississippi River has always been an important location for a city, there just wasn't a great place to build that city. The original development, the French Quarter, was just barely above sea level, about the best that could be found.

Hurricane Katrina was rated a Category 3 hurricane, but discussions about protecting the city from future storms focus on an even worse scenario, a Category 5 hurricane with winds up to 249 km/hr (155 mph). As of 2009, 68,000 homes remained abandoned.[9] Clearly, New Orleans requires an expensive improvement in its site if it is to survive at all. And if it does, will it be restored to its former glory and importance? Will it continue in any fashion, even as a mere shadow of its former self? Fortunately, the city has many residents who love it and are working hard to restore it.

To know how to rebuild the city, to decide whether this is worth doing, and to forecast whether such a restoration is likely, we have to understand the ecology of cities, how cities fit into the environment, the complex interplay between a city and its surroundings, and how a city acts as an environment for its residents.

(a)



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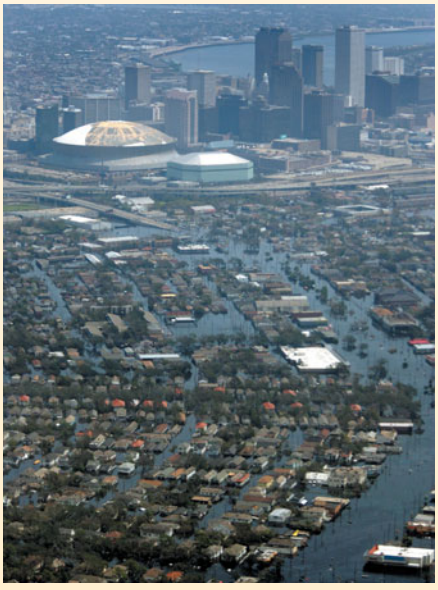

FIGURE 22.5 **(a)** Aerial photograph of New Orleans skyline before Hurricane Katrina struck. The Super Dome is near the center left. **(b)** A similar view of New Orleans, but after Hurricane Katrina struck on August 31, 2005. The widespread flooding of the city from the hurricane is visible.

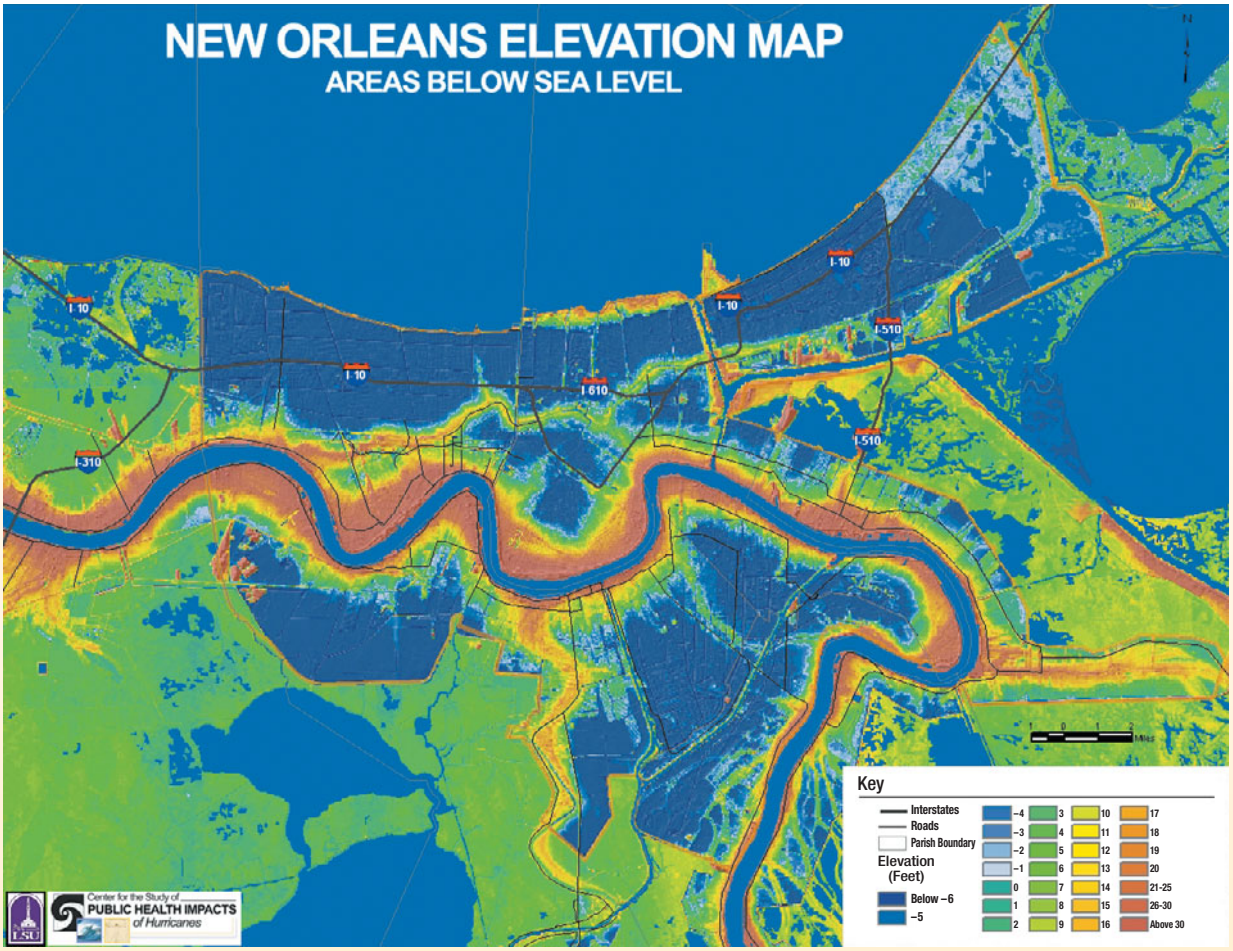

FIGURE 22.6 Map of New Orleans showing how much of the city is below sea level. The city began with the French Quarter, which is above sea level. As the population grew and expanded, levees were built to keep the water out, and the city became an accident waiting to happen. (*Source*: Tim Vasquez/Weather Graphics)

local agricultural land and other natural resources. New Orleans on the other hand, is an example of a city with an important situation but, as Hurricane Katrina made abundantly clear, a poor site (Figure 22.4).

Site Modification

Site is provided by the environment, but technology and environmental change can alter a site for better or worse. People can improve the site of a city and have done so when the situation of the city made it important and when its citizens could afford large projects. An excellent situation can sometimes compensate for a poor site. However, improvements are almost always required to the site so the city can persist.

Changes in a site over time can have adverse effects on a city. For example, Bruges, Belgium, developed as an important center for commerce in the 13th century because its harbor on the English Channel permitted trade with England and other European nations. By the 15th century, however, the harbor had seriously silted in, and the limited technology of the time did not make dredging possible (Figure 22.7). This problem, combined with political events, led to a decline in the importance of Bruges—a decline from which it never recovered. Nevertheless, today, Bruges still lives, a beautiful city with many fine examples of medieval architecture. Ironically, that these buildings were never replaced with modern ones makes Bruges a modern tourist destination.

Ghent, Belgium, and Ravenna, Italy, are other examples of cities whose harbors silted in. As human effects on the environment bring about global change, there may be rapid, serious changes in the sites of many cities.

FIGURE 22.7 Bruges, Belgium, was once an important seaport, but over the years sand that the ocean deposited in the harbor left the city far inland. Today, Bruges is a beautiful historic city, though no longer important for commerce.

22.4 An Environmental History of Cities

The Rise of Towns

The first cities emerged on the landscape thousands of years ago, during the New Stone Age, with the development of agriculture, which provided enough food to sustain a city.[8] In this first stage, the number of city dwellers per square kilometer was much higher than the number of people in the surrounding countryside, but the density was still too low to cause rapid, serious disturbance to the land. In fact, the waste from city dwellers and their animals was an important fertilizer for the surrounding farmlands. In this stage, the city's size was restricted by the primitive means of transporting food and necessary resources into the city and removing waste.[10]

The Urban Center

In the second stage, more efficient transportation made possible the development of much larger urban centers. Boats, barges, canals, and wharves, as well as roads, horses, carriages, and carts, enabled cities to rise up and thrive farther from agricultural areas. Ancient Rome, originally dependent on local produce, became a city fed by granaries in Africa and the Near East.

The population of a city is limited by how far a person can travel in one day to and from work and by how many people can be packed into an area (density). In the second stage, the internal size of a city was limited by pedestrian travel. A worker had to be able to walk to work, do a day's work, and walk home the same day. The density of people per square kilometer was limited by architectural techniques and primitive waste disposal. These cities never exceeded a population of 1 million, and only a few approached this size, most notably Rome and some cities in China.

The Industrial Metropolis

The Industrial Revolution allowed greater modification of the environment than had been possible before. Three technological advances that had significant effects on the city environment were improved medicine and sanitation, which led to the control of many diseases, and improved transportation.

Modern transportation makes a larger city possible. Workers can live farther from their place of work and commerce, and communication can extend over larger areas. Air travel has freed cities even more from the traditional limitation of situation. We now have thriving urban areas where previously transportation was poor: in the Far North (Fairbanks, Alaska) and on islands (Honolulu). These changes increase city dwellers' sense of separateness from their natural environment.

Subways and commuter trains have also led to the development of suburbs. In some cities, however, the negative effects of urban sprawl have prompted many people to return to the urban centers or to smaller, satellite cities surrounding the central city. The drawbacks of suburban commuting and the destruction of the landscape in suburbs have brought new appeal to the city center.

The Center of Civilization

We are at the beginning of a new stage in the development of cities. With modern telecommunications, people can work at home or at distant locations. Perhaps, as telecommunication frees us from the necessity for certain kinds of commercial travel and related activities, the city can become a cleaner, more pleasing center of civilization.

An optimistic future for cities requires a continued abundance of energy and material resources, which are certainly not guaranteed, and wise use of these resources. If energy resources are rapidly depleted, modern mass transit may fail, fewer people will be able to live in suburbs, and the cities will become more crowded. Reliance on coal and wood will increase air pollution. Continued destruction of the land within and near cities could compound transportation problems, making local production of food impossible. The future of our cities depends on our ability to plan and to use our resources wisely.

22.5 City Planning and the Environment

If people live in densely populated cities, ways must be found to make urban life healthy and pleasant and to keep the cities from polluting the very environment that their population depends on. City planners have found many ways to make cities pleasing environments: developing parks and connecting cities to rivers and nearby mountains in environmentally and aesthetically pleasing ways. City planning has a long and surprising history, with the paired goals of defense and beauty. Long experience in city planning, combined with modern knowledge from environmental sciences, can make cities of the future healthier and more satisfying to people and better integrated within the environment. Beautiful cities are not only healthy but also attract more people, relieving pressure on the countryside.

A city can never be free of environmental constraints, even though its human constructions give us a false sense of security. Lewis Mumford, a historian of cities, wrote, "Cities give us the illusion of self-sufficiency and independence and of the possibility of physical continuity without conscious renewal."[8,11] But this security is only an illusion.

A danger in city planning is the tendency to totally transform the features of a city center from natural to artificial—to completely replace grass and soil with pavement, gravel, houses, and commercial buildings, creating an impression that civilization has dominated the environment. Ironically, the artificial aspects of the city that make it seem so independent of the rest of the world actually make it more dependent on its rural surroundings for all resources. Although such a city appears to its inhabitants to grow stronger and more independent, it actually becomes more fragile.[8]

City Planning for Defense and Beauty

Many cities in history grew without any conscious plan. However, **city planning**—formal, conscious planning for new cities in modern Western civilization—can be traced back as far as the 15th century. Sometimes cities have been designed for specific social purposes, with little consideration of the environment. In other cases the environment and its effect on city residents have been major planning considerations.

Defense and beauty have been two dominant themes in formal city planning (see A Closer Look 22.2). We can think of these two types of cities as fortress cities and park cities. The ideas of the fortress city and the park city influenced the planning of cities in North America. The importance of aesthetic considerations is illustrated in the plan of Washington, DC, designed by Pierre Charles L'Enfant. L'Enfant mixed a traditional rectangular grid pattern of streets (which can be traced back to the Romans) with broad avenues set at angles. The goal was to create a beautiful city with many parks, including small ones at the intersections of avenues and streets. This design has made Washington, DC, one of the most pleasant cities in the United States.

The City Park

Parks have become more and more important in cities. A significant advance for U.S. cities was the 19th-century planning and construction of Central Park in New York City, the first large public park in the United States. The park's designer, Frederick Law Olmsted, was one of the most important modern experts on city planning. He took site and situation into account and attempted to blend improvements to a site with the aesthetic qualities of the city.[12]

Central Park is an example of "design with nature," a term coined much later, and its design influenced other U.S. city parks. For Olmsted, the goal of a city park was to provide psychological and physiological relief from city life through access to nature and beauty. Vegetation was one of the keys to creating beauty in the park, and Olmsted carefully considered the opportunities and limitations of topography, geology, hydrology, and vegetation.

In contrast to the approach of a preservationist, who might simply have strived to return the area to its natural, wild state, Olmsted created a naturalistic environment, keeping the rugged, rocky terrain but putting ponds where he thought they were desirable. To add variety, he constructed "rambles, " walkways that were densely planted and followed circuitous patterns. He created a "sheep meadow" by using explosives to flatten the terrain. In the southern part of the park, where there were flat meadows, he created recreational areas. To meet the needs of the city, he built transverse roads through the park and also created depressed roadways that allowed traffic to cross the park without detracting from the vistas seen by park visitors.

Olmsted has remained a major figure in American city planning, and the firm he founded continued to be important in city planning into the 20th century. His skill in creating designs that addressed both the physical and aesthetic needs of a city is further illustrated by his work in Boston. Boston's original site had certain advantages: a narrow peninsula with several hills that could be easily defended, a good harbor, and a good water supply. But as Boston grew, demand increased for more land for buildings, a larger area for docking ships, and a better water supply. The need to control ocean floods and to dispose of solid

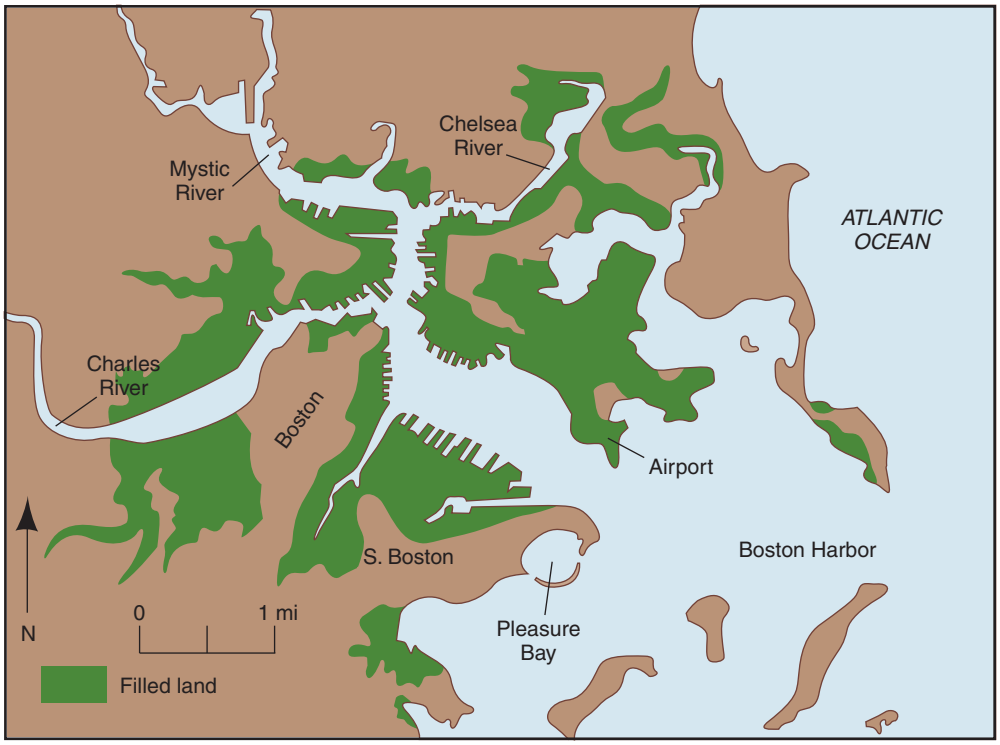

FIGURE 22.8 Nature integrated into a city plan. Boston has been modified over time to improve the environment and provide more building locations. This map of Boston shows land filled in to provide new building sites as of 1982. Although such landfill allows for expansion of the city, it can also create environmental problems, which then must be solved. (*Source*: A.W. Spirn, *The Granite Garden: Urban Nature and Human Design* [New York: Basic Books, 1984].)

and liquid wastes grew as well. Much of the original tidal flats area, which had been too wet to build on and too shallow to navigate, had been filled in (Figure 22.8). Hills had been leveled and the marshes filled with soil. The largest project had been the filling of Back Bay, which began in 1858 and continued for decades. Once filled, however, the area had suffered from flooding and water pollution.

Olmsted's solution to these problems was a water-control project called the "fens." His goal was to "abate existing nuisances" by keeping sewage out of the streams and ponds and building artificial banks for the streams to prevent flooding—and to do this in a natural-looking way. His solution included creating artificial watercourses by digging shallow depressions in the tidal flats, following meandering patterns like natural streams; setting aside other artificial depressions as holding ponds for tidal flooding; restoring a natural salt marsh planted with vegetation tolerant of brackish water; and planting the entire area to serve as a recreational park when not in flood. He put a tidal gate on the Charles River—Boston's major river—and had two major streams diverted directly through culverts into the Charles so that they flooded the fens only during flood periods. He reconstructed the Muddy River primarily to create new, accessible landscape. The result of Olmsted's vision was that control of water became an aesthetic addition to the city. The blending of several goals made the development of the fens a landmark in city planning. Although to the casual stroller it appears to be simply a park for recreation, the area serves an important environmental function in flood control.

Parks near rivers and the ocean are receiving more and more attention. For example, New York City is spending several hundred million dollars to build the Hudson River Park along the Hudson River, where previously abandoned docks and warehouses littered the shoreline and barred public access to the river.

An extension of the park idea was the "garden city," a term coined in 1902 by Ebenezer Howard. Howard believed that city and countryside should be planned together. A **garden city** was one that was surrounded by a **greenbelt**, a belt of parkways, parks, or farmland. The idea was to locate garden cities in a set connected by greenbelts, forming a system of countryside and urban landscapes. The idea caught on, and garden cities were planned and developed in Great Britain and the United States. Greenbelt, Maryland, just outside Washington, DC, is one of these cities, as is Lecheworth, England. Howard's garden city concept, like Olmsted's use of the natural landscape in designing city parks, continues to be a part of city planning today.

A CLOSER LOOK 22.2

A Brief History of City Planning

Defense and beauty have been two dominant themes in formal city planning. Ancient Roman cities were typically designed along simple geometric patterns that had both practical and aesthetic benefits. The symmetry of the design was considered beautiful but was also a useful layout for streets.

During the height of Islamic culture, in the first millennium, Islamic cities typically contained beautiful gardens, often within the grounds of royalty. Among the most famous urban gardens in the world are the gardens of the Alhambra, a palace in Granada, Spain (Figure 22.9). The gardens were created when this city was a Moorish capital, and they were maintained after Islamic control of Granada ended in 1492. Today, as a tourist attraction that receives 2 million visitors a year, the Alhambra gardens demonstrate the economic benefits of aesthetic considerations in city planning. They also illustrate that making a beautiful park a specific focus in a city benefits the city environment by providing relief from the city itself.

After the fall of the Roman Empire, the earliest planned towns and cities in Europe were walled fortress cities designed for defense. But even in these instances, city planners considered the aesthetics of the town. In the 15th century, one such planner, Leon Battista Alberti, argued that large and important towns should have broad and straight streets; smaller, less fortified towns should have winding streets to increase their beauty. He also advocated the inclusion of town squares and recreational areas, which continue to be important considerations in city planning.[13] One of the most successful of these walled cities is Carcassonne, in southern France, now the third most visited tourist site in that country. Today, walled cities have become major tourist attractions, again illustrating the economic benefits of good aesthetic planning in urban development.

The usefulness of walled cities essentially ended with the invention of gunpowder. The Renaissance sparked an interest in the ideal city, which in turn led to the development of the park city. A preference for gardens and parks, emphasizing recreation, developed in Western civilization in the 17th and 18th centuries. It characterized the plan of Versailles, France, with its famous formal parks of many sizes and tree-lined walks, and also the work of the Englishman Capability Brown, who designed parks in England and was one of the founders of the English school of landscape design, which emphasized naturalistic gardens.

FIGURE 22.9 Planned beauty. The Alhambra gardens of Granada, Spain, illustrate how vegetation can be used to create beauty within a city.

22.6 The City as an Environment

A city changes the landscape, and because it does, it also changes the relationship between biological and physical aspects of the environment. Many of these changes were discussed in earlier chapters as aspects of pollution, water management, or climate. You may find some mentioned again in the following sections, generally with a focus on how effective city planning can reduce the problems.

The Energy Budget of a City

Like any ecological and environmental system, a city has an "energy budget." The city exchanges energy with its environment in the following ways: (1) absorption and reflection of solar energy, (2) evaporation of water, (3) conduction of air, (4) winds (air convection), (5) transport of fuels into the city and burning of fuels by people in the city, and (6) convection of water (subsurface and surface stream flow). These in turn affect the climate in the city, and the city may affect the climate in the nearby surroundings, a possible landscape effect.

The Urban Atmosphere and Climate

Cities affect the local climate; as the city changes, so does its climate (see Chapter 20). Cities are generally less windy than nonurban areas because buildings and other structures obstruct the flow of air. But city buildings also channel the wind, sometimes creating local wind tunnels with high wind speeds. The flow of wind around one building is influenced by nearby buildings, and the total wind flow through a city is the result of the relationships among all the buildings. Thus, plans for a new building must take into account its location among other buildings as well as its shape. In some cases, when this has not been done, dangerous winds around tall buildings have blown out windows, as happened to the John Hancock Building in Boston on January 20, 1973, a famous example of the problem.

A city also typically receives less sunlight than the countryside because of the particulates in the atmosphere over cities—often over ten times more particulates than in surrounding areas.[15] Despite reduced sunlight, a city is a heat island, warmer than surrounding areas, for two reasons: (1) the burning of fossil fuels and other industrial and residential activities and (2) a lower rate of heat loss, partly because buildings and paving materials act as solar collectors (Figure 22.10).[14]

Solar Energy in Cities

Until modern times, it was common to use solar energy, through what is called today *passive solar energy*, to help heat city houses. Cities in ancient Greece, Rome, and China were designed so that houses and patios faced south and passive solar energy applications were accessible to each household.[19] The 20th century in America and Europe was a major exception to this approach because cheap and easily accessible fossil fuels led people to forget certain fundamental lessons. Today, the industrialized nations are beginning to appreciate the importance of solar energy once again. Solar photovoltaic devices that convert sunlight to electricity are becoming a common sight in many cities, and some cities have enacted solar energy ordinances that make it illegal to shade another property owner's building in such a way that it loses solar heating capability. (See Chapter 16 for a discussion of solar energy.)

Water in the Urban Environment

Modern cities affect the water cycle, in turn affecting soils and consequently plants and animals in the city. Because city streets and buildings prevent water infiltration, most rain runs off into storm sewers. The streets and sidewalks also add to the heat island effect by preventing water in the soil from evaporating to the atmosphere, a process that cools natural ecosystems. Chances of flooding increase both within the city and downstream outside the city. New, ecological methods of managing stormwater can alleviate these problems by controlling the speed and quality of water running off pavements and into streams. For example, a plan for the central library's parking lot in Alexandria, Virginia, includes wetland vegetation and soils that temporarily absorb runoff from the parking lot, remove some of the pollutants, and slow down the water flow (Figure 22.11).

Most cities have a single underground sewage system. During times of no rain or light rain, this system handles only sewage. But during periods of heavy rain, the runoff is mixed with the sewage and can exceed the capacity

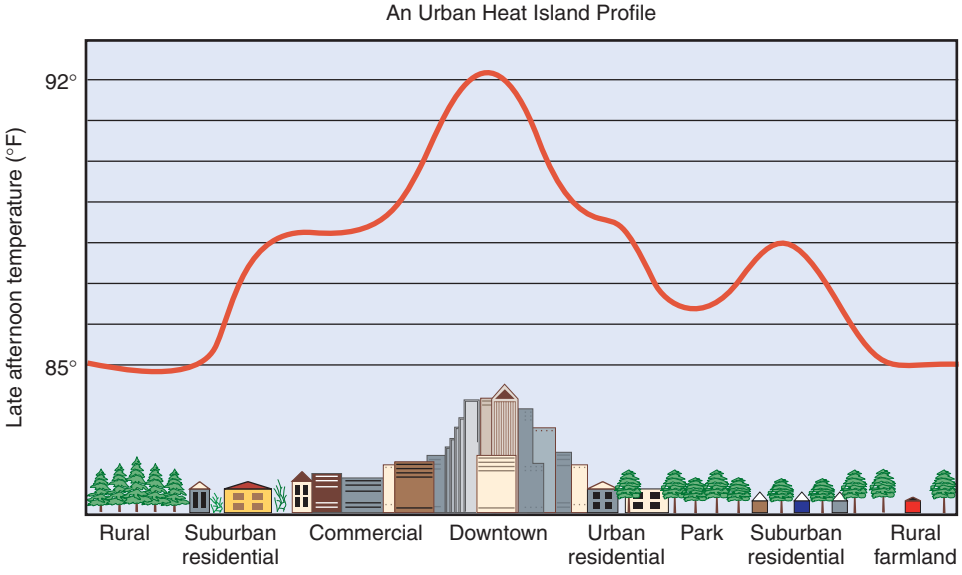

FIGURE 22.10 A typical urban heat island profile. The graph shows temperature changes correlated with the density of development and trees. (*Source*: Andrasko and Huang, in H. Akbari et al., *Cooling Our Communities: A Guidebook on Tree Planting and Light-Colored Surfacing* [Washington, DC: U.S. EPA Office of Policy Analysis, 1992].)

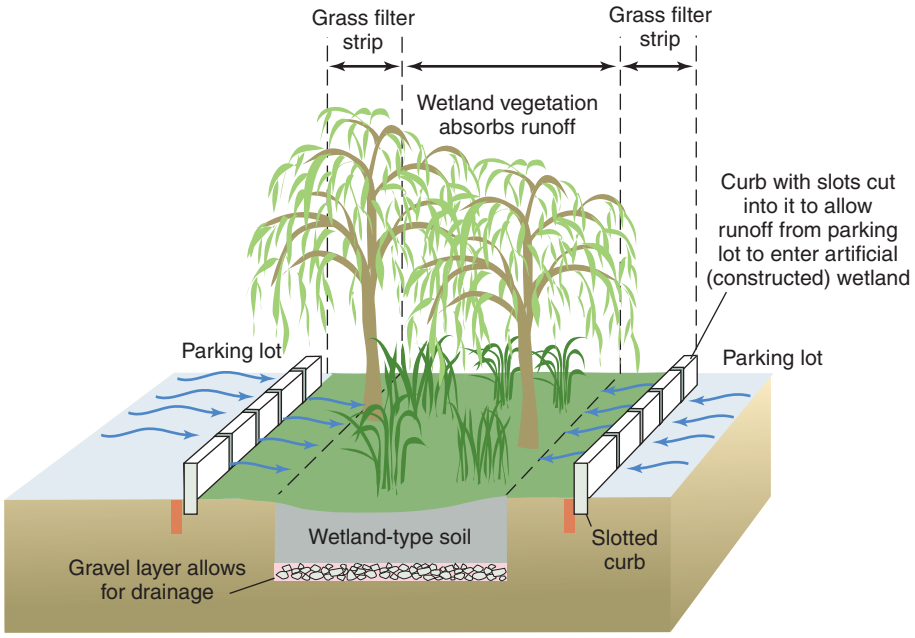

FIGURE 22.11 Planned for better drainage. A plan for the Alexandria, Virginia, central library parking lot includes wetland vegetation and soils that temporarily absorb runoff from the parking lot (see arrows). The landscape architecture firm of Rhodeside & Harwell planned the project. (*Source*: Modified after Rhodeside & Harwell Landscape Architects.)

of sewage-treatment plants, causing sewage to be released downstream without sufficient treatment. In most cities that already have such systems, the expense of building a completely new and separate runoff system is prohibitive, so other solutions must be found. One city that avoids this problem is Woodlands, Texas. It was designed by the famous landscape architect Ian McHarg, who originated the phrase "design with nature," the subject of A Closer Look 22.3.[15]

Because of reduced evaporation, midlatitude cities generally have lower relative humidity (2% lower in winter to 8% lower in summer) than the surrounding countryside. At the same time, cities can have higher rainfall than their surroundings because dust above a city provides particles for condensation of water vapor. Some urban areas have 5–10% more precipitation and considerably more cloud cover and fog than their surrounding areas. Fog is particularly troublesome in the winter and may impede ground and air traffic.

Soils in the City

A modern city has a great impact on soils. Since most of a city's soil is covered by cement, asphalt, or stone, the soil no longer has its natural cover of vegetation, and the natural exchange of gases between the soil and air is greatly reduced. No longer replenished by vegetation growth, these soils lose organic matter, and soil organisms die from lack of food and oxygen. In addition, the construction process and the weight of the buildings compact the soil, which restricts water flow. City soils, then, are more likely to be compacted, waterlogged, impervious to water flow, and lacking in organic matter.

Pollution in the City

In a city, everything is concentrated, including pollutants. City dwellers are exposed to more kinds of toxic chemicals in higher concentrations and to more human-produced noise, heat, and particulates than are their rural neighbors (see Chapter 15). This environment makes life riskier—in fact, lives are shortened by an average of one to two years in the most polluted cities in the United States. The city with the greatest number of early deaths is Los Angeles, with an estimated 5,973 early deaths per year, followed by New York with 4,024, Chicago with 3,479, Philadelphia with 2,590, and Detroit with 2,123.

Some urban pollution comes from motor vehicles, which emit nitrogen oxides, ozone, carbon monoxide, and other air pollutants from exhaust. Electric power plants also produce air pollutants. Home heating is a third source, contributing particulates, sulfur oxides, nitrogen oxides, and other toxic gases. Industries are a fourth source, contributing a wide variety of chemicals. The primary sources of particulate air pollution—which consists of smoke, soot, and tiny particles formed from emissions of sulfur dioxide and volatile organic compounds—are older, coal-burning power plants, industrial boilers, and gas- and diesel-powered vehicles.[16]

Although it is impossible to eliminate exposure to pollutants in a city, it is possible to reduce exposure through careful design, planning, and development. For example, when lead was widely used in gasoline, exposure to lead was greater near roads. Exposure could be reduced by placing houses and recreational areas away from roads and by developing a buffer zone using trees that are resistant to the pollutant and that absorb pollutants.

22.7 Bringing Nature to the City

As we saw in this chapter's opening case study about New York City's High Line, a practical problem is how to bring nature to the city—how to make plants and animals part of a city landscape (see A Closer Look 22.3). This has evolved into several specialized professions, including urban forestry (whose professionals are often called tree wardens), landscape architecture, city planning and management, and civil engineering specializing in urban development. Most cities have an urban forester on the payroll who determines the best sites for planting trees and the tree species best suited to those environments. These professionals take into account climate, soils, and the general influences of the urban setting, such as the shade imposed by tall buildings and the pollution from motor vehicles.

Cities and Their Rivers

Traditionally, rivers have been valued for their usefulness in transportation and as places to dump wastes and therefore not places of beauty or recreation. The old story was that a river renewed and cleaned itself every mile or every 3 miles (depending on who said it). That may have been relatively correct when there was one person or one family per linear river mile, but it is not for today's cities, with their high population densities and widespread use and dumping of modern chemicals.

Kansas City, Missouri, at the confluence of the Kansas and Missouri rivers, illustrates the traditional disconnect between a city and its river. The Missouri River's floodplain provides a convenient transportation corridor, so the south shore is dominated by railroads, while downtown the north shore forms the southern boundary of the city's airport. Except for a small riverfront park, the river has little place in this city as a source of recreation and relief for its citizens or in the conservation of nature.

The same used to be true of the Hudson River in New York, but that river has undergone a major cleanup since the beginning of the project *Clearwater,* led in part by folksinger Pete Seeger and also by activities of the city's Hudson River Foundation and Metropolitan Waterfront Alliance. Not only is the river cleaner, but an extensive Hudson River Park is being completed, transforming Manhattan's previously industrial and uninviting riverside into a beautifully landscaped and inviting park (Figure 22.12) extending for miles from the southern end of Manhattan to near the George Washington Bridge.

The throngs of sunbathers, picnickers, older people, young couples, and parents with children relaxing on the grass and enjoying the river views are proof of city dwellers' need for contact with nature. And a lesson we are learning is that for cities on rivers, one way to bring nature to the city is to connect the city to its river.

A CLOSER LOOK 22.3

Design with Nature

The new town of Woodlands, a suburb of Houston, Texas, is an example of professional planning. Woodlands was designed so that most houses and roads were on ridges; the lowlands were left as natural open space. The lowlands provide areas for temporary storage of floodwater and, because the land is unpaved, allow rain to penetrate the soil and recharge the aquifer for Houston. Preserving the natural lowlands has other environmental benefits as well. In this region of Texas, low-lying wetlands are habitats for native wildlife, such as deer. Large, attractive trees, such as magnolias, grow here, providing food and habitat for birds. The innovative city plan has economic as well as aesthetic and conservational benefits. It is estimated that a conventional drainage system would have cost $14 million more than the amount spent to develop and maintain the wetlands.[21]

A kind of soil important in modern cities is the soil that occurs on **made lands**—lands created from fill, sometimes as waste dumps of all kinds, sometimes to create more land for construction. The soils of made lands are different from those of the original landscape. They may be made of all kinds of trash, from newspapers to bathtubs, and may contain some toxic materials. The fill material is unconsolidated, meaning that it is loose material without rock structure. Thus, it is not well suited to be a foundation for buildings. Fill material is particularly vulnerable to earthquake tremors and can act somewhat like a liquid and amplify the effects of the earthquake on buildings. However, some made lands have been turned into well-used parks. For example, a marina park in Berkeley, California, is built on a solid-waste landfill. It extends into San Francisco Bay, providing public access to beautiful scenery, and is a windy location, popular for kite flying and family strolls. (See Chapter 23 for more information about solid-waste disposal.)

FIGURE 22.12 The newly built Hudson River Park on Manhattan's West Side illustrates the changing view of rivers and the improved use of riverfronts for recreation and urban landscape beauty.

FIGURE 22.13 Paris was one of the first modern cities to use trees along streets to provide beauty and shade, as shown in this picture of the famous Champs-Elysées.

Vegetation in Cities

Trees, shrubs, and flowers add to the beauty of a city. Plants fill different needs in different locations. Trees provide shade, which reduces the need for air-conditioning and makes travel much more pleasant in hot weather. In parks, vegetation provides places for quiet contemplation; trees and shrubs can block some of the city sounds, and their complex shapes and structures create a sense of solitude. Plants also provide habitats for wildlife, such as birds and squirrels, which many urban residents consider pleasant additions to a city.

The use of trees in cities has expanded since the Renaissance. In earlier times, trees and shrubs were set apart in gardens, where they were viewed as scenery but not experienced as part of ordinary activities. Street trees were first used in Europe in the 18th century; among the first cities to line streets with trees were London and Paris (Figure 22.13). In many cities, trees are now considered an essential element of the urban visual scene, and major cities have large tree-planting programs. In New York City, for example, 11,000 trees are planted each year, and in Vancouver, Canada, 4,000 are planted each year.[17] Trees are also increasingly used to soften the effects of climate near houses. In colder climates, rows of conifers planted to the north of a house can protect it from winter winds. Deciduous trees to the south can provide shade in the summer, reducing requirements for air-conditioning, yet allowing sunlight to warm the house in the winter (Figure 22.14).

Cities can even provide habitat for endangered plants. For example, Lakeland, Florida, uses endangered plants in local landscaping with considerable success. However, it is necessary to select species carefully because vegetation in cities must be able to withstand special kinds of stress, such as compacted soils, poor drainage, and air pollution. Because trees along city streets are often surrounded by cement, and because the soils tend to be compacted and drain poorly, the root systems are likely to suffer from extremes of drought on the one hand and soil saturation (immediately following or during a rainstorm) on the other. The solution to this particular problem is to specially prepare streets and sidewalks for tree growth. A tree-planting project was completed for the World Bank Building in Washington, DC, in 1996. Special care was taken to provide good growing conditions for trees, including aeration, irrigation, and adequate drainage so that the soils did not become waterlogged. The trees continue to grow and remain healthy.[23]

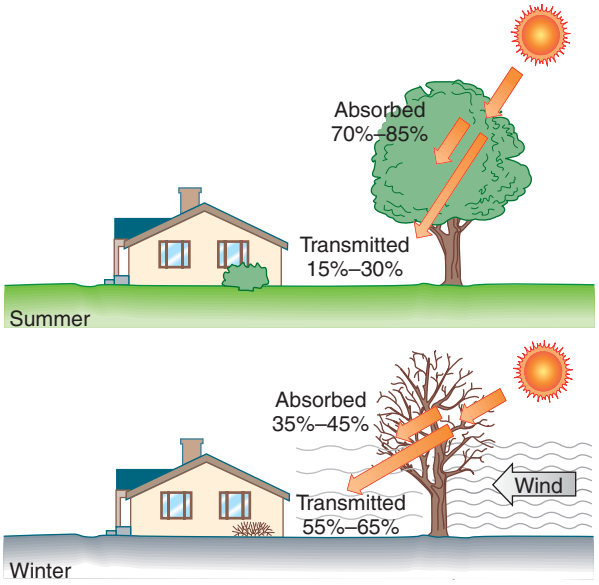

FIGURE 22.14 Trees cool homes. Trees can improve the microclimate near a house, protecting the house from winter winds and providing shade in the summer while allowing sunlight through in the winter. (*Source*: J. Huang and S. Winnett, in H. Akbari et al., *Cooling Our Communities: A Guidebook on Tree Planting and Light-Colored Surfacing* [Washington, DC: U.S. EPA Office of Policy Analysis, 1992].)

Many species of trees and plants are very sensitive to air pollution and will not thrive in cities. The eastern white pine of North America, for example, is extremely sensitive to ozone pollution and does not do well in cities with heavy motor-vehicle traffic or along highways. Dust, too, can interfere with the exchange of oxygen and carbon dioxide necessary for photosynthesis and respiration of the trees. City trees also suffer direct damage from pets, from the physical impact of bicycles, cars, and trucks, and from vandalism. Trees subject to such stresses are more susceptible to attacks by fungus diseases and insects. The lifetime of trees in a city is generally shorter than in their natural woodland habitats unless they are given considerable care.

Some species of trees are more useful and successful in cities than are others. An ideal urban tree would be resistant to all forms of urban stress, have a beautiful form and foliage, and produce no messy fruit, flowers, or leaf litter that required removal. In most cities, in part because of these requirements, only a few tree species are used for street planting. However, reliance on one or a few species results in ecologically fragile urban planting, as we learned when Dutch elm disease spread throughout the eastern United States, destroying urban elms and leaving large stretches of a city treeless. It is prudent to use a greater diversity of trees to avoid the effects of insect infestations and tree diseases.[18]

Cities, of course, have many recently disturbed areas, including abandoned lots and the medians in boulevards and highways. Disturbed areas provide habitat for early-successional plants, including many that we call "weeds," which are often introduced (exotic) plants, such as European mustard. Therefore, wild plants that do particularly well in cities are those characteristic of disturbed areas and of early stages in ecological succession (see Chapter 5). City roadsides in Europe and North America have wild mustards, asters, and other early-successional plants.

Urban "Wilds": The City as Habitat for Wildlife and Endangered Species

We don't associate wildlife with cities—indeed, with the exception of some birds and small, docile mammals such as squirrels, most wildlife in cities are considered pests. But there is much more wildlife in cities, a great deal of it unnoticed. In addition, there is growing recognition that urban areas can be modified to provide habitats for wildlife that people can enjoy. This can be an important method of biological conservation.[19, 20]

We can divide city wildlife into the following categories: (1) species that cannot persist in an urban environment and disappear; (2) those that tolerate an urban environment but do better elsewhere; (3) those that have adapted to urban environments, are abundant there, and are either neutral or beneficial to human beings; and (4) those that are so successful they become pests.

Cooper's hawks probably belong in the third category. They are doing pretty well in Tucson, Arizona, a city of 900,000 people. Although this hawk is a native of the surrounding Sonoran Desert, some of them are nesting in groves of trees within the city. Nest success in 2005 was 84%, between two-thirds and three-quarters of the juvenile hawks that left the nest were still alive six months later, and the population is increasing (Figure 23.15). Scientists studying the hawk in Tucson concluded that "urbanized landscape can provide high-quality habitat."[21]

Cities can even be home to rare or endangered species. Peregrine falcons once hunted pigeons above the streets of Manhattan. Unknown to most New Yorkers, the falcons nested on the ledges of skyscrapers and dived on their prey in an impressive display of predation. The falcons disappeared when DDT and other organic pollutants caused a thinning of their eggshells and a failure in reproduction, but they have been reintroduced into the city. The first reintroduction into New York City took place in 1982, and today 32 falcons are living there.[22] The reintroduction of peregrine falcons illustrates an important recent trend: the growing understanding that city environments can assist in the conservation of nature, including the conservation of endangered species.

In sum, cities are a habitat, albeit artificial. They can provide all the needs—physical structures and necessary resources such as food, minerals, and water—for many plants and animals. We can identify ecological food chains in cities, as shown in Figure 22.16 for insect-eating birds and for a fox. These can occur when areas cleared of buildings and abandoned begin to recover and are in an early stage of ecological succession. For some species, cities' artificial structures are sufficiently like their original habitat to be home.[23] Chimney swifts, for example, which once lived in hollow trees, are now common in chimneys and other vertical shafts, where they glue their nests to the walls with saliva. A city can easily have more chimneys per square kilometer than a forest has hollow trees.

FIGURE 22.15 Cooper's hawks, like this one, live, nest, and breed in the city of Tucson, Arizona.

Cities also have natural habitats in parks and preserves. In fact, modern parks provide some of the world's best wildlife habitats. In New York City's Central Park, approximately 260 species of birds have been observed—100 in a single day. Urban zoos, too, play an important role in conserving endangered species, and the importance of parks and zoos will increase as truly wild areas shrink.

Finally, cities that are seaports often have many species of marine wildlife at their doorsteps. New York City's waters include sharks, bluefish, mackerel, tuna, striped bass, and nearly 250 other species of fish.[24]

City environments can contribute to wildlife conservation in a number of ways. Urban kitchen gardens—backyard gardens that provide table vegetables and decorative plants—can be designed to provide habitats. For instance, these gardens can include flowers that provide nectar for threatened or endangered hummingbirds. Rivers and their riparian zones, ocean shorelines, and wooded parks can provide habitats for endangered species and ecosystems. For example, prairie vegetation, which once occupied more land area than any other vegetation type in the United States, is rare today, but one restored prairie exists within the city limits of Omaha, Nebraska. (Some urban nature preserves are not accessible to the public or offer only limited access, as is the case with the prairie preserve in Omaha.)

Urban drainage structures can also be designed as wildlife habitats. A typical urban runoff design depends on concrete-lined ditches that speed the flow of water from city streets to lakes, rivers, or the ocean. However, as with Boston's Back Bay design, discussed earlier, these features can be planned to maintain or create stream and marsh habitats, with meandering waterways and storage areas that do not interfere with city processes. Such areas can become habitats for fish and mammals (Figure 22.17). Modified to promote wildlife, cities can provide urban corridors that allow wildlife to migrate along their natural routes.[25] Urban corridors also help to prevent some of the effects of ecological islands (see Chapter 8) and are increasingly important to biological conservation.

Animal Pests

Pests are familiar to urban dwellers. The most common city pests are cockroaches, fleas, termites, rats, pigeons, and (since banning DDT) bedbugs, but there are many more, especially species of insects. In gardens and parks, pests include insects, birds, and mammals that feed on fruit and vegetables and destroy foliage of shade trees and plants. Pests compete with people for food and spread diseases. Indeed, before modern sanitation and medicine, such diseases played a major role in limiting human population density in cities. Bubonic plague is spread by fleas found on rodents; mice and rats in cities

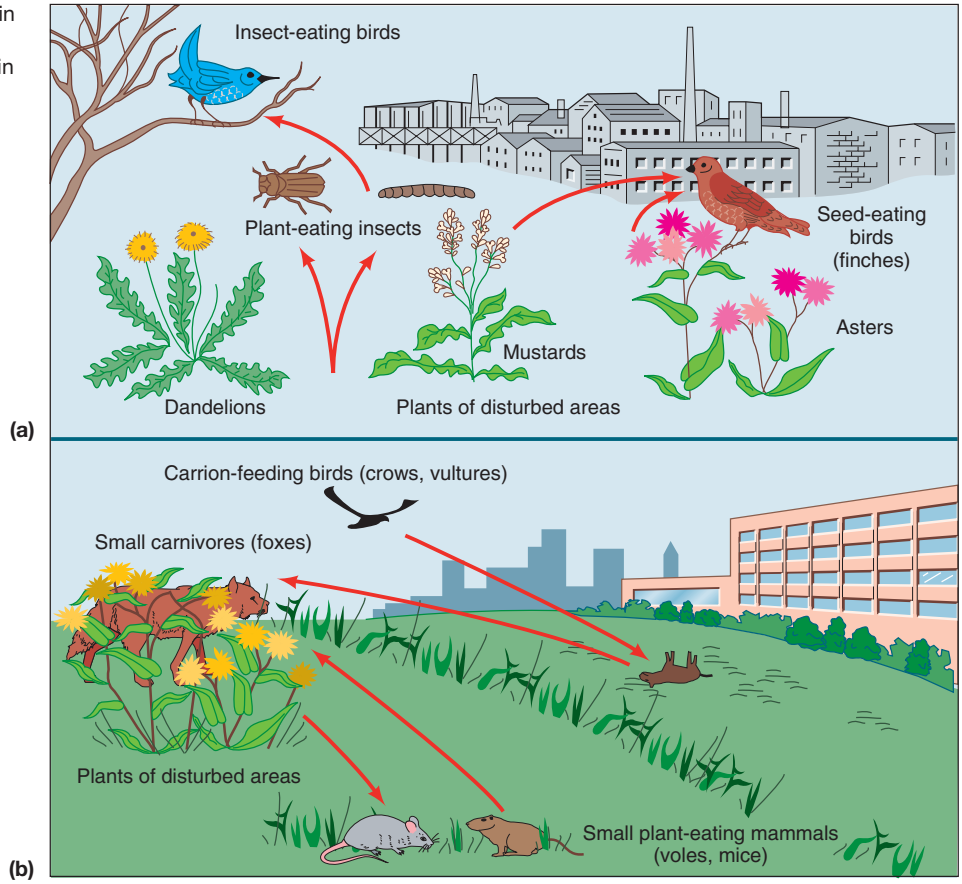

FIGURE 22.16 **(a)** An urban food chain based on plants of disturbed places and insect herbivores. **(b)** An urban food chain based on roadkill.

promoted the spread of the Black Death. Bubonic plague continues to be a health threat in cities—the World Health Organization reports several thousand cases a year.[26] Poor sanitation and high population densities of people and rodents set up a situation where the disease can strike.

An animal is a pest to people when it is in an undesired place at an undesirable time doing an unwanted thing. A termite in a woodland helps the natural regeneration of wood by hastening decay and speeding the return of chemical elements to the soil, where they are available to living plants. But termites in a house are pests because they threaten the house's physical structure.

Animals that do well enough in cities to become pests have certain characteristics in common. They are generalists in their food choice, so they can eat what we eat (including the leftovers we throw in the trash), and they have a high reproductive rate and a short average lifetime.

Controlling Pests

We can best control pests by recognizing how they fit their natural ecosystem and identifying the things that control them in nature. People often assume that the only way to control animal pests is with poisons, but there are limitations to this approach. Early poisons used in pest control were generally also toxic to people and pets (see Chapter 11). Another problem is that reliance on one toxic compound can cause a species to develop a resistance to it, which can lead to rebound—a renewed increase in that pest's population. A pesticide used once and spread widely will greatly reduce the population of the pest. However, when the pesticide loses its effectiveness, the pest population can increase rapidly as long as habitat is suitable and food plentiful. This is what happened when an attempt was made to control Norway rats in Baltimore.

One of the keys to controlling pests is to eliminate their habitats. For example, the best way to control rats is to reduce the amount of open garbage and eliminate areas to hide and nest. Common access areas used by rats are the spaces within and between walls and the openings between buildings where pipes and cables enter. Houses can be constructed to restrict access by rats. In older buildings, we can seal areas of access.

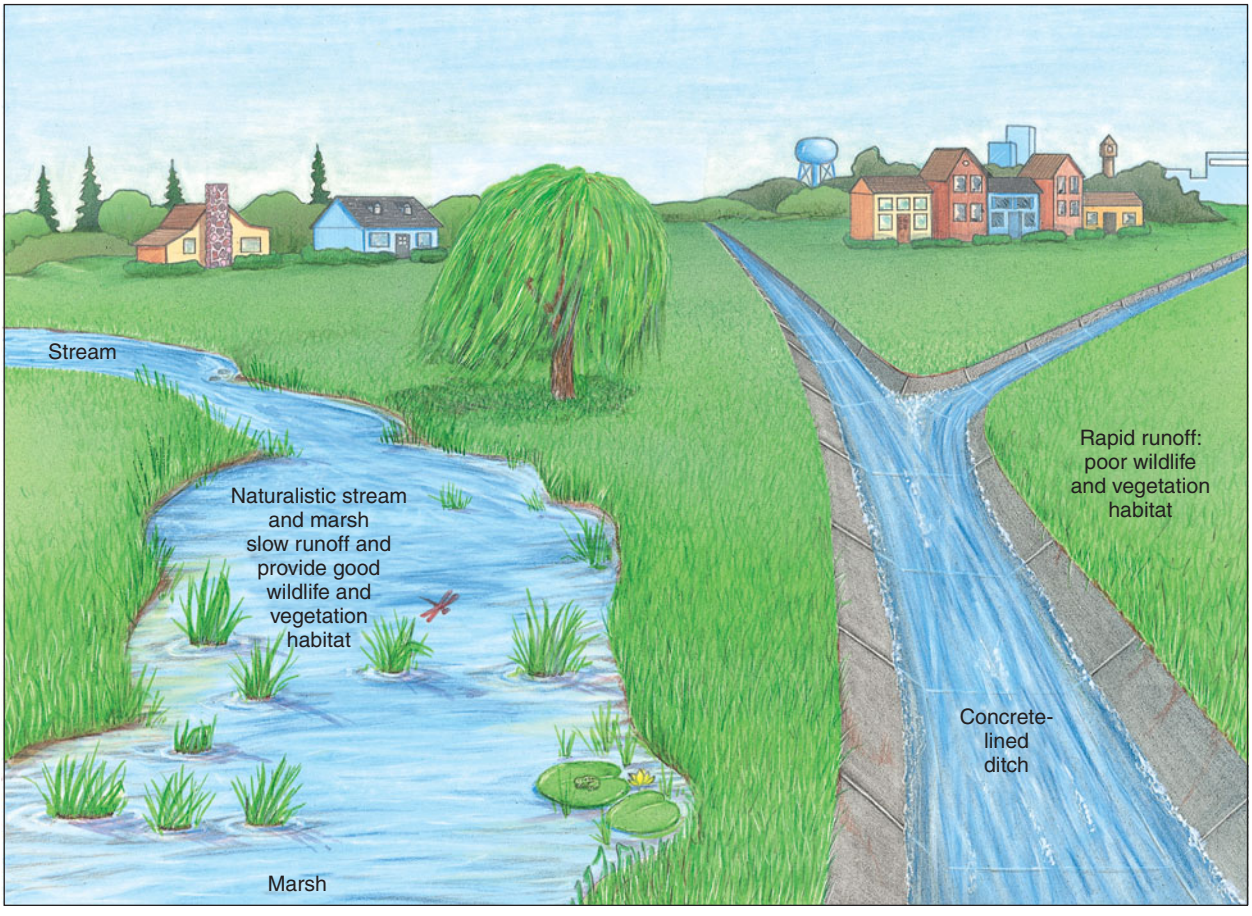

FIGURE 22.17 How water drainage systems in a city can be modified to provide wildlife habitat. In the community on the right, concrete-lined ditches speed runoff and have little value to fish and wildlife. In the community on the left, the natural stream and marsh were preserved; water is retained between rains, and an excellent habitat is provided. (*Source*: D.L. Leedly and L.W. Adams, A *Guide to Urban Wildlife Management* [Columbia, MD: National Institute for Urban Wildlife, 1984], pp. 20–21.)

CRITICAL THINKING ISSUE

How Can Urban Sprawl Be Controlled?

As the world becomes increasingly urbanized, individual cities are growing in area as well as population. Residential areas and shopping centers move into undeveloped land near cities, impinging on natural areas and creating a chaotic, unplanned human environment. "Urban sprawl" has become a serious concern in communities all across the United States. According to the U.S. EPA, in a recent six-month period approximately 5,000 people left Baltimore City to live in suburbs, with the result that nearly 10,000 acres of forests and farmlands were converted to housing. At this rate, the state of Maryland could use as much land for development in the next 25 years as it has used in the entire history of the state.[27] In the past ten years, 22 states have enacted new laws to try to control urban sprawl.

The city of Boulder, Colorado, has been in the forefront of this effort since 1959, when it created the "blue line"—a line at an elevation of 1,761 m (the city itself is at 1,606 m) above which it would not extend city water or sewer services. Boulder's citizens felt, however, that the blue line was insufficient to control development and maintain the city's scenic beauty in the face of rapid population growth. (Boulder's population had grown in the decade before 1959 from 29,000 to 66,000 and reached 96,000 by 1998.) To prevent uncontrolled development in the area between the city and the blue line, in 1967 Boulder began to use a portion of the city sales tax to purchase land, creating a 10,800-hectare greenbelt around the city proper.

In 1976 Boulder went one step further and limited increases in new residences to 2% a year. Two years later, recognizing that planned development requires a regional approach, the city and surrounding Boulder County adopted a coordinated development plan. By the early 1990s, it had become apparent that further growth control was needed for nonresidential building. The plan that the city finally adopted reduced the allowable density of many commercial and industrial properties, in effect limiting jobs rather than limiting building space.

Boulder's methods to limit the size of its population have worked. The most recent census (2002) showed that the population had increased by a mere 2,000 people and totaled just a little more than 94,000.

The benefits of Boulder's controlled-growth initiatives have been a defined urban–rural boundary; rational, planned development; protection of sensitive environmental areas and scenic vistas; and large areas of open space within and around the city for recreation. And in spite of its growth-control measures, Boulder's economy has remained strong. However, restraints on residential growth forced many people who found jobs in Boulder to seek affordable housing in adjoining communities, where populations ballooned. The population of Superior, Colorado, for example, grew from 225 in 1990 to 9,000 in 2000. Further, as commuting workers—40,000 a day—tried to get to and from their jobs in Boulder, traffic congestion and air pollution increased. In addition, because developers had built housing but not stores in the outlying areas, shoppers flocked into Boulder's downtown mall. When plans for a competing mall in the suburbs were finally announced, however, Boulder officials worried about the loss of revenue if the new mall drew shoppers away from the city. At the same time, sprawl from Denver (only 48 km from Boulder), as well as its infamous "brown cloud" of polluted air, began to spill out along the highway connecting the two communities.

Critical Thinking Questions

1. Is a city an open or a closed system (see Chapter 3)? Use examples from the case of Boulder to support your answer.
2. As Boulder takes steps to limit growth, it becomes an even more desirable place to live, which subjects it to even greater growth pressures. What ways can you suggest to avoid such a positive-feedback loop?
3. Some people in Boulder think the next step is to increase residential density within the city. Do you think people living there will accept this plan? What are the advantages and disadvantages of increasing density?
4. To some, the story of Boulder is the saga of a heroic battle against commercial interests that would destroy environmental resources and a unique quality of life. To others, it is the story of an elite group building an island of prosperity and the good life for themselves. Which do you think it is?

SUMMARY

- As an urban society, we must recognize the city's relation to the environment. A city influences and is influenced by its environment and is an environment itself.
- Like any other life-supporting system, a city must maintain a flow of energy, provide necessary material resources, and have ways of removing wastes. These functions are accomplished through transportation and communication with outlying areas.
- Because cities depend on outside resources, they developed only when human ingenuity resulted in modern agriculture and thus excess food production. The history of cities divides into four stages: (1) the rise of

towns; (2) the era of classic urban centers; (3) the period of industrial metropolises; and (4) the age of mass telecommunication, computers, and new forms of travel.

- Locations of cities are strongly influenced by environment. It is clear that cities are not located at random but in places of particular importance and environmental advantage. A city's site and situation are both important.
- A city creates an environment that is different from surrounding areas. Cities change local climate; they are commonly cloudier, warmer, and rainier than surrounding areas.
- In general, life in a city is riskier because of higher concentrations of pollutants and pollutant-related diseases.
- Cities favor certain animals and plants. Natural habitats in city parks and preserves will become more important as wilderness shrinks.
- Trees are an important part of urban environments, but cities place stresses on trees. Especially important are the condition of urban soils and the supply of water for trees.
- Cities can help to conserve biological diversity, providing habitat for some rare and endangered species.
- As the human population continues to increase, we can envision two futures: one in which people are dispersed widely throughout the countryside and cities are abandoned except by the poor; and another in which cities attract most of the human population, freeing much landscape for conservation of nature, production of natural resources, and public-service functions of ecosystems.

REEXAMINING THEMES AND ISSUES

Human Population

As the world's human population increases, we are becoming an increasingly urbanized species. Present trends indicate that in the future, most citizens of most nations will live in their country's single largest city. Thus, concern about urban environments will be increasingly important.

Cities contain the seeds of their own destruction: The very artificiality of a city gives its inhabitants the sense that they are independent of their surrounding environment. But the opposite is the case: The more artificial a city, the more it depends on its surrounding environment for resources and the more susceptible it becomes to major disasters unless this susceptibility is recognized and planned for. The keys to sustainable cities are an ecosystem approach to urban planning and a concern with the aesthetics of urban environments.

Sustainability

Cities depend on the sustainability of all renewable resources and must therefore recognize that they greatly affect their surrounding environments. Urban pollution of rivers that flow into an ocean can affect the sustainability of fish and fisheries. Urban sprawl can have destructive effects on endangered habitats and ecosystems, including wetlands. At the same time, cities designed to support vegetation and some wildlife can contribute to the sustainability of nature.

Global Perspective

The great urban centers of the world produce global effects. As an example, because people are concentrated in cities and because many cities are located at the mouths of rivers, most major river estuaries of the world are severely polluted.

Urban World

The primary message of this chapter is that Earth is becoming urbanized and that environmental science must deal more and more with urban issues.

People and Nature

It has been a modern tendency to focus environmental conservation efforts on wilderness, large parks, and preserves outside of cities. Meanwhile, city environments have been allowed to decay. As the world becomes increasingly urbanized, however, a change in values is necessary. If we are serious about conserving biological diversity, we must assign greater value to urban environments. The more pleasant city environments are, and the more recreation people can find in them, the less pressure there will be on the countryside.

Science and Values

Modern environmental sciences tell us much that we can do to improve the environments of cities and the effects of cities on their environments. What we choose to do with this knowledge depends on our values. Scientific information can suggest new options, and we can select among these for the future of our cities, depending on our values.

KEY TERMS

city planning **506**
fall line **501**
garden city **507**
greenbelt **507**
made lands **511**
site **500**
situation **500**

STUDY QUESTIONS

1. Should we try to save New Orleans or just give up and move the port at the mouth of the Mississippi River elsewhere? Explain your answer in terms of environment and economics.
2. Which of the following cities are most likely to become ghost towns in the next 100 years? In answering this question, use your knowledge of changes in resources, transportation, and communications.
   (a) Honolulu, Hawaii
   (b) Fairbanks, Alaska
   (c) Juneau, Alaska
   (d) Savannah, Georgia
   (e) Phoenix, Arizona
3. Some futurists picture a world that is one giant biospheric city. Is this possible? If so, under what conditions?
4. The ancient Greeks said that a city should have only as many people as can hear the sound of a single voice. Would you apply this rule today? If not, how would you plan the size of a city?
5. You are the manager of Central Park in New York City and receive the following two offers. Which would you approve? Explain your reasons.
   (a) A gift of $1 billion to plant trees from all the eastern states.
   (b) A gift of $1 billion to set aside half the park to be forever untouched, thus producing an urban wilderness.
6. Your state asks you to locate and plan a new town. The purpose of the town is to house people who will work at a wind farm—a large area of many windmills, all linked to produce electricity. You must first locate the site for the wind farm and then plan the town. How would you proceed? What factors would you take into account?
7. Visit your town center. What changes, if any, would make better use of the environmental location? How could the area be made more livable?
8. In what ways does air travel alter the location of cities? The value of land within a city?
9. You are put in charge of ridding your city's parks of slugs, which eat up the vegetable gardens rented to residents. How would you approach controlling this pest?
10. It is popular to suggest that in the Information Age people can work at home and live in the suburbs and the countryside, so cities are no longer necessary. List five arguments for and five arguments against this point of view.

FURTHER READING

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Ndubisi, F., ***Ecological Planning: A Historical and Comparative Synthesis*** (Baltimore: Johns Hopkins University Press, 2002). An important discussion of an ecological approach to cities.