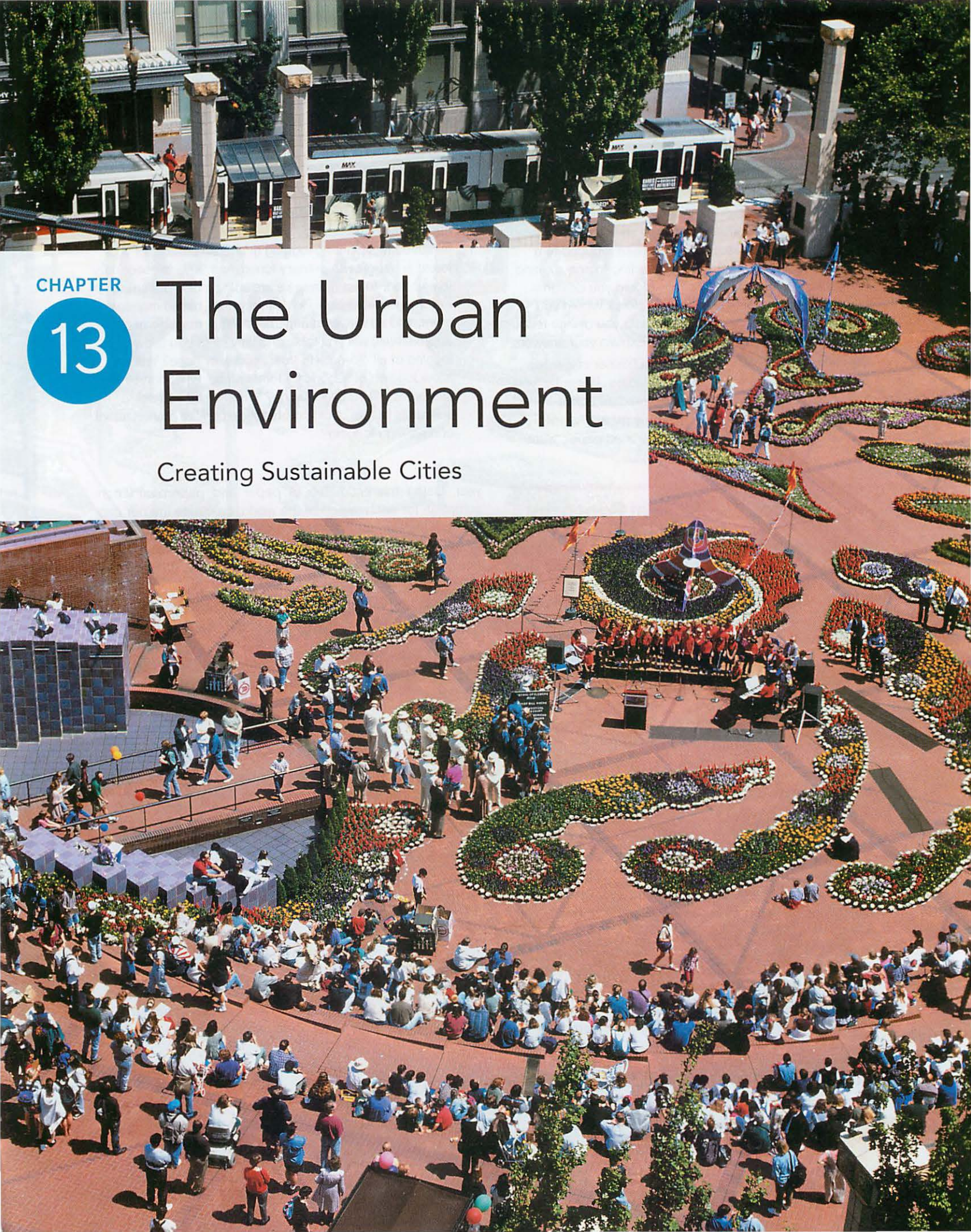
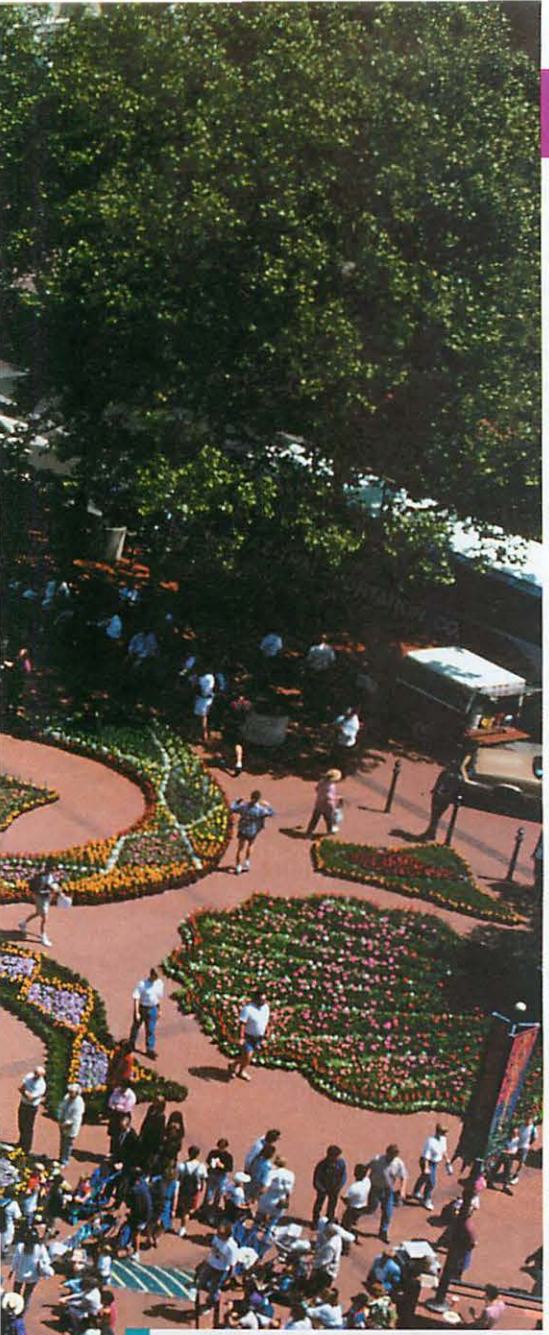


CHAPTER 13

The Urban Environment

Creating Sustainable Cities



CENTRAL
case study

Managing Growth in Portland, Oregon

> **Sagebrush subdivisions, coastal condomania, and the ravenous rampage of suburbia . . . all threaten to mock Oregon's status as the environmental model for the nation.**
> Oregon Governor Tom McCall, 1973

> **We have planning boards. We have zoning regulations. We have urban growth boundaries and 'smart growth' and sprawl conferences. And we still have sprawl.**
> Environmental scientist Donella Meadows, 1999

With fighting words, Oregon governor Tom McCall challenged his state's legislature in 1973 to take action against runaway sprawling development, which many Oregonians feared would ruin the communities and landscapes they loved. McCall was echoing the growing concerns of state residents that farms, forests, and open space were being gobbled up and paved over.

Foreseeing a future of subdivisions, strip malls, and traffic jams engulfing the pastoral Willamette Valley, Oregon acted. The state legislature passed Senate Bill 100, creating a sweeping land use law that would become the focus of acclaim, criticism, and careful study for years afterward by other states and communities trying to manage their own urban and suburban growth.

Oregon's land use law required every city and county to draw up a comprehensive land use plan in line with statewide guidelines that had gained popular support from the state's electorate. As part of each land use plan, each metropolitan area had to establish an **urban growth boundary** (UGB), a line on a map separating areas desired to be urban from areas desired to remain rural. Development for housing, commerce, and industry would be encouraged within these urban growth boundaries but restricted beyond them. The intent was to revitalize city centers; prevent suburban sprawl; and protect farmland, forests, and open landscapes outside urban areas.

Residents of the area around Portland, the state's largest city, established a new regional planning entity to apportion land in their region. The Metropolitan Service District, or Metro, represents 24 municipalities and three counties. Metro adopted the Portland-area urban growth boundary in 1979, enclosing 92,000 ha (227,000 acres) of land, and has tried to focus growth in existing urban centers and to build communities where people can walk, bike, or take mass transit between home, work, and shopping. These policies have largely worked as intended. Portland's downtown and older neighborhoods have thrived, regional urban centers are becoming denser and more community oriented, mass transit has expanded, and farms and forests have been preserved on land beyond the UGB. Portland began attracting international attention for its "livability."

Upon completing this chapter, you will be able to:

- Describe the scale of urbanization
- Define sprawl and discuss its causes and consequences
- Outline city and regional planning and land use strategies
- Evaluate transportation options, urban parks, and green buildings
- Analyze environmental impacts and advantages of urban centers
- Assess urban ecology and the pursuit of sustainable cities

◀ **Flower festival at Pioneer Courthouse Square in downtown Portland, Oregon**

▲ **Mount Hood overlooking downtown Portland**

To many Portlanders today, the UGB remains the key to maintaining quality of life in city and countryside alike. In the view of its critics, however, the "Great Wall of Portland" is an elitist and intrusive government regulatory tool. In 2004, Oregon voters approved a ballot measure that threatened to eviscerate their state's land use rules. Ballot Measure 37 required the state to compensate certain landowners if government regulation had decreased the value of their land. For example, regulations prevented landowners outside UGBs from subdividing their lots and selling them for housing development. Under Measure 37, the state had to pay these landowners to make up for theoretically lost income—or else allow them to ignore the regulations. Because state and local governments did not have enough money to pay such claims, the measure was on track to gut Oregon's zoning, planning, and land use rules.

Landowners filed more than 7500 claims for payments or waivers affecting 295,000 ha (730,000 acres). Although the measure had been promoted to voters as a way to protect the rights of small family landowners, most claims were filed by large developers. Neighbors suddenly found themselves confronting the prospect of massive housing subdivisions, gravel mines, strip malls, or industrial facilities being developed next to their homes, and many who had voted for Measure 37 came to have misgivings.

The state legislature, under pressure from opponents and supporters alike, settled on a compromise: to introduce a new ballot measure. Oregon's voters passed Ballot Measure 49 in 2007. It restricts development outside the UGB that is on a large scale or that degrades sensitive natural areas, but it protects the rights of small landowners to gain income from their property by developing small numbers of homes.

In 2010, Metro finalized a historic agreement with its region's three counties to determine where urban growth will be allowed over the next 50 years. Metro and the counties considered 121,000 ha (300,000 acres) of undeveloped land and apportioned some into "urban reserves" open for development and most into "rural reserves" where farmland and forests would be preserved. Boundaries were precisely mapped to give clarity and direction for landowners and governments.

People are confronting similar issues in communities everywhere, and debates like those in Oregon will determine how our cities and landscapes will change in the future.

Our Urbanizing World

In 2009, we passed a turning point in human history. For the first time ever, more people were living in urban areas (cities and suburbs) than in rural areas. As we undergo this historic shift from the countryside into towns and cities—a process called **urbanization**—two pursuits become ever more important. One is to make our urban areas more livable by meeting residents' needs for a safe, clean, healthy urban environment and a high quality of life. The other is to make urban areas sustainable by creating cities that can prosper in the long term while minimizing ecological impacts.

Industrialization drove urbanization

Since 1950, the world's urban population has multiplied by more than five times, whereas the rural population has not even doubled. Urban populations are growing because the human population overall is growing (Chapter 8) and because more people are moving from rural areas to urban areas than are moving from urban areas to rural areas.

This shift from country to city began long ago. Agricultural harvests that produced surplus food freed a proportion of citizens from farm life and allowed the rise of specialized manufacturing professions, class structure, political hierarchies, and urban centers (p. 245). The industrial revolution (p. 5) spawned technological innovations that created jobs and opportunities in urban centers for people who were no longer needed on farms and ranches. Industrialization, urbanization, and technology increased production efficiencies, and economic opportunities grew faster in cities. This process of positive feedback continues today.

United Nations demographers project that in 2050, more than two of every three people will live in urban areas. Between now and then, they estimate, the urban population will increase by 53%, whereas the rural population will decline by 10%. Trends differ between more developed and less developed regions, however (**FIGURE 13.1**). In more developed

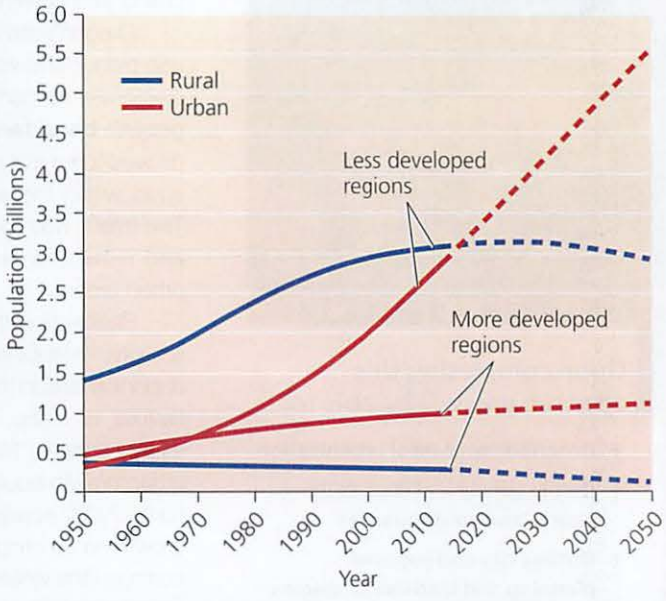


FIGURE 13.1 Population trends differ between poor and wealthy nations. In less developed regions, urban populations are growing quickly, and rural populations will soon begin declining. More developed regions are already largely urbanized, so their urban populations are growing slowly, whereas rural populations are falling. Solid lines indicate past data, and dashed lines indicate future projections. *Data from UN Population Division, 2018. World urbanization prospects: The 2018 revision. By permission.*

DATA Go to **Interpreting Graphs & Data** on **Mastering Environmental Science**

nations such as the United States, urbanization has slowed because four of every five people already live in cities, towns, and **suburbs,** the smaller communities that ring cities. Back in 1850, the U.S. Census Bureau classified only 15% of U.S. citizens as urban-dwellers. That percentage now stands at 82%. Most U.S. urban-dwellers reside in suburbs; fully half the U.S. population today is suburban.

In contrast, today's less developed nations, where most people still reside on farms and in rural villages, are urbanizing rapidly. As industrialization diminishes the need for farm labor while increasing urban commerce and jobs, rural people are streaming to cities. Sadly, across the globe, wars, conflict, and ecological degradation are also driving millions of people from the countryside into urban centers. For all these reasons, most fast-growing cities today are in the less developed world. In cities such as Delhi, India; Lagos, Nigeria; and Karachi, Pakistan, population growth often exceeds economic growth, and the result is overcrowding, pollution, and poverty. United Nations demographers estimate that urban areas of less developed nations will absorb nearly all of the world's population growth from now on.

Environmental factors influence the location of urban areas

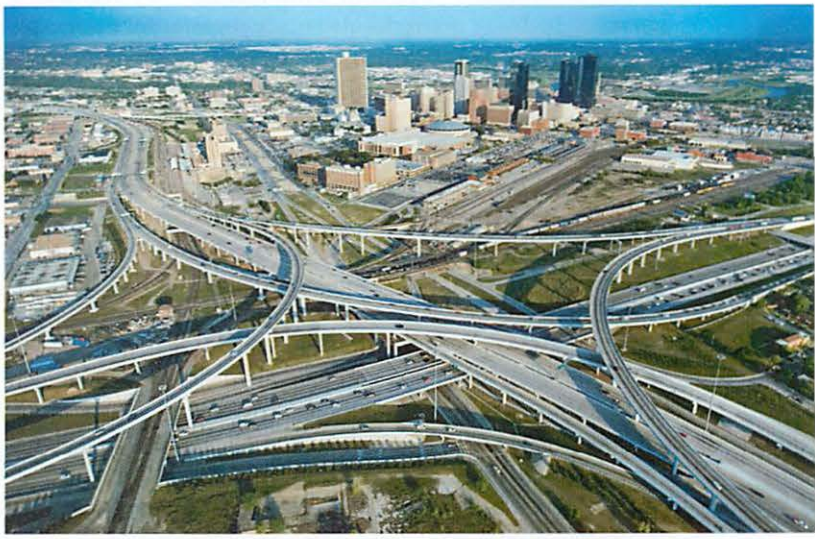
Real estate agents use the saying, "Location, location, location" to stress how a home's setting determines its value. Location is vital for urban centers as well. Think of any major city, and chances are it's situated along a major river, seacoast, railroad, or highway—some corridor for trade that has driven economic growth (**FIGURE 13.2**).

Well-located cities often serve as linchpins in trading networks, funneling in resources from agricultural regions, processing them, manufacturing products, and shipping those products to other markets. Portland, Oregon, got its start in the mid-19th century as pioneers arriving by the Oregon Trail settled where the Willamette River joins the Columbia River, just upriver from where the Columbia flows into the Pacific Ocean. With this strategic location for trade, Portland grew as it received, processed, and shipped overseas the agricultural products from farms of the river valleys, and as it imported goods shipped in from other ports.

Another example of this geographic pattern is Chicago, which grew with extraordinary speed in the 19th and early 20th centuries. At that time, railroads funneled through it the resources from the vast lands of the Midwest and West on their way to consumers and businesses in the populous cities of the East. Chicago became a center for grain processing, livestock slaughtering, meatpacking, and much else.

Today, powerful technologies and cheap transportation enabled by fossil fuels have allowed cities to thrive even in resource-poor regions. The Dallas–Fort Worth area prospers from oil-fueled transportation by interstate highways and a major international airport. Southwestern cities such as Los Angeles, Las Vegas, and Phoenix flourish in desert regions by appropriating water from distant sources. Whether such cities can sustain themselves as oil and water become increasingly scarce in the future is an important question.

(a) St. Louis, Missouri



(b) Fort Worth, Texas

FIGURE 13.2 Cities tend to develop along trade corridors. St. Louis **(a)** is situated on the Mississippi River near its confluence with the Missouri River, where river trade drove its growth in the 19th and early 20th centuries. Fort Worth, Texas **(b),** grew in the late 20th century as a result of the interstate highway system and a major international airport.

In recent years, many cities in the southern and western United States have grown as people have moved there in search of warmer weather, more space, new economic opportunities, or places to retire. Between 1990 and 2018, the population of the Denver metropolitan area grew by 81%, that of the Dallas–Fort Worth metropolitan area by 87%, that of the Houston area by 88%, that of the Atlanta region by 101%, that of the Phoenix area by 117%, and that of the Las Vegas metropolitan area by a whopping 162%.

WEIGHING the **issues**

What Made Your City?

Consider the town or city in which you live or the major urban center located nearest you. Why do you think it developed where it did? What physical, social, or environmental factors may have aided its growth? Do you think it will prosper in the future? Why or why not?

People moved to suburbs

U.S. cities grew rapidly in the 19th and early 20th centuries as a result of immigration from abroad and increased trade as the nation expanded west. The bustling economic activity of downtown districts held people in cities despite growing crowding, poverty, and crime. However, by the mid-20th century, many affluent city-dwellers were choosing to move outward to cleaner, less crowded suburban communities. These people were pursuing more space, better economic opportunities, cheaper real estate, less crime, and better schools for their children.

The exodus to the suburbs in 20th-century America was aided by the rise of the automobile, an expanding road network, and inexpensive and abundant oil. Millions of people could now commute by car to downtown workplaces from new homes in suburban "bedroom communities." By facilitating transport, highway networks also made it easier for businesses to import and export resources, goods, and waste. The federal government's development of the interstate highway system was pivotal in promoting these trends.

As affluent people moved out into the expanding suburbs, jobs followed. This hastened the economic decline of downtown districts, and American cities stagnated. Chicago's population declined to 80% of its peak as residents moved to its suburbs. Philadelphia's population fell to 76% of its peak, Washington, D.C.'s to 71%, and Detroit's to just 55%.

Portland followed this trajectory: Its population growth stalled in the 1950s through the 1970s as crowding and deteriorating economic conditions drove city-dwellers to the suburbs. But the city bounced back. Policies to revitalize the city center helped restart Portland's growth (**FIGURE 13.3**).

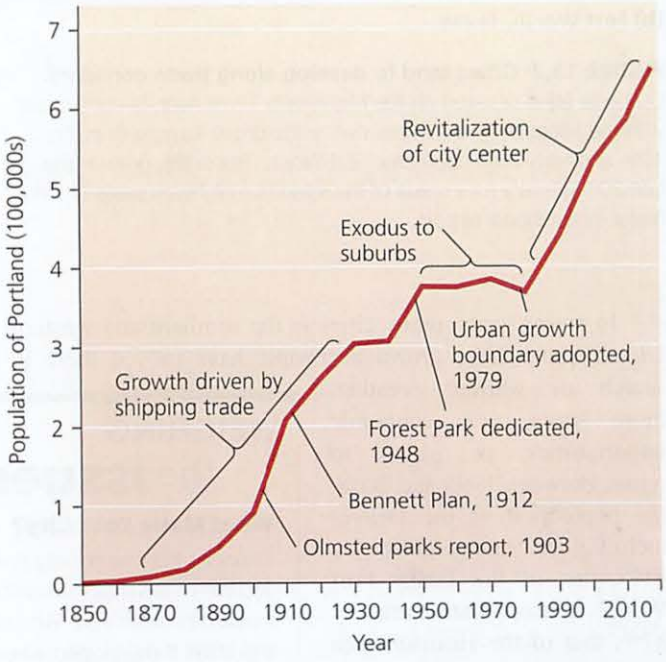


FIGURE 13.3 Portland's population grew, stalled, and then grew again. The shipping trade helped boost Portland's economy and population in the 1890s–1920s. City residents left for the suburbs in the 1950s–1970s, but policies to enhance the city center revitalized Portland's growth. *Data from U.S. Census Bureau.*

Today, the picture is complex. On the one hand, many cities have revitalized themselves as thriving cultural centers, as Portland has, and have reclaimed their allure. As a result, young people in particular are eagerly streaming back into city centers. At the same time, many affluent individuals and families seeking more space and privacy are moving still farther out into **exurbs,** communities beyond the suburbs. In our age of the Internet, cell phones, and videoconferencing, people can easily communicate from far-flung locations, so living and working in a city is no longer as vital to business or career success.

In most ways, suburbs and exurbs have delivered the qualities people have sought in them. The wide spacing of homes, with each on its own plot of land, gives families room and privacy. However, by allotting more space to each person, suburban and exurban growth spreads human impacts across the landscape. Natural areas disappear as housing developments are constructed. Road networks ease travel, but people find themselves needing to climb into a car to get anywhere. People commute longer distances to work and spend more time stuck in traffic. As expanding rings of suburbs and exurbs grow larger than the cities they surround, towns merge into one another. These aspects of growth inspired a new term: *sprawl*.

Sprawl

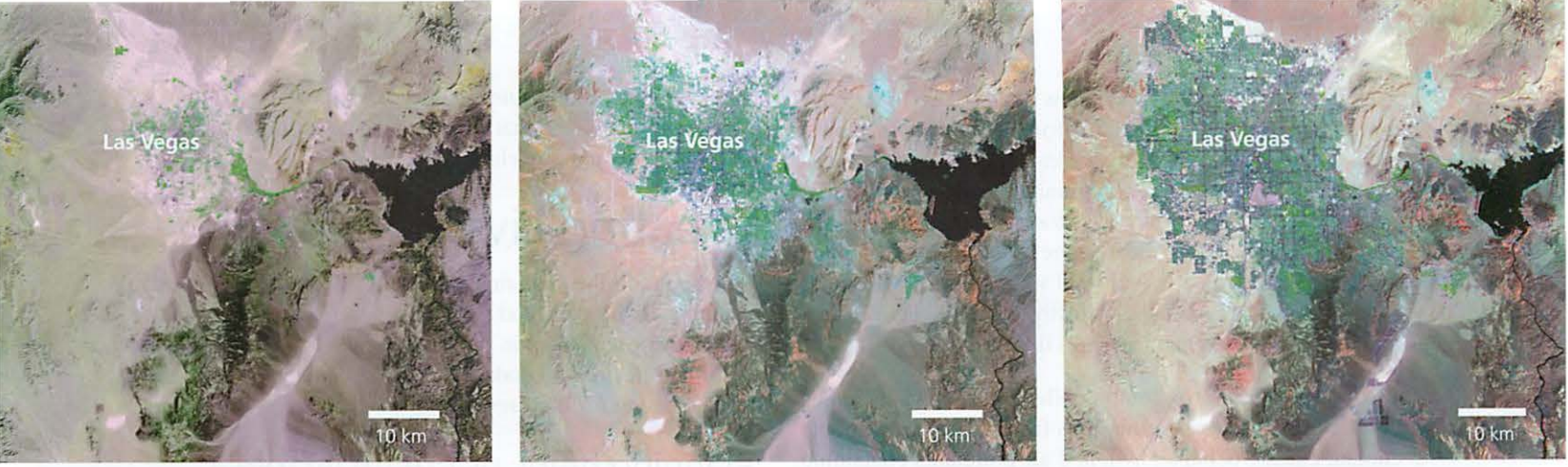
The term *sprawl* has become laden with meanings and suggests different things to different people, but we can begin our discussion by giving **sprawl** a simple, nonjudgmental definition: the spread of low-density urban, suburban, or exurban development outward from an urban center.

Urban areas spread outward

The spatial growth of urban and suburban areas is clear from maps and satellite images of rapidly spreading cities such as Las Vegas (**FIGURE 13.4**). Another example is Chicago, whose metropolitan area spreads over a region 40 times the size of the city. All in all, new houses and roads supplant more than 2700 ha (6700 acres) of U.S. land every day.

Sprawl results from development approaches that place homes on spacious lots in residential tracts that spread over large areas but are far from urban centers and commercial amenities (**FIGURE 13.5**). Such approaches allot each person more space than in cities. For example, the average resident of Chicago's suburbs takes up 11 times more space than a resident of the city. As a result, the outward spatial growth of suburbs and exurbs across the landscape generally outpaces growth in numbers of people.

In fact, many researchers define *sprawl* as the physical spread of development at a rate that exceeds the rate of population growth. For instance, the population of Phoenix grew 12 times larger between 1950 and 2000, yet its land area grew 27 times larger. Between 1950 and 1990, the population of 58 major U.S. metropolitan areas rose by 80%, but the land area they covered rose by 305%. Even in 11 metro areas where population declined between 1970 and 1990 (as with Rust



(a) 1972 (b) 1997 (c) 2018

FIGURE 13.4 Satellite images of Las Vegas, Nevada, show the rapid urban and suburban expansion referred to as sprawl. Las Vegas is one of the fastest-growing cities in North America. From **(a)** 1972 to **(b)** 1997 to **(c)** 2018, its population and its developed area each grew immensely. *Landsat data courtesy of U.S. Geological Survey, Department of the Interior/USGS. Landsat product IDs: (a) LM01-L1TP-042035-19720913-20180429-01-T2, (b) LT05-L1TP-039035-19970417-20160923-01-T1, and (c) LC08-L1TP-039035-20180411-20180417-01-T1.*

Belt cities such as Detroit, Cleveland, and Pittsburgh), the amount of land covered increased.

Sprawl has several causes

There are two main components of sprawl. One is human population growth—there are simply more of us alive each year (Chapter 8). The other is per capita land consumption—each person is taking up more land than in the past. The amount of sprawl is a function of the number of people added to a region times the amount of land each person occupies.

A study of U.S. metropolitan areas between 1970 and 1990 found that these two factors contribute about equally to sprawl but that cities vary in which is more influential. The Los Angeles metro area increased in population density by 9% between 1970 and 1990, becoming the nation's most densely populated metro area. Increasing density should be a good recipe for preventing sprawl, yet L.A. grew in size by a whopping 1021 km^2 (394 mi^2) because of an overwhelming influx of new people. In contrast, the Detroit metro area lost 7% of its population between 1970 and 1990, yet it expanded in area by 28%. In this case, sprawl was caused solely by increased per capita land consumption.

Each person is taking up more space these days in part because of factors mentioned earlier: Better highways, inexpensive gasoline, telecommunications, and the Internet freed businesses from reliance on the centralized infrastructure a major city provides and gave workers greater flexibility to live where they desire.

Economists and politicians long encouraged the unbridled spatial expansion of cities and suburbs. The conventional assumption has been that growth is always good and that attracting business, industry, and residents will enhance a community's economic well-being, political power, and cultural influence. Today, this assumption is being challenged as growing numbers of people feel negative effects of sprawl on their lifestyles.

FIGURE 13.5 Sprawl is characterized by the spread of development across large areas of land. This kind of development requires people to drive cars to reach commercial amenities or community centers.

What's wrong with sprawl?

To some people, the word *sprawl* evokes strip malls, traffic jams, homogeneous commercial development, and tracts of cookie-cutter houses encroaching on farmland, ranchland, or forests. For other people, sprawl is simply the collective result of choices made by millions of well-meaning people trying to make a better life for their families. What can scientific research tell us about the impacts of sprawl?

Transportation Most studies show that sprawl constrains transportation options, essentially forcing people to own a vehicle, drive it most places, drive greater distances, and spend more time in it. Sprawling communities suffer more traffic accidents and have few or no mass transit options. Across the United States since 1980, the average length of the commute to work has risen by 24%, and total vehicle miles driven has risen far faster than population growth. A car-oriented culture encourages congestion and increases dependence on oil.

Pollution By promoting automobile use, sprawl increases pollution. Carbon dioxide emissions from vehicles contribute to climate change (Chapter 18), and air pollutants containing nitrogen and sulfur lead to tropospheric ozone, urban smog, and acid precipitation (Chapter 17). Runoff of water from roads and parking lots may be polluted by motor oil that has leaked from vehicles and by road salt applied to combat ice. Paved areas produce 16 times more runoff than do naturally vegetated areas, and polluted runoff that reaches waterways can pose risks to ecosystems and human health.

Health Beyond the health impacts of pollution, some research suggests that sprawl promotes physical inactivity because driving cars largely takes the place of walking during daily errands. Physical inactivity increases obesity and high blood pressure, which can lead to other ailments. A 2003 study found that people from the most-sprawling U.S. counties show higher blood pressure and weigh 2.7 kg (6 lb) more for their height than people from the least-sprawling U.S. counties.

WEIGHING the **issues**

Sprawl Near You

Is there sprawl in the area where you live? Does it bother you or not? Has development in your area had any of the impacts described on this page? Do you think your city or town should encourage outward growth? Why or why not?

Land use As more land is developed, less is left as forests, fields, farmland, or ranchland. Of the estimated 1 million ha (2.5 million acres) of U.S. land converted each year, roughly 60% is agricultural land and 40% is forest. These lands provide vital resources, recreation, aesthetic beauty, wildlife habitat, and air and water purification. Today an alarming number of children grow up without the ability to roam through woods, fields, and open space, which used to be a normal part of childhood. Being deprived of regular access to nature as a child, many experts maintain, can inflict psychological and emotional harm on an individual, with consequences for society (p. 282).

Economics Sprawl drains tax dollars from communities and funnels money into infrastructure for new development on the fringes of those communities. Funds that could be spent maintaining and improving downtown centers are instead spent on extending the road system, water and sewer system, electricity grid, telephone lines, police and fire service, schools, and libraries. The costs of extending public infrastructure are generally not charged to developers but are paid by taxpayers of the community. In theory, fees on developers or property taxes on new homes and businesses can pay back the public investment, but studies find that in most cases existing taxpayers end up subsidizing new development.

Creating Livable Cities

To respond to the challenges presented by sprawl, architects, planners, developers, and policymakers are trying to revitalize city centers and to plan and manage how urbanizing areas develop. They aim to make cities safer, cleaner, healthier, and more pleasant for their residents.

Planning helps us create livable urban areas

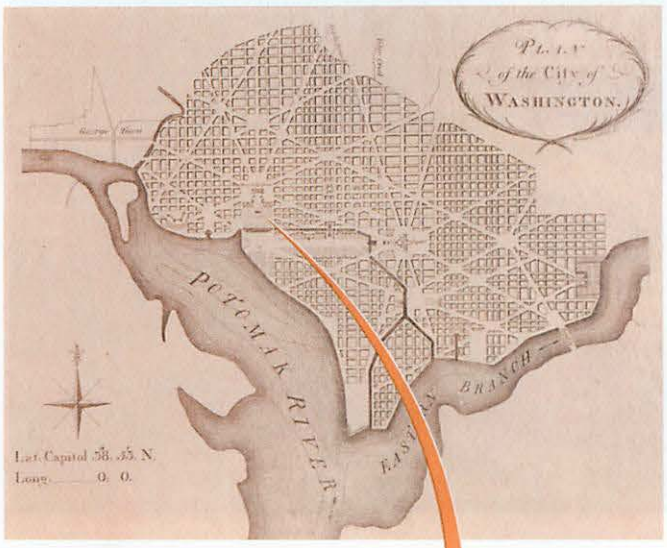
How can we design cities to maximize their efficiency, functionality, and beauty? This question is central to **city planning** (also known as **urban planning**). City planners advise policymakers on development options, transportation needs, public parks, and other matters.

Washington, D.C., is the earliest example of city planning in the United States. President George Washington hired French architect Pierre Charles L'Enfant in 1791 to design a capital city for the new nation on undeveloped land along the Potomac River. L'Enfant laid out a baroque-style plan of diagonal avenues cutting across a grid of streets, with space allotted for majestic public monuments, and the city was built largely according to his plan (**FIGURE 13.6**). A century later, as the city became crowded and dirty, a special commission in 1901 undertook new planning efforts to beautify the city while staying true to the intentions of L'Enfant's original plan. These planners imposed a height restriction on new buildings to keep the magnificent government edifices and monuments from being dwarfed by modern skyscrapers, thus preserving the spacious, stately feel of the city.

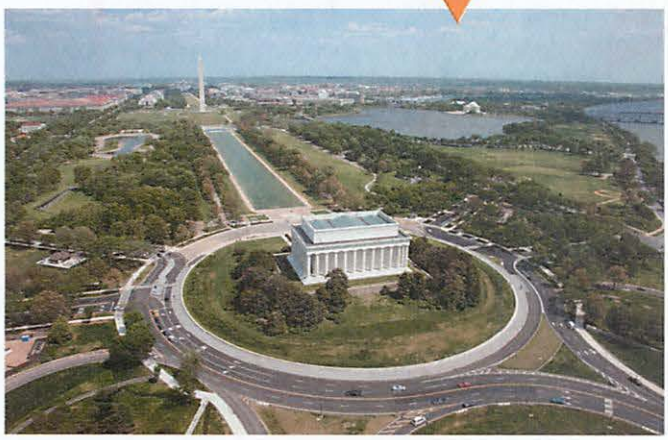
City planning in North America came into its own at the turn of the 20th century as urban leaders sought to beautify and impose order on fast-growing, unruly cities. Landscape architect Daniel Burnham's 1909 *Plan of Chicago* was perhaps the grandest effort of this time. As implemented over decades, Burnham's plan expanded Chicago's parks and playgrounds, streamlined traffic, improved neighborhood living conditions, and cleared industry and railroads from the shore of Lake Michigan to provide public access to the water.

Portland gained its own comprehensive plan just three years later, in 1912. Edward Bennett's *Greater Portland Plan* proposed to rebuild the harbor; dredge the river channel; construct new docks, bridges, tunnels, and a waterfront railroad; superimpose wide radial boulevards on the old city street grid; establish civic centers downtown; and greatly expand the number of parks. Voters approved the plan by a two-to-one margin, but they defeated a bond issue that would have paid for park development. As the century progressed, other major planning efforts were conducted, and some ideas, such as establishing public squares downtown, came to fruition.

In today's world of sprawling metropolitan areas, **regional planning** has become at least as important as city planning. Regional planners deal with the same issues as



(a) The L'Enfant plan, 1791



(b) Washington, D.C., today

FIGURE 13.6 Washington, D.C., is a prime example of early city planning. The 1791 plan **(a)** for the new U.S. capital laid out splendid diagonal avenues cutting across gridded streets, allowing space for the magnificent public monuments **(b)** that grace the city today.

city planners, but they work on broader geographic scales and coordinate their work with multiple municipal governments. In some places, regional planning has been institutionalized in formal government bodies; the Portland area's Metro is such a regional planning entity. A historic accomplishment in regional planning was sealed when Metro and its region's three counties in 2010 announced their collaborative plan apportioning undeveloped land into "urban reserves" and "rural reserves." The agreement enables homeowners, farmers, developers, and policymakers to feel informed and secure knowing what kinds of land uses lie in store on and near their land over the next half-century.

Zoning is a key tool for planning

One tool that planners use is **zoning,** the practice of classifying areas for different types of development and land use (**FIGURE 13.7**). For instance, to preserve the cleanliness and tranquility of residential neighborhoods, industrial facilities may be kept out of districts zoned for residential use. By specifying zones for different types of development, planners can guide what gets built where. Zoning also gives home buyers and business owners security because they know in advance what types of development can and cannot be located nearby.

Zoning involves government restriction on the use of private land and represents a constraint on personal property rights. For this reason, some people consider zoning a regulatory taking (p. 169) that violates individual freedoms. Most people defend zoning, however, saying that government has a proper and useful role in setting limits on property rights for the good of the community.

WEIGHING the issues

Your Urban Area

Think of your favorite parts of the city you know best. What do you like about them? What do you dislike about your least favorite parts of the city? What could this city do to improve quality of life for its residents?

When Oregon voters passed Ballot Measure 37 in 2004 (see Central Case Study, p. 338), it shackled government's ability to enforce zoning regulations with landowners who bought their land before the regulations were enacted. However, many Oregonians soon began witnessing new development they did not condone, so in 2007 they passed Ballot Measure 49 to restore public oversight over development. The passage of Oregon's Measure 37 spawned similar ballot measures in other U.S. states, but voters defeated most of them. In general,

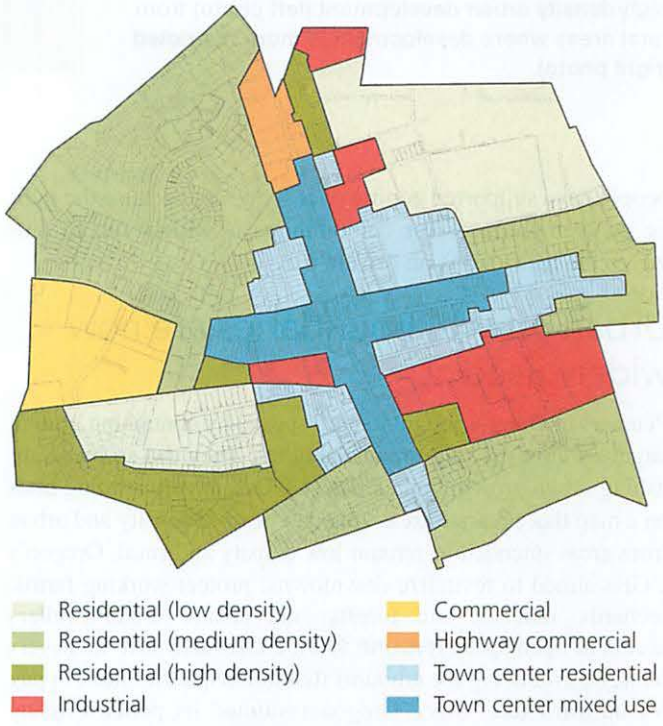


FIGURE 13.7 This zoning map for Littletown, Pennsylvania, shows several typical zoning patterns. Public and institutional uses are clustered together in "mixed-use" areas in the center of town and along major roads. Industrial zones tend to be located away from most residential areas. Residential zones vary in the density of homes allowed.

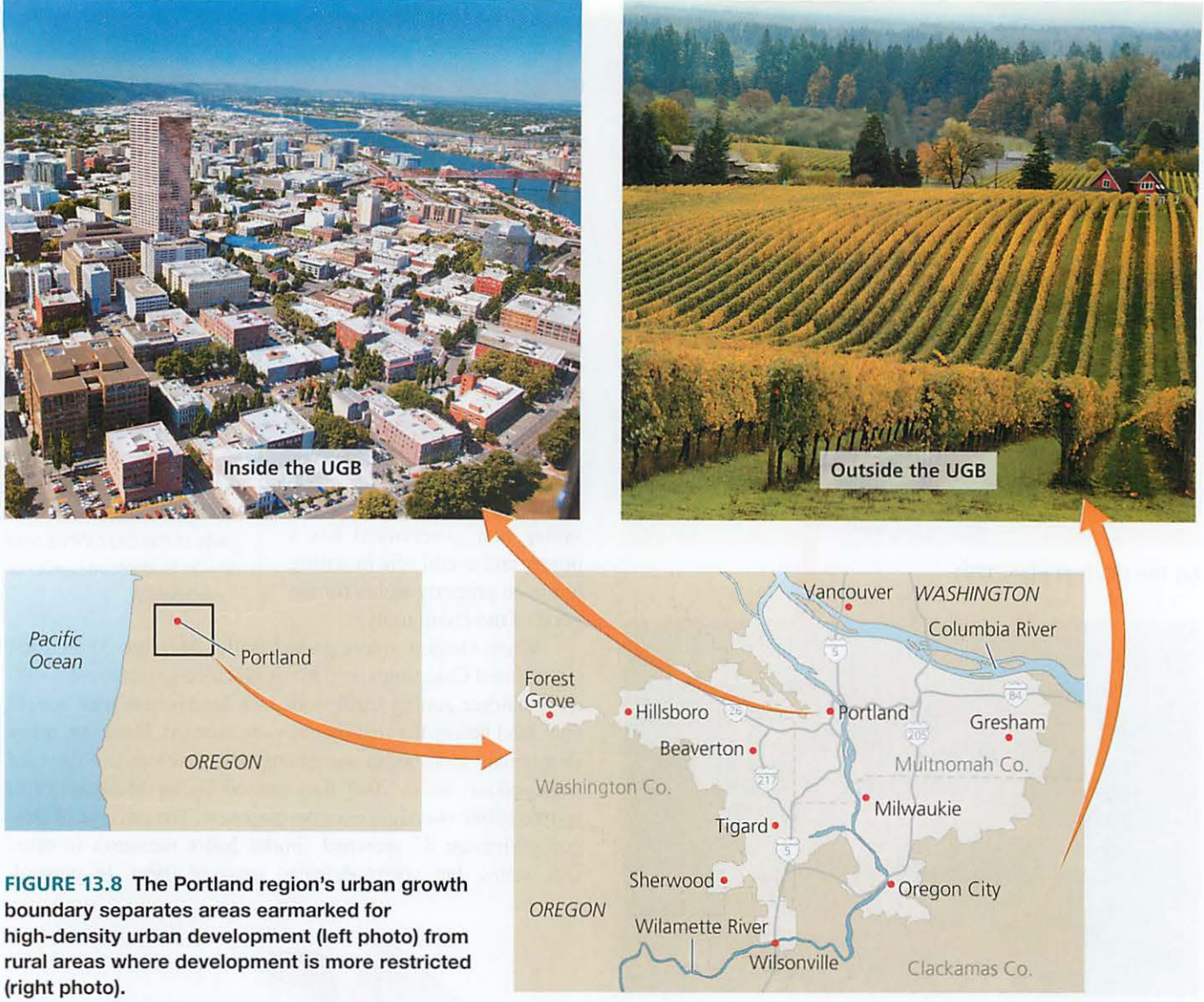


FIGURE 13.8 The Portland region's urban growth boundary separates areas earmarked for high-density urban development (left photo) from rural areas where development is more restricted (right photo).

people have supported zoning over the years because the public good it produces for communities is widely felt to outweigh the restrictions on private use.

Urban growth boundaries are now widely used

Planners in Oregon sought to curb sprawl by containing growth largely within existing urbanized areas. They did so by establishing urban growth boundaries (UGBs), legally binding lines on a map that separate areas zoned to be high density and urban from areas intended to remain low density and rural. Oregon's UGBs aimed to revitalize downtowns; protect working farms, orchards, ranches, and forests; and ensure urban-dwellers access to open space (**FIGURE 13.8**). UGBs also save taxpayers money by reducing the amounts that municipalities need to pay for infrastructure. Since Oregon instituted its policies, many other regions have adopted UGBs, including the states of Washington, Tennessee, and California, as well as a number of cities, including Boulder, Colorado; Lancaster, Pennsylvania; Honolulu, Hawai'i; Miami, Florida; Minneapolis–St. Paul, Minnesota; and Virginia Beach, Virginia.

In most ways, the Portland region's UGB has worked as intended. It has lowered prices for land outside the UGB while raising prices within it. It has preserved farms and forests by restricting development outside the UGB. It has increased the density of new housing inside the UGB by more than 50% as homes are built on smaller lots and as multistory apartments replace low-rise structures. Downtown employment has grown as businesses and residents invest anew in the central city. Through it all, Portland has been able to absorb considerable immigration while avoiding rampant sprawl.

Nonetheless, the Portland region's urbanized area grew by 101 km^2 (39 mi^2) in the decade after its UGB was established, because 146,000 people were added to the population. Intensifying population pressure has led Metro to enlarge the UGB three dozen times since its establishment, adding 32,000 acres to its original 227,000. In addition, UGBs tend to increase housing prices within their boundaries. In Portland, housing has become far less affordable than it was, leading the mayor and city council in 2015 to declare a "housing emergency," which has not yet been lifted. Today in the city, demand for housing exceeds supply, rents are soaring, and low- and middle-income people are being forced out of

neighborhoods they have lived in for years as these neighborhoods experience **gentrification,** a transformation to conditions that cater to wealthier people. These trends suggest that relentless population growth may thwart even the best anti-sprawl efforts and that livable cities can fall victim to their own success if they are in high demand as places to live.

Smart growth and new urbanism aim to counter sprawl

As more people feel impacts of sprawl on their everyday lives, efforts to manage growth are springing up throughout North America. Oregon's Senate Bill 100 (p. 337) was one of the first, and since then, dozens of states, regions, and cities have adopted similar land use policies. Urban growth boundaries and other approaches from these policies have coalesced under the concept of **smart growth** (TABLE 13.1).

Proponents of smart growth aim to rejuvenate the older existing communities that so often are drained and impoverished by sprawl. Smart growth means "building up, not out," focusing development and economic investment in existing urban centers and favoring denser, mixed-use architecture—multistory housing blended with commercial space.

A related approach among architects, planners, and developers is **new urbanism,** which seeks to design walkable neighborhoods with homes, businesses, schools, and other amenities all nearby for convenience. The aim is to create functional neighborhoods in which families can meet most of their needs close to home without using a car. Trees, green spaces, a mix of architectural styles, and creative street layouts add to the visual interest of new-urbanist developments. These developments mimic the traditional urban neighborhoods that existed before the advent of suburbs.

New-urbanist neighborhoods are often served by public transit systems. In **transit-oriented development,** compact communities in the new-urbanist style are arrayed around stops on a rail line, enabling people to travel most places they need to go by train and foot alone. Several lines of the Washington, D.C., Metro system have been developed in this manner.

Among the 600 communities in the new-urbanist style across North America are Seaside, Florida; Kentlands in Gaithersburg, Maryland; Addison Circle in Addison, Texas; Mashpee Commons in Mashpee, Massachusetts; Harbor Town in Memphis, Tennessee; Celebration in Orlando, Florida; and Orenco Station, west of Portland.

Transit options help cities

Traffic jams on roadways cause air pollution, stress, and countless hours of lost time. They cost Americans an estimated $305 billion each year—almost $1000 per person—in fuel and lost productivity. To encourage more efficient transportation, policymakers can raise fuel taxes, charge trucks for road damage, tax inefficient modes of transport, and reward carpoolers with carpool lanes. But a key component of improving the quality of urban life is to give residents alternative transportation options.

Bicycle transportation is one key option (FIGURE 13.9). Portland has embraced bicycles like few other American cities,

TABLE 13.1 Ten Principles of "Smart Growth"

1. Mix land uses.
2. Take advantage of compact building design.
3. Create a range of housing opportunities and choices.
4. Create walkable neighborhoods.
5. Foster distinctive, attractive communities with a strong sense of place.
6. Preserve open space, farmland, natural beauty, and critical environmental areas.
7. Strengthen existing communities, and direct development toward them.
8. Provide a variety of transportation choices.
9. Make development decisions predictable, fair, and cost-effective.
10. Encourage community and stakeholder collaboration in development decisions.

Source: U.S. Environmental Protection Agency.

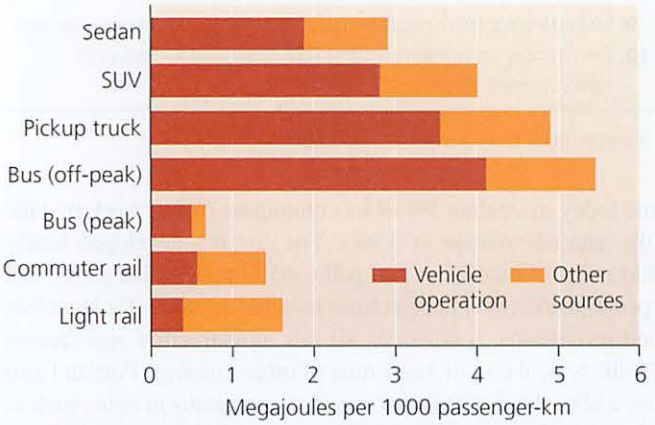
and today more than 5% of its commuters ride to work by bike (the national average is 0.5%). The city has developed nearly 400 miles of bike lanes and paths, 6500 public bike racks, and special markings at intersections to enhance safety for bicyclists and pedestrians. Amazingly, all this infrastructure was created for the typical cost of just 1 mile of urban freeway. Portland also has a bike-sharing program similar to programs in cities such as Montreal, Toronto, Denver, Minneapolis, Miami, San Antonio, Boston, New York City, and Washington, D.C.

Like many other major cities, Portland is now experimenting with electric scooters. Proponents of e-scooters say that they help reduce car traffic by enabling people needing to travel only short distances to take scooters instead. Opponents complain that the scooters clutter sidewalks and cause safety concerns. In 2018, Portland ran a four-month pilot program, allowing three companies to rent scooters downtown. About 34% of Portland

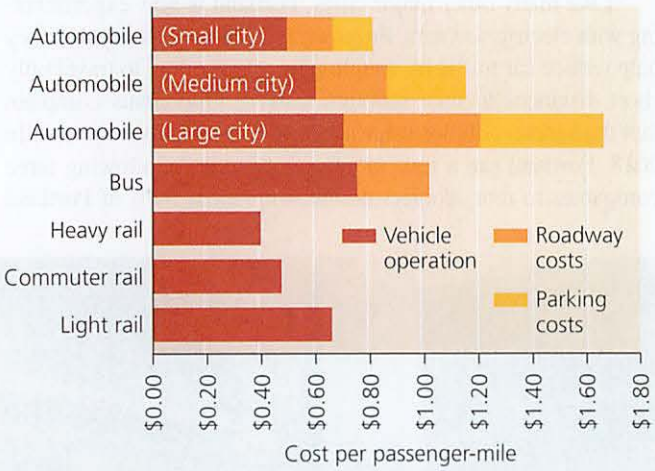
FIGURE 13.9 Bicycles provide a healthy alternative to transportation by car. This Portland bicycle lot accommodates riders who commute downtown by bike and is conveniently located at a streetcar stop.

residents and 48% of visitors used a scooter instead of driving at some point during this period, according to the Portland Bureau of Transportation—but people also lodged 6000 complaints to the agency. The city established a further 1-year trial period before it decides on whether to allow them permanently.

Other transportation options include **mass transit** systems: public systems of buses, trains, subways, or *light rail* (smaller rail systems powered by electricity). Mass transit systems move large numbers of passengers while easing traffic congestion, taking up less space than road networks, and emitting less pollution than cars. A 2005 study (**FIGURE 13.10**) calculated that each year, rail systems in U.S. metropolitan areas save taxpayers $67.7 billion in costs related to congestion, parking, road maintenance, and accidents—far more than the $12.5 billion that governments spend to subsidize rail systems each year. As long as an urban center is large enough to support the infrastructure necessary, rail systems are cheaper, more energy-efficient, and less polluting than roadways choked with cars—as are bus systems when they are heavily used.



(a) Energy consumption for different modes of transit



(b) Operating costs for different modes of transit

FIGURE 13.10 Public transit tends to (a) consume less energy and (b) cost less than automobile transit. Bus transit is highly efficient in places and at times of high use ("peak" in figure), but much less so when and where use is low ("off-peak" in figure). Data presented for light rail are averages of systems in Boston and San Francisco. Data for greenhouse gas emissions (not shown) are very similar to those for energy consumption. *Data from (a, b) Chester, M., and Horvath, A., 2009. Environmental assessment of passenger transportation should include infrastructure and supply chains.* Environmental Research Letters *4: 024008 (8 pp.); and (c) Litman, T., 2005.* Rail transit in America: A comprehensive evaluation of benefits. *© 2005 T. Litman.*

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In Portland, buses and light rail (together with *streetcars*, trolleys that serve short trips downtown and share rights-of-way with cars) carry 100 million riders per year (**FIGURE 13.11**). The most-used train systems in the United States are the "heavy rail" systems of its largest cities, such as New York City's subways, Washington, D.C.'s Metro, the T in Boston, and the San Francisco Bay area's BART. Each of these rail systems carries more than one-fourth of its city's daily commuters.

In general, however, the United States lags behind most nations in mass transit. Many countries, rich and poor alike, have extensive and accessible bus systems that ferry citizens within and between towns and cities cheaply and effectively (see **SUCCESS STORY**). And whereas Japan, China, and many European nations have developed entire systems of modern high-speed "bullet" trains (**FIGURE 13.12**), the United States has only one such train, Amtrak's *Acela Express*. This train connects Boston and Washington, D.C., via New York, Philadelphia, and Baltimore, and it travels more slowly than most bullet trains.

The United States chose instead to invest in road networks for cars and trucks largely because (relative to most other nations) its population density was low and gasoline was cheap. As energy costs and population rise, however, mass transit becomes increasingly appealing, and residents begin to clamor for train and bus systems in their communities. Americans may eventually see more high-speed rail; the 2009 stimulus bill passed by Congress set aside $8 billion for developing high-speed rail, and the Obama administration identified 10 potential corridors for its development. Projects are proceeding in several of these corridors, including in California, where the state is debating how fully to fund construction of a system connecting Los Angeles, San Francisco, San Diego, and Sacramento.

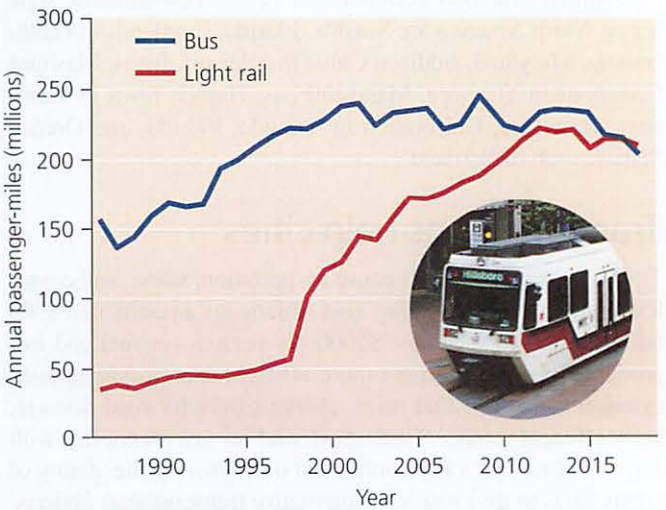

FIGURE 13.11 Ridership has grown on Portland's buses and on its MAX light rail system. *Data from Trimet.*

FIGURE 13.12 "Bullet trains" of high-speed rail systems in Europe and Asia can travel at 150–220 mph. This Chinese train is speeding through the city of Qingdao.

FIGURE 13.13 Central Park in New York City was one of America's first city parks, and it remains one of the largest and finest.

Urban residents need park lands

City-dwellers often desire some escape from the noise, commotion, and stress of urban life. Natural lands, public parks, and open space provide greenery, scenic beauty, freedom of movement, and places for recreation. In addition, these green spaces keep ecological processes functioning by helping regulate climate, purify air and water, and provide wildlife habitat. The animals and plants of urban and suburban parks also serve to satisfy our natural affinity for contact with other organisms (sometimes called biophilia; p. 282). In the wake of urbanization and sprawl, protecting natural lands and establishing public parks have become vital as most of us come to feel increasingly disconnected from nature.

City parks in North America arose in the late 19th century as urban leaders yearning to make crowded and dirty cities more livable established public spaces using aesthetic ideals borrowed from European parks, gardens, and royal hunting grounds. The lawns, shaded groves, curved pathways, and pastoral vistas of many American city parks grew from these European ideals, as interpreted by America's leading landscape architect, Frederick Law Olmsted. Olmsted designed Central Park in New York City (**FIGURE 13.13**) and many other urban parks.

East Coast cities such as New York, Boston, and Philadelphia developed parks early on, but western cities were not far behind. In San Francisco, William Hammond Hall transformed 2500 ha (1000 acres) of the peninsula's dunes into Golden Gate Park, a verdant playground of lawns, trees, gardens, and sports fields. Portland's quest for parks began in 1900, when city leaders created a parks commission and hired Olmsted's son, John Olmsted, to design a park system. His 1904 plan proposed acquiring land to ring the city generously with parks, but no action was taken. A full 44 years later, residents pressured city leaders to create Forest Park along a forested ridge on the northwest side of the city. At 11 km (7 mi) long, it is one of the largest city parks in North America.

SUCCESS **story**

Creating a Global Model for Bus Transit

Establishing a mass transit system often requires strong and visionary political leadership. Such was the case in Curitiba, a metropolis of 2.5 million people in southern Brazil. Faced with an influx of immigrants from outlying farms in the 1970s, city leaders led by Mayor Jaime Lerner undertook an aggressive planning process so that they could direct their city's growth rather than being overwhelmed by it. They established a fleet of hundreds of public buses, took steps to encourage bicycles and pedestrians, and reconfigured Curitiba's road system to maximize its efficiency. The buses were given dedicated lanes, while preboarding fare purchase in futuristic tube stations sped things along, giving this innovative "bus rapid transit" system the speed and efficiency of a rail system. Three-fourths of Curitiba's population began using the buses daily, car usage dropped, and surveys showed that residents were happier than people in other Brazilian cities. The city's system began to attract international acclaim, and eventually more than 160 other cities worldwide followed Curitiba's lead and adopted bus rapid transit systems. Today, this much-celebrated city is—like Portland, Oregon—becoming a victim of its own success as rapid population growth begins to overwhelm its infrastructure and car congestion grows. Curitiba's new generation of leaders will need to innovate further, but already Curitiba has shown the rest of the world how investing thoughtfully in well-planned transportation infrastructure can pay big dividends.

Commuters boarding a bus in Curitiba, Brazil

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Park lands come in various types

Large city parks are vital to a healthy urban environment, but even small spaces make a big difference. Playgrounds give children places to be active outdoors and interact with their peers. Community gardens allow people to grow vegetables and flowers in a neighborhood setting.

Greenways are strips of land that connect parks or neighborhoods. They often run along rivers, streams, or canals and provide access to walking trails. Greenways can protect water quality, boost property values, and serve as corridors for the movement of wildlife. Across North America, the Rails-to-Trails Conservancy has helped convert more than 38,000 km (23,500 mi) of abandoned railroad rights-of-way into greenways for walking, jogging, and biking.

One newly developed linear park along an old rail line is the High Line Park in Manhattan in New York City (**FIGURE 13.14**). An elevated freight line running above the city's streets was going to be demolished, but a group of citizens saw its potential for a park and pushed the idea until city leaders came to share their vision. Today, more than 13,000 people per day use the 23-block-long High Line for recreation or on their commute to work.

FIGURE 13.14 The High Line Park was created thanks to a visionary group of Manhattan citizens. They pushed to make a park out of an abandoned elevated rail line.

FIGURE 13.15 Toronto, Ontario, boasts the world's largest greenbelt. This immense swath of natural land circling the city acts as an urban growth boundary and provides recreation and ecosystem services for Toronto-area residents.

The concept of the corridor is sometimes implemented on a large scale. **Greenbelts** are long and wide corridors of park lands, often encircling an entire urban area. The world's largest greenbelt surrounds the city of Toronto, Ontario, and its major suburbs (**FIGURE 13.15**). At nearly 800,000 ha (2 million acres) in size, this massive system of parkland, forested land, and urban rivers is calculated to provide $3.2 billion in ecosystem services each year to the people of the region. Toronto and certain other Canadian cities such as Ottawa and Vancouver employ greenbelts as urban growth boundaries, containing sprawl while preserving open space for urban residents.

In the United States, a major greenbelt is the Chicago area's forest preserve system, a 40,000-ha (100,000-acre) network of oak woodlands, prairies, and wetlands that stretches through Chicago's suburbs like a necklace. These natural lands—the largest system of urban green space in the United States—accommodate 62 million recreation visits each year.

Green buildings bring benefits

Although we need park lands, we spend most of our time indoors, so the buildings in which we live and work affect our health and well-being. Buildings also consume 40% of our energy and 70% of our electricity, contributing to the greenhouse gas emissions that drive climate change. As a result, there is a thriving movement in architecture and construction to design and build **green buildings,** structures meant to minimize the ecological footprint of their construction and operation.

Green buildings are built from sustainable materials, limit their use of energy and water, minimize adverse health impacts, control pollution, and recycle waste (**FIGURE 13.16**). Constructing or renovating buildings using new efficient

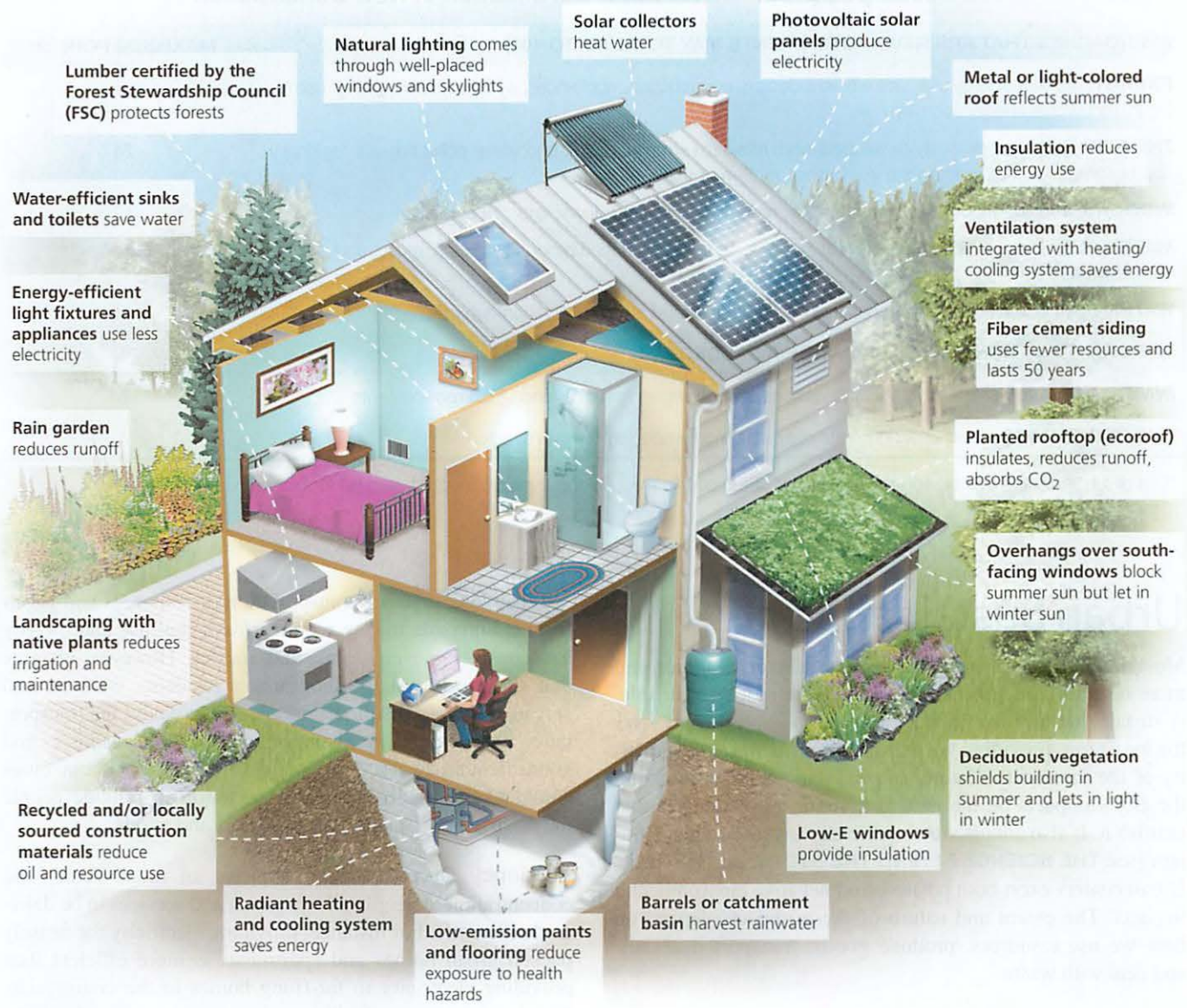


FIGURE 13.16 **A green building incorporates design features to minimize its ecological footprint.**

technologies is probably the most effective way cities can reduce energy consumption and greenhouse gas emissions.

The U.S. Green Building Council promotes sustainable building efforts through the **Leadership in Energy and Environmental Design** (LEED) certification program. Builders apply for certification (for new buildings or renovation projects) and, depending on their performance, may be granted silver, gold, or platinum status (**TABLE 13.2**, p. 350).

Green building techniques add expense to construction, but the added cost generally ranges only from 0 to 10%. Moreover, this cost is recouped over time as money is saved on utility bills. Studies indicate that over a building's lifetime, green buildings save up to 10 times more money than their extra construction cost. In addition, studies suggest that workers tend to be more productive in green buildings.

Today, LEED certification is booming. Portland features several dozen LEED-certified buildings, including the nation's first LEED Gold–certified sports arena (the Moda Center, where the Trailblazers basketball team plays). Savings on energy, water, and waste at the Moda Center paid for the cost of its LEED upgrade after just one year.

Schools, colleges, and universities are leaders in sustainable building. In Portland, the Rosa Parks Elementary School was built with locally sourced and nontoxic materials, uses 24% less energy and water than comparable buildings, and diverted nearly all its construction waste from the landfill. Schoolchildren learn about renewable energy by watching a display of the electricity produced by their building's photovoltaic solar system. Portland State University, the University of Portland, Reed College, and Lewis and Clark College are just a few of the many colleges and universities nationwide constructing green buildings as part of their campus sustainability efforts (pp. 18–19).

TABLE 13.2 **Green Building Approaches for LEED Certification of New Construction**

APPROACHES THAT ARE REWARDED (POINTS MAY TOTAL UP TO 100):	MAXIMUM POINTS*
ENERGY: Monitor energy use; use efficient design, construction, appliances, systems, and lighting; use clean, renewable energy sources	37
THE SITE: Build on previously developed land; minimize erosion, runoff, and water pollution; use regionally appropriate landscaping; integrate with transportation options	21
INDOORS: Improve indoor air quality; provide natural daylight and views; improve acoustics	17
MATERIALS: Use local or sustainably grown, harvested, and produced products; reduce, reuse, and recycle waste	14
WATER USE: Use efficient appliances inside; landscape for water conservation outside	11
THEN, UP TO 10 BONUS POINTS MAY BE AWARDED FOR:	
INNOVATION: New and innovative technologies and strategies to go beyond LEED requirements	6
THE REGION: Addressing environmental concerns most important for one's region	4

*Out of 110 possible points, 40 are required for LEED certification, 50 for silver, 60 for gold, and 80 for platinum levels.

Urban Sustainability

Most of our efforts to make cities safer, cleaner, healthier, and more beautiful are also helping make them more sustainable. A sustainable city is one that can function and prosper over the long term, providing generations of residents a good quality of life far into the future. In part, this entails minimizing the city's impacts on the natural systems and resources that nourish it. It also entails viewing the city as an ecological system (see **THE SCIENCE BEHIND THE STORY**, pp. 352–353). Urban centers exert both positive and negative environmental impacts. The extent and nature of these impacts depend on how we use resources, produce goods, transport materials, and deal with waste.

Urban resource consumption brings a mix of environmental effects

You might guess that urban living has a greater environmental impact than rural living. However, the picture is not that simple; instead, urbanization brings a complex mix of consequences.

Resource sinks Cities and towns are sinks (p. 121) for resources, needing to import from source areas beyond their borders nearly everything they need to feed, clothe, and house their inhabitants and power their commerce. Urban and suburban areas rely on large expanses of land elsewhere to supply food, fiber, water, timber, metal ores, and mined fuels. Urban centers also need areas of natural land to provide ecosystem services, including purification of water and air, nutrient cycling, and waste treatment. Indeed, for their day-to-day survival, major cities such as New York, Boston, San Francisco, and Los Angeles depend on water they pump in from faraway watersheds (**FIGURE 13.17**).

The long-distance transportation of resources and goods from countryside to city requires fossil fuel use and thereby has considerable environmental impact. However, imagine that the world's 4.3 billion urban residents were instead spread evenly across the landscape. What would the transportation requirements be, then, to move all those resources and goods around to all those people? A world without cities would likely require *more* transportation to provide people the same degree of access to resources and goods.

Efficiency Once resources arrive at an urban center, the concentration of people allows goods and services to be delivered efficiently. For instance, providing electricity for densely packed urban homes and apartments is more efficient than providing electricity to far-flung homes in the countryside. The density of cities facilitates the provision of medical services, education, water and sewer systems, waste disposal, public transportation, and more.

More consumption Because cities draw resources from afar, their ecological footprints are much greater than their actual land areas. For instance, urban scholar Herbert Girardet calculated that the ecological footprint of London, England, extends 125 times larger than the city's actual area. By another estimate, cities take up only 2% of the world's land surface but consume more than 75% of its resources.

However, the ecological footprint concept is most meaningful when used on a per-person basis. So, in asking whether urbanization intensifies resource consumption, we must ask whether the average urban- or suburban-dweller has a larger footprint than the average rural-dweller. The answer is yes, but urban and suburban residents also tend to be wealthier than rural residents, and wealth correlates with resource consumption. Thus, although urban and suburban citizens tend to consume more than their rural counterparts, the reason could simply be that they tend to be wealthier.

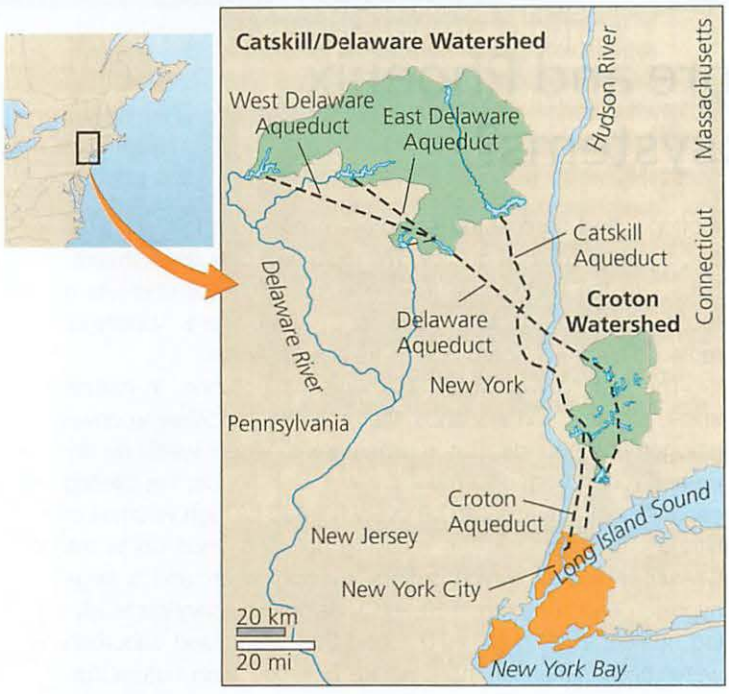


FIGURE 13.17 New York City pipes in its drinking water from reservoirs in two upstate watersheds. The city acquires, protects, and manages upstate watershed land to minimize pollution of these water sources.

Urbanization preserves land

Because people pack together densely in cities, more land outside cities is left undeveloped. Indeed, that is the very idea behind urban growth boundaries. If cities did not exist and all 7 billion of us were evenly spread across the planet's land area, no large blocks of land would be left uninhabited, and we would have far less room for agriculture, wilderness, biodiversity, or privacy. The fact that half the human population is concentrated in discrete locations helps allow space for natural ecosystems to continue functioning and provide the ecosystem services on which all of us, urban and rural, depend.

Cities suffer and export pollution

Just as cities import resources, they export wastes, either passively through pollution or actively through trade. In so doing, urban centers transfer the costs of their activities to other regions—and mask the costs from their own residents. Citizens of Indianapolis, Columbus, or Buffalo may not recognize that pollution from the coal-fired power plants that supply them electricity worsens acid precipitation hundreds of miles to the east. New York City residents may not realize how much garbage their city produces if it is shipped elsewhere for disposal.

However, not all waste and pollution leave the city. Urban-dwellers are exposed to heavy metals, industrial compounds, and chemicals from manufactured products that accumulate in soil and water. Airborne pollutants cause smog and acid precipitation (Chapter 17). Fossil fuel combustion releases greenhouse gases as well as pollutants that pose health risks.

City residents suffer thermal pollution as well because cities tend to have ambient temperatures that are several degrees higher than those of surrounding areas. This **urban heat island effect** (FIGURE 13.18) results from the concentration of heat-generating buildings, vehicles, factories, and

FAQ

Aren't cities bad for the environment?

Stand in the middle of a big city and look around. You see concrete, cars, and pollution. Environmentally bad, right? Not necessarily. The widespread impression that urban living is less sustainable than rural living is largely a misconception. Consider that in a city you can walk to the grocery store instead of driving. You can take the bus or the train. Police, fire, and medical services are close at hand. Water and electricity are easily supplied to your entire neighborhood, and waste is easily collected. In contrast, if you live in the country, resources must be used to transport all these services for long distances, or you need to burn gasoline traveling to reach them. By clustering people together, cities distribute resources efficiently while also preserving natural lands outside the city.

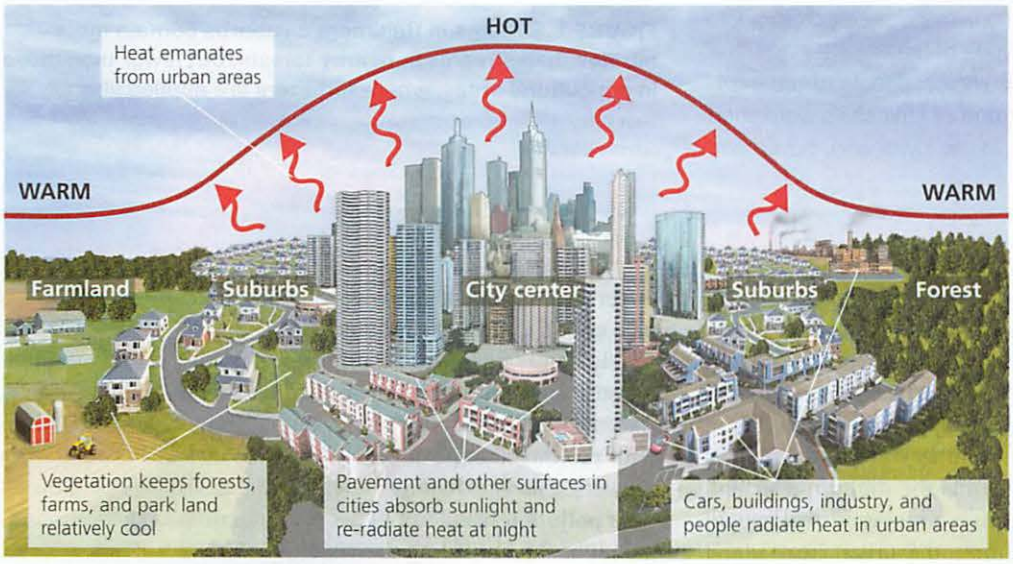
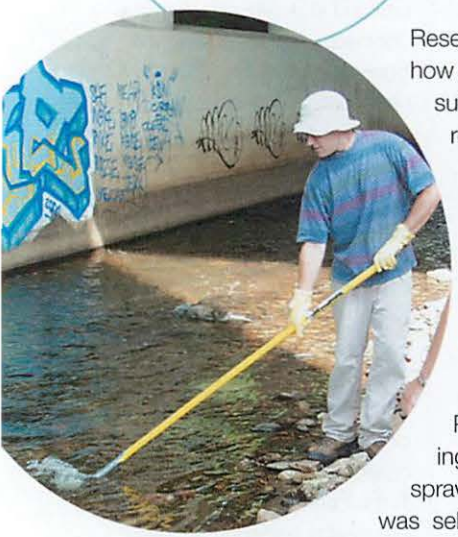


FIGURE 13.18 Cities produce urban heat islands, creating temperatures warmer than surrounding areas.

THE SCIENCE **behind the story**

How Do Baltimore and Phoenix Function as Ecosystems?



Sampling water beneath an overpass in Baltimore

Researchers in urban ecology examine how ecosystems function in cities and suburbs, how natural systems respond to urbanization, and how people interact with the urban environment. Today, Baltimore and Phoenix are centers for urban ecology.

These two cities are very different: Baltimore is an Atlantic port city on the Chesapeake Bay with a long history, whereas Phoenix is a young and fast-growing southwestern metropolis that sprawls across the desert. Each was selected by the U.S. National Science Foundation as a research site in its Long Term Ecological Research program, which funds multidecade ecological research. Since 1997, hundreds of researchers have studied Baltimore and Phoenix explicitly as ecosystems, examining nutrient cycling, biodiversity, air and water quality, environmental health risks, and more.

Research teams in both cities are combining old maps, aerial photos, and new remote sensing satellite data to reconstruct the history of landscape change. In Phoenix, one group showed how urban development spread across the desert in a "wave of advance," affecting soils, vegetation, and microclimate as it went. In Baltimore, mapping showed that development fragmented the forest into smaller patches over the past 100 years, even while the overall amount of forest remained the same.

For each city, study regions encompass both heavily urbanized central city areas and outlying rural and natural areas. To measure the impacts of urbanization, many research projects compare conditions in these two types of areas.

Baltimore scientists can see ecological effects of urbanization by comparing the urban lower end of their site's watershed with its less developed upper end. In the lower end, pavement, rooftops, and compacted soil prevent rain from infiltrating the soil, so water runs off quickly. The rapid flow cuts deep streambeds into the earth while leaving surrounding soil drier. As a result, wetland-adapted trees and shrubs are vanishing, replaced by dry-adapted upland trees and shrubs.

The fast flow of water also worsens pollution. In natural areas, streams and wetlands filter pollution by breaking down nitrogen compounds. But in urban areas, where wetlands dry up and runoff from pavement creates flash floods, the filtering capacities of streams can be overwhelmed by high volumes of nitrates. In Baltimore, the resulting pollution ends up in the Chesapeake Bay, which suffers eutrophication and a large hypoxic dead zone (pp. 110, 410). Baltimore scientists studying nutrient cycling (p. 121) found that urban and suburban watersheds suffer far more nitrate pollution than natural forests, yet also found that the filtering ability of urban park lands helps keep pollution much lower than in agricultural landscapes (**FIGURE 1**).

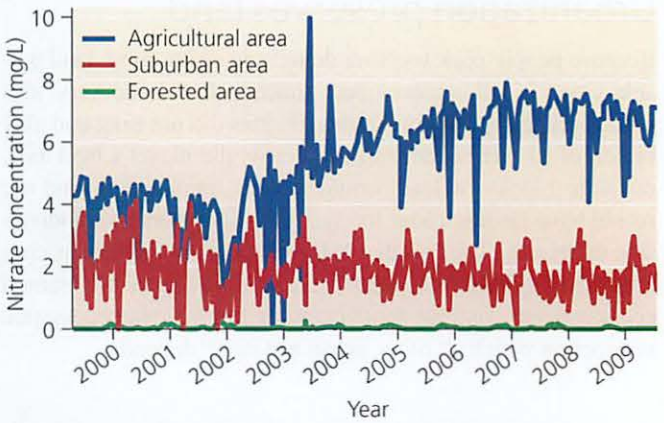


FIGURE 1 Streams in Baltimore's suburbs contain more nitrates than streams in nearby forests, but fewer than those in agricultural areas, where fertilizers are applied liberally.
Data from Baltimore Ecosystem Study, www.lternet.edu/research/keyfindings/urban-watersheds.

people. It also results from the way buildings and dark paved surfaces absorb sunlight throughout the day and then release the energy slowly at night as heat. In addition, buildings block cooling wind currents, and impervious surfaces cause rainwater to run off into sewers rather than evaporating and cooling the air. Much of the energy a city gathers in the daytime is released as heat at night, which warms the nighttime air and interferes with patterns of convective circulation that would otherwise cool the city. To minimize the urban heat island effect, we can plant more vegetation and can paint rooftops pale colors to reflect sunlight.

Urban residents also suffer noise pollution and light pollution. **Noise pollution** consists of undesired ambient sound. Excess noise can cause stress, and at intense levels (such as with prolonged exposure to the sounds of leaf blowers, lawn mowers, and jackhammers) can harm hearing. The glow of **light pollution** from city lights may impair sleep and obscures the night sky, impeding the visibility of stars.

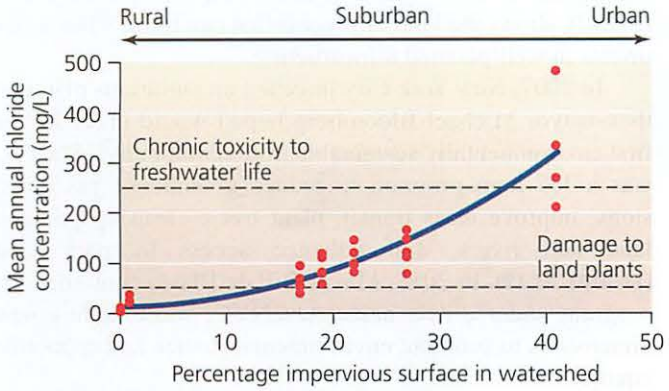


FIGURE 2 Salt concentrations in Baltimore-area streams are high enough to damage plants in the suburbs and to kill aquatic animals in urban areas. Data samples (red dots) were obtained over a five-year period. *Adapted from Kaushal, S.S., et al., 2005. Increased salinization of fresh water in the northeastern United States.* Proc. Natl. Acad. Sci. USA *102: 13517–13520, Fig 2. ©2005 National Academy of Sciences, U.S.A. By permission.*

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Baltimore research also reveals impacts of applying salt to icy roads in winter. Road salt makes its way into streams, which become up to 100 times saltier. Such high salinity kills organisms (**FIGURE 2**), degrades habitat and water quality, and impairs streams' ability to remove nitrate.

To study contamination of groundwater and drinking water, researchers are using isotopes (p. 26) to trace where salts in the most polluted streams are coming from. Baltimore is now improving water quality substantially with a $900-million upgrade of its sewer system.

Urbanization also affects species and ecological communities. Cities and suburbs facilitate the spread of non-native species, because people introduce exotic ornamental plants and because urbanization's impacts on the soil, climate, and landscape favor weedy generalist species over more specialized native ones. In Baltimore, non-native plant species are most abundant in urban areas. In Phoenix's dry climate, pollen from some non-native plants causes allergy problems for city residents.

Community ecologists studying the wild animals and plants that persist within Phoenix are finding that urbanization alters relationships among them. Compared with natural landscapes, cities offer steadier and more reliable food resources—think of people's bird feeders or food scraps from dumpsters.

Growing seasons are extended and seasonal variation is buffered in cities as well. The urban heat island effect (p. 351) raises nighttime temperatures and makes temperatures more similar year-round. Buildings and ornamental vegetation shelter animals from extreme conditions, and irrigation in yards and gardens provides water. In a desert city like Phoenix, watering boosts primary productivity and lowers daytime temperatures. Together, all these changes lead to higher population densities of animals but lower species diversity as generalists thrive and displace specialists.

Urban ecologists in Phoenix and Baltimore are also studying social and demographic aspects of the urban environment. Some research measures how natural amenities affect property values. One study found that proximity to a park increases a home's property values—unless crime is pervasive. If the robbery rate surpasses 6.5 times the national average (as it does in Baltimore), proximity to a park begins to depress property values.

Other studies focus on environmental justice concerns (pp. 139–141). These studies have repeatedly found that sources of industrial pollution tend to be located in neighborhoods that are less affluent and that are home primarily to people of racial and ethnic minorities. Phoenix researchers mapped patterns of air pollution and toxic chemical releases and found that minorities and the poor are exposed to a greater share of these hazards. As a result, they suffer from higher rates of childhood asthma.

In Baltimore, researchers found a more complex pattern. Toxic release sites were more likely to be in working-class white neighborhoods than in African American neighborhoods. This, the researchers concluded, was a result of historical inertia. In the past, living close to one's workplace—the factories that release toxic chemicals—was something people preferred, and white workers claimed the privilege of living near their workplaces.

Whether addressing the people, natural communities, or changing ecosystems of the urban environment, studies on urban ecology like those in Phoenix and Baltimore will be vitally informative in our ever more urban world.

These various forms of pollution and the health risks they pose are not evenly shared among urban residents. Those who receive the brunt of the pollution are often those who are too poor to live in cleaner areas. Environmental justice concerns (pp. 139–141) center on the fact that a disproportionate number of people living near, downstream from, or downwind from factories, power plants, and other polluting facilities are people who are poor and, often, people of racial or ethnic minorities.

Urban centers foster innovation

Cities promote a flourishing cultural life and, by mixing together diverse people and influences, spark innovation and creativity. The urban environment can promote education and scientific research, and cities have long been viewed as engines of technological and artistic inventiveness. This inventiveness can lead to solutions to societal problems, including ways to reduce environmental impacts. For instance, research

into renewable energy is helping us develop ways to replace fossil fuels. Technological advances have helped us reduce pollution. Wealthy and educated urban populations also provide markets for low-impact goods, such as organic produce. Recycling programs help reduce the solid waste stream. Environmental education is helping people choose their own ways to live cleaner, healthier, lower-impact lives. All these phenomena are facilitated by the education, innovation, science, and technology that are part of urban culture.

Urban ecology helps cities move toward sustainability

Cities that import all their resources and export all their wastes have a linear, one-way metabolism. Linear models of production and consumption tend to destabilize environmental systems and are ultimately not sustainable. Proponents of sustainability for cities stress the need to develop circular systems, akin to systems found in nature, which recycle materials and use renewable sources of energy.

Researchers in the field of **urban ecology** hold that cities can be viewed explicitly as ecosystems and that the fundamentals of ecosystem ecology and systems science (Chapter 5) apply to the urban environment. Major urban ecology projects are ongoing in Baltimore and Phoenix, where researchers are studying these cities as ecological systems (see **The Science behind the Story,** pp. 352–353).

Planners and visionary leaders have come up with designs for entire "eco-cities" built from scratch that follow cyclical, sustainable patterns of resource use and waste recycling. So far, none of these efforts have come to fruition, but existing cities across the world are adopting ecologically sustainable strategies by maximizing the efficient use of resources, recycling waste and wastewater, and developing green technologies. Urban agriculture that recycles organic waste and produces locally consumed food is thriving in many places, from Portland to Cuba to Japan. Curitiba, Brazil (p. 347), shows the kind of success that can result when a city invests in well-planned infrastructure.

In 2007, New York City unveiled an ambitious plan that then-mayor Michael Bloomberg hoped would make it "the first environmentally sustainable 21st-century city." PlaNYC was a 132-item program to reduce greenhouse gas emissions, improve mass transit, plant trees, clean up polluted land and rivers, and enhance access to park land (**FIGURE 13.19**). In 2015, Mayor Bill de Blasio continued the program under a new name, OneNYC, while adding new dimensions to promote environmental justice and economic equity.

Under the plan thus far, according to city documents, New York City has enhanced energy efficiency in hundreds of buildings, installed thousands of solar panels, planted 1.5 million trees, and opened or renovated several hundred parks, playgrounds, and community gardens. It expanded curbside recycling and composting while reducing landfill disposal by 10%. To fight water pollution, it installed green infrastructure, upgraded wastewater treatment, and cleaned up 750 polluted **brownfield** sites (p. 638) while acquiring 36,000 acres to protect upstate drinking water supplies. To promote cleaner transportation, city leaders installed bike lanes and racks and launched a bike-sharing program, retrofitted ferries to reduce pollution, converted hundreds of taxis to hybrid vehicles, expanded biodiesel use, and introduced more than 1200 electric vehicles and 500 charging stations. The city also divested its pension plan from fossil fuel stocks and is providing green job training to several thousand workers. Altogether, these actions have helped reduce the city's greenhouse gas emissions since 2005 by 15%. Today, New York City's air is the cleanest in 50 years and its water is the cleanest in more than a century.

FIGURE 13.19 New York City is making impressive strides in urban sustainability under its OneNYC program. The newly completed One World Trade Center tower that now dominates the skyline has many energy-saving and water-saving green building features.

Steps toward livability enhance sustainability

Most steps being taken to make cities more livable also help make them more sustainable. Planning and zoning are pursuits that specifically entail a long-term vision. By projecting further into the future than political leaders or businesses generally do, planning and zoning are powerful forces for sustaining urban communities. The principles and practices of smart growth and new urbanism cut down on energy consumption, helping us address the looming challenge of climate change (Chapter 18). Encouraging mass transit reduces gasoline consumption and carbon emissions. Parks offer ecosystem services while promoting residents' health. And green buildings bring a diversity of health and environmental benefits.

Successes from Portland to Curitiba to New York City show how we can make cities more sustainable. Indeed, because they affect the environment in many positive ways and can promote efficient resource use, urban centers are a key element in achieving progress toward global sustainability.

CENTRAL CASE STUDY

connect & continue

TODAY, as the human population shifts from rural to urban lifestyles, our impacts become less direct but more far-reaching. Making urban and suburban areas both more livable and sustainable will be vital for our future. Portland, Oregon, is one city that has enhanced the quality of life for its residents while making strides toward environmental sustainability. In a great many ways, Portland's reputation as a green city and international model of livability is well justified.

However, as people stream to Portland in droves, the city risks becoming a victim of its own success. Growth forecasts estimate that the number of households in Portland will jump by 44–57% as early as 2035 and that households throughout the region will rise in number by 56–74%. As density increases inside the urban growth boundary, new challenges—such as rising rents, highway traffic jams, parking congestion on residential streets, and debates over gentrification—are beginning to strain the smart-growth vision that has worked so well thus far.

In a search for solutions amid an ongoing declared "housing emergency," Portland's leaders have been engaging citizens in planning processes to keep their city "prosperous, healthy, equitable, and resilient." In 2016, they formally adopted the 2035 Comprehensive Plan to help guide decision making through 2035. Currently debate is swirling over the Residential Infill Project, a proposed program of changes to boost population density by allowing more multifamily dwellings in single-family residential neighborhoods. Similar changes are being enacted several hours away in Bend, Oregon's fastest-growing city.

To deal with traffic congestion, city, regional, and state leaders are planning to construct new light rail lines between Portland and its suburbs. They are also exploring adding more lanes to the freeways and charging tolls to discourage rush-hour traffic and encourage carpooling.

Portland is just one of many urban centers seeking to expand economic opportunity and enhance quality of life while protecting environmental quality. Planning and zoning, smart growth and new urbanism, mass transit, parks, and green buildings are all ingredients in sustainable cities, and we should be encouraged about our progress in these endeavors. Ongoing experimentation throughout our urbanizing world will help us determine how to continue creating better and more sustainable communities in which to live.

- **CASE STUDY SOLUTIONS** After you earn your college degree, you decide to settle in the Portland, Oregon, region, where you are being offered three equally desirable jobs in three very different locations. If you accept the first, you will live in downtown Portland, amid commercial and cultural amenities but where population density is high and growing. If you take the second, you will live in one of Portland's suburbs where you have more space but where commute times are long and sprawl may soon surround you for miles. If you select the third, you will live in a rural area outside the urban growth boundary with plenty of space and scenic beauty but few cultural amenities. You are a person who aims to live in an ecologically sustainable way. Where would you choose to live? Why? What considerations will you factor into your decision?

- **LOCAL CONNECTIONS** Consider the region where you live or attend school, including your nearest large city. For each of the following pursuits, describe what this area possesses, and suggest at least one way you think the area could enhance its quality of life and its sustainability: (a) planning and zoning policies; (b) walkable neighborhoods as promoted by smart growth and new urbanism; (c) transportation options (mass transit, bike lanes, ways to avoid car congestion); (d) parks, green spaces, and natural lands; and (e) green buildings.

- **EXPLORE THE DATA** How do experts measure the pros and cons of mass transit in urban areas? → **Explore Data** relating to the case study on **Mastering Environmental Science**.

REVIEWING **Objectives**

You should now be able to:

+ **Describe the scale of urbanization**

The world's population has become predominantly urban. Our ongoing shift from rural to urban living is driven largely by industrialization and is proceeding fastest in the developing world. The location and growth of cities have always been influenced by environmental factors, but the geography of urban areas changes as cities decentralize and suburbs grow and expand. (pp. 338–340)

+ **Define sprawl and discuss its causes and consequences**

Sprawl covers large areas of land with low-density development. Both population growth and increased per capita land use contribute to sprawl. Sprawl results from the home-buying choices of individuals who prefer suburbs to cities, but has been facilitated by government policy and technological developments. Sprawl may lead to negative impacts involving transportation, pollution, health, land use, natural habitat, and economics. (pp. 340–342)

+ **Outline city and regional planning and land use strategies**

City planning and regional planning, along with zoning, are key tools for improving the quality of urban life. Urban growth boundaries, smart growth, and new urbanism attempt to re-create compact and vibrant urban spaces. (pp. 342–345)

+ **Evaluate transportation options, urban parks, and green buildings**

Mass transit systems can enhance the efficiency and sustainability of urban areas. Urban park lands provide recreation, soothe the stress of urban life, and give people access to natural areas. Green buildings minimize their ecological footprints by using sustainable materials, limiting the use of energy and water, minimizing health impacts on their occupants, controlling pollution, and recycling waste. (pp. 345–350)

+ **Analyze environmental impacts and advantages of urban centers**

Cities are resource sinks with high per capita resource consumption, and they create substantial waste and pollution. However, cities also maximize efficiency, help preserve natural lands, and foster innovation. (pp. 350–354)

+ **Assess urban ecology and the pursuit of sustainable cities**

Linear modes of consumption and production are unsustainable, and more circular modes will be needed to create truly sustainable cities. Many cities worldwide are taking steps to decrease their ecological footprints. Most steps taken for urban livability also function to enhance sustainability. (pp. 352–355)

SEEKING **Solutions**

1. Describe the causes of the spread of suburbs and outline the environmental, social, and economic impacts of sprawl. Overall, do you think the spread of urban and suburban development that is commonly labeled *sprawl* is predominantly a good thing or a bad thing? Do you think it is inevitable? Give reasons for your answers.
2. Would you personally want to live in a neighborhood developed in the new-urbanist style? Why or why not? Would you like to live in a city or region with an urban growth boundary? Why or why not?
3. All things considered, do you think cities are a positive thing or a negative thing for environmental quality? How much do you think we may be able to improve the sustainability of our urban areas?
4. **THINK IT THROUGH** You are the facilities manager on your campus, and your school's administration has committed funds to retrofit one existing building with sustainable green construction techniques so that it earns LEED certification. Consider the various buildings on your campus, and select one that you believe is unhealthy or that wastes resources in some way and that you would like to see retrofitted. Describe for an architect three specific ways in which green building techniques might be used to improve this particular building.
5. **THINK IT THROUGH** You are the president of your college or university, and students are clamoring for you to help create the world's first fully sustainable campus. Considering how people enhance livability and sustainability in cities, what lessons might you try to apply to your college or university? You are scheduled to give a speech to the campus community about your plans and will need to name five specific actions you plan to take to pursue a sustainable campus. What will they be, and what will you say about each choice to describe its importance?

CALCULATING **Ecological Footprints**

One way to reduce your ecological footprint is with alternative transportation. Each gallon of gasoline is converted during combustion to approximately 20 pounds of carbon dioxide (CO_2), which is released into the atmosphere. The table lists typical amounts of CO_2 released per person per mile through various modes of transportation, assuming typical fuel efficiencies.

For an average North American person who travels 12,000 miles per year, calculate and record in the table the CO_2 emitted yearly for each transportation option. Then calculate and record the reduction in CO_2 emissions, relative to single-occupant automobile driving, that one could achieve by relying solely on each option.

MODE OF TRANSPORT	CO_2 PER PERSON PER MILE	CO_2 PER PERSON PER YEAR	CO_2 EMISSION REDUCTION	YOUR ESTIMATED MILEAGE PER YEAR	YOUR CO_2 EMISSIONS PER YEAR
Automobile (driver only)	0.825 lb	9900 lb	0		
Automobile (2 persons)	0.413 lb				
Bus	0.261 lb				
Walking	0.082 lb				
Bicycle	0.049 lb				
				Total = 12,000	

1. Which transportation option provides the most miles traveled per unit of carbon dioxide emitted?
2. Clearly, it is unlikely that any of us will walk or bicycle 12,000 miles per year. In the last two columns, estimate what proportion of the 12,000 annual miles you think you actually travel by each method, and then calculate the CO_2 emissions that you are responsible for generating over the course of a year. Which transportation option accounts for the most emissions for you?
3. How could you reduce your CO_2 emissions? How many pounds of emissions do you think you could realistically eliminate over the course of the next year by making changes in your transportation decisions?

Mastering Environmental Science

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