

CHAPTER

14

Land Use

IN THIS CHAPTER

Summary: Population increases have changed land use from rural to urban. Development and suburban living is much more common. Private and public resource management is under debate. Sustainability of forests, wildlife refuges, national parks, and wilderness areas must be addressed. Mining restoration and recycling are important for clean air, water, and long-term environmental stewardship.

Keywords

★ Urbanization, megacity, suburban sprawl, ecological footprint, preservation, remediation, mitigation, restoration, strip mining, recycling

KEY IDEA

Land Use

Since ancient times, people have lived in rural areas where resources came from fishing, hunting, farming, herding, and mining. Occasionally, they gathered to sell, trade, and buy necessities. Over time, some found jobs and stayed in the gathering places permanently. This gave rise to villages and groups of homes joined by family ties, culture, tradition, and the land.

Historically, towns and cities grew into urban areas with large populations specializing in arts, crafts, services, or professions not necessarily tied to local resources and land. Cities expanded out from seaports and major rivers. Imported and exported resources, along with industrialization, brought prosperity to inhabitants, increased jobs, and drew even more people and industries to the city. This gradual change in land use and culture is known as *urbanization*.



Over 80% of the U.S. population lives in cities. Currently around 50% of the world's population lives in cities, and that number is projected to be over 60% by 2035. In fact, China plans to build 400 new cities of $\frac{1}{2}$ million residents each in the next 20 years.

One hundred years ago, London was the only city with over 5 million people. The United Nations Population Division now estimates that 30 cities have larger populations than that. Today, many cities have become *megacities* (i.e., with over 10 million inhabitants). It is projected that by 2015, a dozen cities will have populations between 15 and 30 million residents, 75% of these in the developing world. Additionally, millions of undocumented, temporary workers work in urban areas (e.g., Beijing) daily or seasonally.

Urban Growth Factors

Urban populations increase naturally by more births than deaths and by immigration. Natural increases come from good and plentiful food and water, sanitation, and medical services. Globally, natural increases account for the majority of population jumps (e.g., Eastern Asia and South America). In Western Asia and Africa, immigration to cities for employment and services is a leading cause of urban growth.



Immigration is affected by different characteristics or *push and pull factors*. Overpopulation, conflicts, and lack of resources in a country push new generations into the cities for work and a better life. Communications, arts, and an exciting, modern lifestyle pull people into urban areas as well.

Urban Problems

In large cities, resources and land are strained if not exhausted. For example, in Atlanta, Georgia, and Phoenix, Arizona, strict summer water rationing is mandatory since public water resources are shrinking and nearly exhausted during drought periods.

Traffic congestion, fuel consumption, and subsequent air pollution is a huge problem in densely populated cities such as Jakarta, Indonesia. The average worker spends between three and four hours traveling to and from work each way from suburban areas due to traffic jams. Underdeveloped countries, with the added burden of belching factories, coal and wood fires, and vehicle exhaust, have an ever-present gray veil of pollution affecting their citizens. Lung cancer deaths from smoking and pollution in Shanghai, China, are five to seven times higher than in the countryside.

Developing countries struggle with sewage treatment and proper sanitation. With no money to build modern facilities, only a small percentage of urban residents have access to adequate sanitation. In Latin America, only 2% of urban sewage is treated. In Cairo, Egypt, aging treatment facilities designed to provide for around 2 million inhabitants are servicing over 10 million people.

In Mexico City, roughly 50% of the population (20 million) lives in shantytowns built on undeveloped land from scavenged materials such as packing crates, plastic, and brush. There is no clean water or sanitation. Sometimes people build on hazardous waste sites purposely left undeveloped. When the government removes the shacks from these hazardous areas, people either rebuild or move to another unauthorized area.

Suburban Sprawl

People in developed countries, disenchanted with urban crush, crime, and congestion, moved into the suburbs. Developers advertised lower taxes, spacious living with no industrial pollution, and better family life. They were right at first, but once large numbers of city

inhabitants and businesses joined the suburbs, they became noisy, crowded, and were taxed even higher to provide services already in place in the city.

Because of the land sprawl, people could no longer walk to the store or work. Congestion and traffic thickened, resulting in jams lasting hours. People with city jobs had to sit in traffic for 10 to 15 hours or more weekly. When fuel prices soared, cities scrambled to set up mass transit. Some met their populations' needs, but as populations grew, subways and city trains far exceeded their original carrying capacity.

Increased driving has also impacted suburbanite health. Those sitting for long hours in cars and at jobs get little exercise. When people lived in cities and walked everywhere, obesity and heart disease rates were much lower.

Transportation

Urban and suburban living may seem like a good option, but moving millions of people in and out of a city daily without mass transit is a huge task with a negative environmental impact. Millions of vehicles carrying one person cause traffic jams and increase air pollution.

Bus systems, subways, and monorail transportation have eased congestion and pollution, but not all cities can afford modern transportation. Cities successful at reducing urban sprawl started before their populations got huge. Unfortunately, cities like Houston, Texas (population nearly 4^{1/2} million), face tremendous costs and construction nightmares in converting from an historically one-person, one-car mentality to subway and light-rail transportation.



In cities such as Portland, Oregon, however, where bike routes are common, light-rails have been constructed, zoning has been enacted, and developers are required to invest in established neighborhoods, environmental sustainability works.

Other forward-thinking cities augmented existing federal highways with green alternatives. Many Canadian coastal cities use large vehicle-carrying ferries to transport people and cars to local destinations. Cities such as Venice, Italy, use canals as tourist attractions as well as for transportation.

Water

Land use is also important in other ways. Its impact on the hydrologic cycle and on soil and water quality is direct, as well as indirect. Direct impacts increase soil erosion, flood, drought, and river and groundwater changes.

Indirect effects come from the environmental impacts of land use, and the subsequent climate and environmental changes. For example, land cover can limit water available for groundwater recharge, reducing groundwater discharge to rivers. These hydrologic cycle effects can greatly impact downstream flow.

Ecological Footprint

In the past few centuries, more and more people have moved to towns, cities, or other centrally developed areas. For example, only 15% of U.S. citizens lived in cities during the Civil War. Today it is over 80%. Urban sprawl creates problems in feeding, transporting, sheltering, providing water, and disposing of waste from all those people.

KEY IDEA

A population's *ecological footprint* is the amount of surface area needed to provide for its needs and dispose of its waste.

Americans have a large ecological footprint, around 10 hectares per person. (*Note:* One hectare = 10,000 square meters [\sim 2.5 acres].) Other developed countries such as Argentina (2.5 hectares/person), Sweden (5.0 hectares/person), and Australia (7.5 hectares/person) have smaller footprints. The world's average ecological footprint is estimated at 2.2 hectares/person.

STRATEGY

A mathematical equation, called IPAT, is used to calculate human impact on the environment:

$$I = P \times A \times T$$

The equation solves for I (total impact) by using P (population size), A (affluence), and T (technology level), and provides an idea of a specific population's influence on its local and regional resources.

Loss of Coastal Habitat

Since over half of the world's population currently lives within 60 km of coastal waters and this number is expected to double within the next three to four decades, the oceans will definitely feel an impact. Six of the world's eight largest cities (population over 10 million) are coastal. Moves to coastal areas are driven by poverty and affluence. Low-income people move to cities for jobs, while wealthy people expand shoreline development for resort hotels and seaside homes. The World Resources Institute estimates about half of the world's coastal ecosystems are threatened by development, with most located in northern temperate and equatorial regions, including the coastal zones of Europe, Asia, the United States, and Central America.

Water treatment technology has improved, leading to further growth in developed areas where the new technology is used. However, many developing countries cannot afford to implement these new technologies, and population growth in coastal cities continues to overwhelm existing waste treatment systems. Disease from contaminated water creates a limiting factor on many species' growth in coastal regions.

Population growth also affects the world's oceans. Many interacting factors add to the degradation of marine ecosystems and loss of biodiversity. Population impacts on ocean resources must be better understood if resources are to be sustained without exceeding carrying capacity.

Public and Federal Lands

The world's land area covers around 133 million km² (56 million mi²) or nearly 30% of the planet. Grassland, agriculture, and forests cover around 65% of this. Regions that don't fall into the three main categories are made up of desert, tundra, wetlands, brush, urban areas, ice, snow, and bare rock. Figure 14.1 shows global land use as estimated by the Food and Agriculture Organization.

Not all of this land can be easily or freely utilized. Nearly 10% is currently protected in wildlife refuges, national forests, parks, and nature preserves. Over 11% is

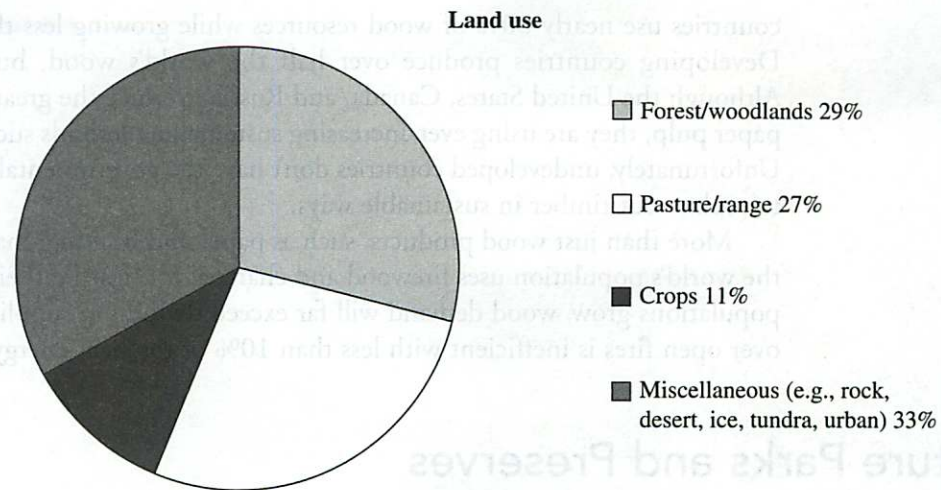


Figure 14.1 Globally, land is used in different ways depending on culture, economics, soil, and climate.

under cultivation for crops. However, many countries are expanding agriculture with new methods for feeding ever-growing populations.

This is nothing new. Billions of acres of forests have been put to the ax over the past 10,000 years in central Asia and Europe, while continents such as South America are only recently feeling the pressure to use more of their forests.

Communal Property

A resource management problem is that we all share global resources (e.g., air, wildlife, mountains, ocean fish). Unfortunately, these can be exploited by a single person, group of people, or nation.

In 1968, biologist Garret Hardin wrote, “The Tragedy of the Commons,” an article explaining how commonly held resources are often misused through self-interest. He thought since everyone shared the same resources and need for those resources (e.g., groundwater), it made it easier to disclaim responsibility for misuse of the resource.

Current ecologists say an *open-access system*, where there are no rules regulating a resource, makes management difficult. Instead they suggest a *communal resource management system* where (1) there are clear boundaries, (2) people live on the land a long time, (3) community size is regulated, (4) people must work together to preserve scarce resources, (5) people have input into rule setting, (6) resource use is actively monitored, (7) conflict management is in place, and (8) compliance incentives exist. When an entire community is responsible for an area or resource, they work together to sustain it, to the benefit of all.

STRATEGY

Forests

Although over half of the planet’s original forests are gone, the 3.8 billion hectares left cover nearly 30% of the global land surface. In fact, nearly every industry uses wood or wood products in manufacturing or marketing activities. Worldwide wood consumption has almost doubled in the past 50 years.

Timber is used for building lumber, plywood, particle board, chipboard, and veneer, about one-half of the world’s wood consumption. As with other resources, developed

TIP

countries use nearly 80% of wood resources while growing less than half of that amount. Developing countries produce over half the world's wood, but only use about 20%. Although the United States, Canada, and Russia produce the greatest amount of wood and paper pulp, they are using ever-increasing sustainable methods such as replanting cut areas. Unfortunately, undeveloped countries don't have the governmental requirements or funding to replace cut timber in sustainable ways.

More than just wood products, such as paper and building materials, fully one-third of the world's population uses firewood and charcoal for heating their homes and cooking. As populations grow, wood demand will far exceed dwindling supplies. Additionally, cooking over open fires is inefficient with less than 10% of the heat energy actually being used.

Nature Parks and Preserves

For centuries, natural areas have been protected for religious or hunting reasons or as a playground for royalty. Only recently, in the past 100 years or so, have some areas been set aside to protect the environment and native species.

Yosemite, in California, was the first area in the United States set aside during the Civil War to protect nature. President Abraham Lincoln deeded it to the state of California, since there was no national office to care for that area then. In 1890, Yosemite was given back to the federal government as a national park. President Ulysses S. Grant designated 800,000 hectares (about 2 million acres) of Wyoming, Montana, and Idaho territories as the first national park (Yellowstone) in the world in 1872. Yellowstone was established to protect the natural curiosities and wonders encompassed in geysers, hot springs, and canyons. Yellowstone has 300 million visitors yearly.



In 1901, President Theodore Roosevelt established 51 national *wildlife refuges* in the United States. The number of these areas now totals 540, comprising nearly 40 million hectares of land for the protection of species. The latest addition was made by President Jimmy Carter when he created the Alaska National Interest Lands Conservation Act in 1980 (protecting about 22 million acres).

Since the establishment of the first parks, the U.S. national park system has expanded to 388 parks, monuments, historic sites, and other areas totaling 280,000 km² (108,000 mi²). Canada has over 1,470 parks and protected areas enclosing around 150,000 km².

Restoration Ecology

Unfortunately, not everyone agrees costly parks and preserves are the best way to protect nature. Some herds like the elk in the Grand Teton National Park have increased so much that park officials have reintroduced wolves, a natural predator, into the park to keep the herds from overpopulating and starving. Local residents are not excited about having wolves nearby.

Controversy over wilderness areas, wildlife refuges, nature preserves, and parks revolves around whether countries are protecting natural resources, species, and ecosystems, or whether they are setting aside sightseeing and recreational areas.



The *1964 Wilderness Act* defined wilderness as an area of undeveloped land affected primarily by the forces of nature, where man is a visitor who does not remain; it contains, ecological, geological, or other features of scientific or historic value; it possesses outstanding opportunities for solitude or a primitive and unconfined type of recreation; it is an area large enough so that continued use will not change its unspoiled natural conditions.

Environmentalists want more undisturbed areas designated as wilderness areas. Miners, loggers, and ranchers want fewer areas set aside. The rationale for wilderness areas is that they provide (1) wildlife refuges and reproductive areas, (2) a research basis for species' changes, (3) a place of solitude and primitive recreation (no motor vehicles), and (4) an area of undisturbed natural beauty for future generations.

Water pollution has become a problem in over 75% of all U.S. refuges. Energy activities (e.g., oil and gas drilling) on the north slope of Alaska's Brooks Range is an example of a hotly disputed extension into a natural area. Environmentalists foresee ecosystem destruction and toxic pollution like that which resulted from the Exxon Valdez oil spill, compromising protected waterways and species.

Marine Preserves

Globally, fish stocks are decreasing from overfishing. Although many nations have recognized this serious issue and have policies protecting their shores, others have not.

Biologists report that "no take" refuges average twice as many species as surrounding areas, and individuals are 30% larger. To protect depleted marine resources, ecologists urged nations to protect at least 20% of coastal shore territories as marine refuges.

Coral reefs are especially at risk. Remote sensing currently shows living coral reef over approximately 285,000 km² (110,000 mi²), which is less than half prior estimates. In fact, scientists report 90% of all reefs are threatened by sea temperature change, coral mining, sediment runoff, ocean dumping, and destructive fishing methods. With current trends, researchers predict living coral reefs will be gone by 2060.


 STRATEGY

Conservation Methods


 TIP

Worldwide, there are over 100,000 protected areas enclosing nearly 19 million km² of biological habitat. The *International Union for the Conservation of Nature* (IUCN) created a world conservation strategy to (1) maintain critical ecological processes (soil and nutrient recycling and water purification), (2) preserve genetic diversity in plants and animals, and (3) ensure sustainability of wild species and ecosystems.

Forest protection, management, and establishment of national parks and preserves are often accomplished via economics. Environmental organizations (e.g., Nature Conservancy, World Wildlife Fund, and Conservation International) buy bank debts and work with developing countries to forgive debts if they strive to protect important biological regions. These debt-for-nature swaps have been done in a number of countries, including Bolivia, Costa Rica, the Dominican Republic, Guatemala, Panama, and Peru.

The IUCN developed a world conservation strategy for natural resources. It focuses on the following three objectives: (1) preserving ecological processes essential to human life and development (e.g., nutrient recycling, soil regeneration, and water purification), (2) protecting genetic diversity of plants and animals, and (3) upholding sustainability of wild species and ecosystems.

In 1986, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) came up with a plan to merge human and wildlife needs in protected areas. The *Man and Biosphere (MAB)* program divides protected areas into different use zones. A core zone is reserved for crucial ecosystems and endangered wildlife. Very limited scientific study is allowed in the core. An outer pristine buffer zone permits some research facilities and ecotourism. Beyond this, zones for sustainable harvesting, a multiuse area, and permanent housing are allowed.

An example of a MAB reserve is the Sian Ka'an Reserve south of Cancun, Mexico. The core includes 528,000 hectares (1.3 million acres) of coral reef, bays, marshes, and tropical forest. Over 335 bird species, manatees, jungle cats, monkeys, and sea turtles reside there. The local economy gets a boost from tourism, farming, and lobster fishing. Community leaders protect the reserve, while also working to improve local living standards.

Mining

Mining involves the extraction of economically important minerals and metals by different methods. Most economic minerals have high metal levels (e.g., aluminum, copper). Nonmetallic resources (e.g., diamond, graphite) are often sought for practical or aesthetic reasons.

Minerals

Most rocks are composed of *minerals* with an assorted combination of differing chemical elements.



KEY IDEA

A *mineral* is a naturally found, inorganic solid with a specific crystalline structure and chemical composition.

The chemical structure of minerals is exact, or slightly varied within limits. Minerals have specific crystalline structures and belong to different groups according to the way the mineral's atoms are arranged. Elements like gold, silver, and copper are found naturally and considered to be minerals.

Crystalline Structure



TIP

Most minerals have a crystalline form with specific geometric arrangements. These structures can be the same between different minerals, but their chemical makeup is different. A mineral's internal structure determines its physical and optical properties, shape, hardness, cleavage, fracture lines, specific gravity, refractive index, and optical axes. The regularly occurring arrangement of atoms and molecules in space determines form.

Geologists have identified over 3,000 minerals all over the world. Australia has particularly rich sources of aluminum, lead, and zinc, while Russia and Canada are rich in nickel. The United States is a prime source of copper.

Mineral Formation and Extraction



TIP

Minerals are found in deposits formed from evaporation, wind deposit, sedimentation, or ancient volcanic heating. Depending on a deposit's depth, minerals are extracted through open-pit mines, *strip mining*, or deep underground mines. The California Gold Rush of the mid-1800s saw thousands of miners trying *placer mining* (i.e., using water to wash away soil from nuggets in shallow pans or in long wooden troughs). Today, placer mining in Canada and Alaska is done by blasting hills with water cannons to separate gold and other minerals. This method uses tons of water and clogs streams with sediment.

Mining Impacts

Other mining methods remove and crush huge amounts of soil and rock to obtain desired metals. Cyanide, mercury, and other hazardous elements are often used during extraction, along with large amounts of water to wash away extra rock. Consequently, ore removal and purification causes water pollution through postprocessing contamination by arsenic, heavy metals, and acids. Mining runoff pollutes streams, lakes, and reservoirs, killing marine life and poisoning ecosystems.



The EPA lists over 100 toxic air pollutants released yearly from U.S. mining operations. Much of this pollution comes from *smelting* or cooking ore to release its metals. In the past 150 years, wood fires have been used to extract copper from ore. This process released sulfur dioxide gas, killed plants, and acidified soil for miles.

Heap-leach extraction, where ore piles are sprayed with a weak cyanide solution to extract gold, is another bad idea. Costing the EPA millions of dollars for cleanup, one abandoned mine in Colorado had tons of remaining mine waste in addition to large, leaking cyanide ponds.

Mining Legislation

The 1977 *Surface Mining Control and Reclamation Act* mandated restoration of strip-mined land. Though expensive (i.e., \$10,000/hectare) and difficult due to the amount of acidified soils, progress has been made. Additionally, the *Clean Air Act of 1970* began regulating many toxic and environmentally harmful mining waste compounds.

In addition to strict regulations, community recycling mandates lower the need for new mining. For example, recycling waste aluminum requires one-twentieth of the energy of extracting new aluminum. Today over 65% of aluminum drink cans are recycled.

Review Questions

Multiple-Choice Questions

- Urbanization came about from
 - less mass transit
 - change in growing seasons
 - lack of high-rise properties
 - gradual changes in land use and societal culture
 - lower city taxes
- Push and pull immigration factors include
 - overpopulation
 - the arts
 - lack of country resources
 - communications
 - all the above
- The amount of surface area needed to provide for a population's needs and dispose of its waste is called its
 - niche
 - tillage area
 - ecological footprint
 - growth index
 - urbanization
- When ore piles are sprayed with a weak cyanide solution to extract gold, it is known as
 - strip mining
 - deep shaft drilling
 - open-pit mining
 - placer mining
 - heap-leach extraction
- All of the following affect a mineral's internal structure except
 - cleavage
 - boiling point
 - shape
 - hardness
 - optical axes
- Deposits formed from evaporation, wind deposit, sedimentation, or volcanic heating contain
 - minerals
 - water
 - lava
 - algae
 - radioactive tracers
- The Surface Mining Control and Reclamation Act mandated
 - a 20% decrease in sulfur emissions
 - no new mining without smokestack filters
 - clear air
 - restoration of strip-mined land
 - recycling of aluminum
- Megacities have over
 - 1 million inhabitants
 - 4 million inhabitants
 - 5 million inhabitants
 - 10 million inhabitants
 - 20 million inhabitants
- A naturally found, inorganic solid with a specific crystalline structure and chemical composition is called a
 - rock
 - fossil
 - mineral
 - biome
 - carbon nanotube
- What percent of urban sewage is treated in Latin America?
 - 1%
 - 2%
 - 3%
 - 5%
 - 10%

11. Bike routes, light-rail, zoning, and development regulations increase
- (A) cultural diversity
 - (B) exercise options
 - (C) taxes
 - (D) corporate options
 - (E) environmental sustainability
12. Direct impacts on the hydrologic cycle include all the following except
- (A) flood
 - (B) drought
 - (C) mining
 - (D) river flow
 - (E) groundwater reservoirs
13. Feeding, transporting, sheltering, providing water, and waste disposal are all problems of
- (A) small countries
 - (B) rural living
 - (C) urban sprawl
 - (D) island nations
 - (E) Arctic scientists
14. Grassland, agriculture, and forests
- (A) provide visual appeal
 - (B) use very little water
 - (C) are all planted by humans
 - (D) cover the world's land area
 - (E) are always found in great amounts worldwide
15. When ore is heated to extract minerals, it is known as
- (A) deep shaft mining
 - (B) smelting
 - (C) placer mining
 - (D) a sustainable method of extraction
 - (E) ablation
16. What percent of Mexico City's population lives in shantytowns built on undeveloped land from scavenged materials?
- (A) 10%
 - (B) 25%
 - (C) 35%
 - (D) 50%
 - (E) 70%
17. An unforeseen result of suburban living is
- (A) less traffic
 - (B) less exercise
 - (C) closer community ties
 - (D) lower taxes
 - (E) greater vehicle wear and tear
18. When water is used to wash away soil from gold nuggets in shallow pans or in long wooden troughs, it is called
- (A) strip mining
 - (B) deep shaft drilling
 - (C) open-pit mining
 - (D) placer mining
 - (E) heap-leach extraction
19. A communal resource management system includes all the following factors except
- (A) clear boundaries
 - (B) active monitoring of resource use
 - (C) people living on the land a long time
 - (D) privatization and self-interest
 - (E) people having input into rule setting