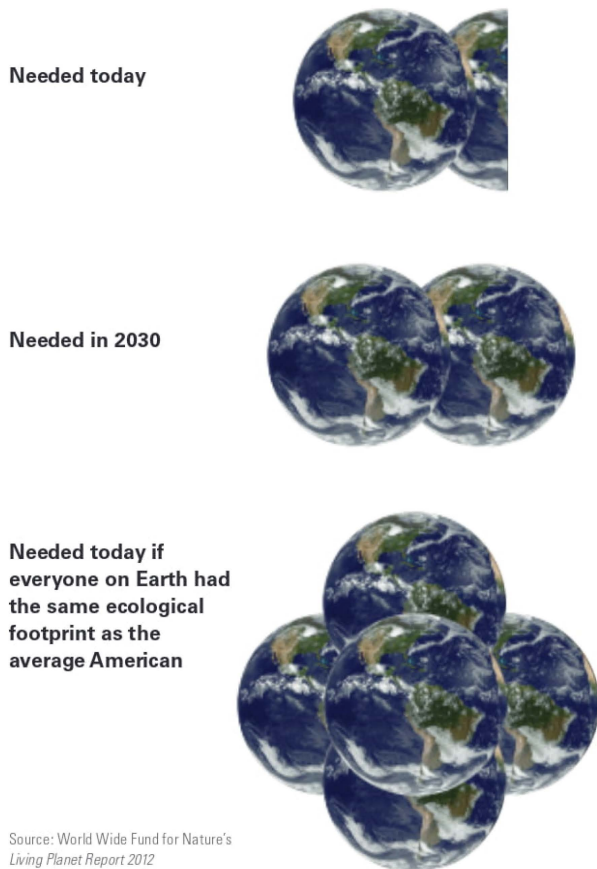


FIGURE 1-11 ▼

Global Ecological Deficit Each scenario shows the estimated number of Earths needed to support humankind's ecological footprint.



checkpoint Give some examples of how ecological footprints are increasing.

1.2 Assessment

- 1. Explain** Why is nonpoint source pollution more difficult to control than point source pollution?
- 2. Research** Find a reliable ecological footprint calculator and use it to determine the size of your own ecological footprint. How does your footprint compare to the average? How do you think the calculator's accuracy could be improved?

CROSSCUTTING CONCEPTS

- 3. Scale, Proportion, and Quantity** In 2012, the total ecological footprint of China was only just below that of the European Union. But the ecological footprint of the average European was nearly three times greater than that of the average Chinese person's. Explain how this is possible.

1.3 What Causes Environmental Problems and Why Do They Persist?

CORE IDEAS AND SKILLS

- Discuss the major causes of environmental problems.
- Describe the different forms of environmental degradation that can result from affluence and from poverty.
- Explain how one's environmental worldview affects one's attitude toward living sustainably.
- Compare the three major categories of environmental worldviews.

KEY TERMS

exponential growth	environmental ethics	life-centered worldview
environmental worldview	human-centered worldview	Earth-centered worldview

The Human Population Is Growing at a Rapid Rate

According to a significant number of environmental and social scientists, population growth is one of the major causes of environmental problems (Figure 1-12).

Exponential growth occurs when a quantity increases at a fixed percentage per unit of time, such as 2% a year. Exponential growth starts slowly, but after a few doublings, grows to enormous numbers because each doubling is twice the total of all earlier growth. For example, a sheet of paper is very thin, but when folded in half, the thickness doubles. Now imagine if you doubled the thickness of the folded sheet of paper—then it would be four times thicker. If you repeated this process just 50 times the paper would be thick enough to almost reach the sun, which is 150 million kilometers (93 million miles) from Earth.

The human population has been growing exponentially, though the rate has slowed in recent years. In 2015, the rate of growth was 1.16%. By 2021, the rate of growth was 1.03%. Today there are more than 7.9 billion people on the planet. By 2050, the population could reach 9.7 billion. Because of recent declines in the growth rate, it is difficult to forecast exactly how the global population will change in the future. There are many predictions as to why the rate is decreasing, but one fact is certain: the population in 2050 will be significantly greater than it is today.



FIGURE 1-7

Logs stand five stories high in Alberta, Canada. How is clearing of forests an example of natural capital degradation?

the cost of replanting, the government may subsidize (pay part of the cost of) planting new trees.

Each individual—including you—plays an important role in the drive to become a more sustainable society. History has shown that most of the significant changes in human systems have begun through the collective actions of individuals.

checkpoint What are some human activities that degrade natural capital?

1.1 Assessment

- 1. Classify** Is solar energy an ecosystem service? Why or why not?
- 2. Contrast** What is the difference between ecosystem services and natural resources?
- 3. Apply** Give an example of an ecosystem service that is not mentioned in the text and defend your answer.

CROSSCUTTING CONCEPTS

- 4. Stability and Change** Life has existed on Earth for about 3.8 billion years despite gradual and sudden environmental changes. How do the scientific factors of sustainability help explain how life has continued to survive and evolve?

1.2 How Are Our Ecological Footprints Affecting Earth?

CORE IDEAS AND SKILLS

- Recognize some major environmental problems that lead to natural capital degradation.
- Describe the purpose of the ecological footprint and IPAT models.

KEY TERMS

environmental degradation	point source nonpoint source	ecological footprint
pollution		

Good News: Many People Have a Better Quality of Life

As the world's dominant animal, humans have an immense power to degrade or sustain Earth's life support system. Collectively, people have the power to decide such matters as whether a forest is preserved or cut down, or whether a river is dammed or allowed to flow. People's actions will have an impact on the temperature of the atmosphere, the temperature and the acidity of the ocean, and which species survive or become extinct. At the same time, creative thinking, economic growth, scientific research, grassroots political pressure by citizens, and regulatory laws have improved the quality of life for many of Earth's people, especially in the United States and most other more-developed countries.

Humans have developed an amazing array of useful materials and products. We have learned how to use wood, fossil fuels, the sun, wind, the nuclei of certain atoms, and Earth's heat (geothermal energy) to supply us with enormous amounts of energy. We live and work in artificial environments in the form of buildings and cities. We have invented computers to extend our brains, robots to perform repetitive tasks with great precision, and electronic networks to enable instantaneous global communication.

Globally, life spans are increasing, infant mortality is decreasing, education is on the rise, some diseases are being conquered, and the population growth rate has slowed. The food supply is generally more abundant and safer, air and water are getting cleaner in many parts of the world, and exposure to toxic chemicals is more avoidable. People have protected some endangered species and ecosystems, and forests are growing back in some areas.

Scientific research and technological advances financed by affluence helped achieve these improvements in life and environmental quality. Education also spurred many citizens to insist that businesses and governments work toward improving environmental quality.

People have learned a lot about how Earth works and how to identify environmental problems, their causes, and their solutions. With the internet and

mobile phones, humans are a connected species with growing access to information that could help society shift to a more sustainable path.

checkpoint Give at least three reasons why many people around the world have an improved quality of life.

Humans Are Living Unsustainably

According to a large body of scientific evidence, people are living unsustainably. People continually waste, deplete, and degrade much of Earth's natural capital—a process known as **environmental degradation** or natural capital degradation (Figure 1-8). Biologist Garrett Hardin (1915–2003) called such degradation the “tragedy of the commons.” Some renewable resources are not owned by anyone and can be used by almost anyone. Examples include the atmosphere, the ocean, and its fish. Degradation occurs because each user reasons, “The little bit that I use or pollute is not enough to matter.” When the level of use is small, this logic works. Eventually, however, the total effect of large numbers of people trying to exploit a widely available or shared resource can degrade the resource, eventually exhausting or ruining it. Then no one benefits and everyone loses. That is the tragedy.

FIGURE 1-8 ►
Natural Capital Degradation Climate change, environmental pollutants in water and air, and soil erosion are examples of natural capital degradation.

Degradation of Normally Renewable Natural Resources

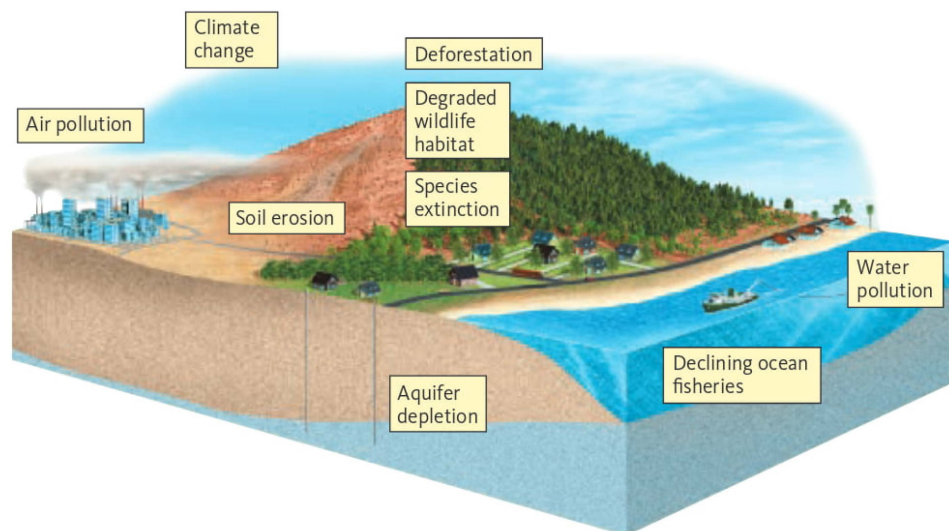


FIGURE 1-9

Pollution, in the form of plastic waste, washes up on a beach in Venezuela.



In 2005, the United Nations (UN) released a report titled *Millennium Ecosystem Assessment*. It is the product of a four-year study conducted by 1,360 experts from 95 countries. According to this study, human activities have overused about 60% of Earth's ecosystem services. (See the orange boxes in Figure 1-6.) Most of this has occurred since 1950, which suggests the pace of degradation has increased. The UN's summary warned that "human activity is putting such a strain on the natural functions of Earth that the ability of the planet's ecosystems to sustain future generations can no longer be taken for granted." The problems are extremely complex, but scientific, economic, and political solutions could be implemented within the near future.

Countries, like individuals, differ in their resource use and environmental impact. The world's states can be classified economically as either "more developed" or "less developed," based primarily on their average income per person. Distinguishing between countries in terms of their economic activity is useful for studying the resource use and environmental impacts of countries and regions.

More-Developed Countries Industrialized countries with high average incomes account for only 16% of the world's population. They include the United States, Canada, Japan, Australia, and most European countries.

Less-Developed Countries All other nations, in which 84% of the world's people live, are considered less developed economically. Most of these countries are in Africa, Asia, and Latin America. Some less-developed countries are further classified as middle-income, moderately developed countries such as China, Brazil, Thailand, and Mexico. Others are low-income, least-developed countries, including Congo and Haiti.

checkpoint What is the tragedy of the commons?

Pollution Comes from a Number of Sources

A major environmental problem is pollution. **Pollution** is contamination of the environment by any chemical or agent, such as noise or thermal energy, at levels considered harmful to the health, survival, or activities of organisms. Some pollution occurs naturally. Volcanic eruptions are a natural source of pollutants that contaminate the air and water. Other pollution is the result of human activities such as energy production, industry, agriculture, and transportation.

Pollutants originate from point sources and nonpoint sources. According to the Environmental Protection Agency (EPA), a **point source** of pollution is "any single identifiable source of pollution from which pollutants are discharged." Examples are air pollution from the exhaust pipes of motor vehicles, chimneys, and smokestacks and water pollution from the drainage pipes and ditches of industrial and sewage treatment plants. **Nonpoint source** pollution consists of pollutants that come from many diffuse sources that are hard to pinpoint. Examples are runoff of water pollutants from croplands, residential areas, clear-cut forests, and construction sites, as well as deposition of pollutants on land from the atmosphere.

People have tried to deal with pollution in two very different ways. One approach is pollution cleanup, which involves cleaning up or diluting pollutants that have already been, or are being, released. For example, devices in smokestacks and automobile exhaust systems can remove various types of pollutants. Polluted water can be treated to remove pollutants before they are discharged.

The other approach is pollution prevention, which focuses on reducing or eliminating the production of pollutants. For example, governments can enact pollution control laws that ban or minimize the emissions of certain pollutants. Scientists and engineers can come up with new designs for automobile engines, power plants, or industrial processes that do not produce certain pollutants. According to many environmental scientists, pollution prevention is an important step toward a more sustainable future because, in the long run, it is more effective and less expensive than cleanup.

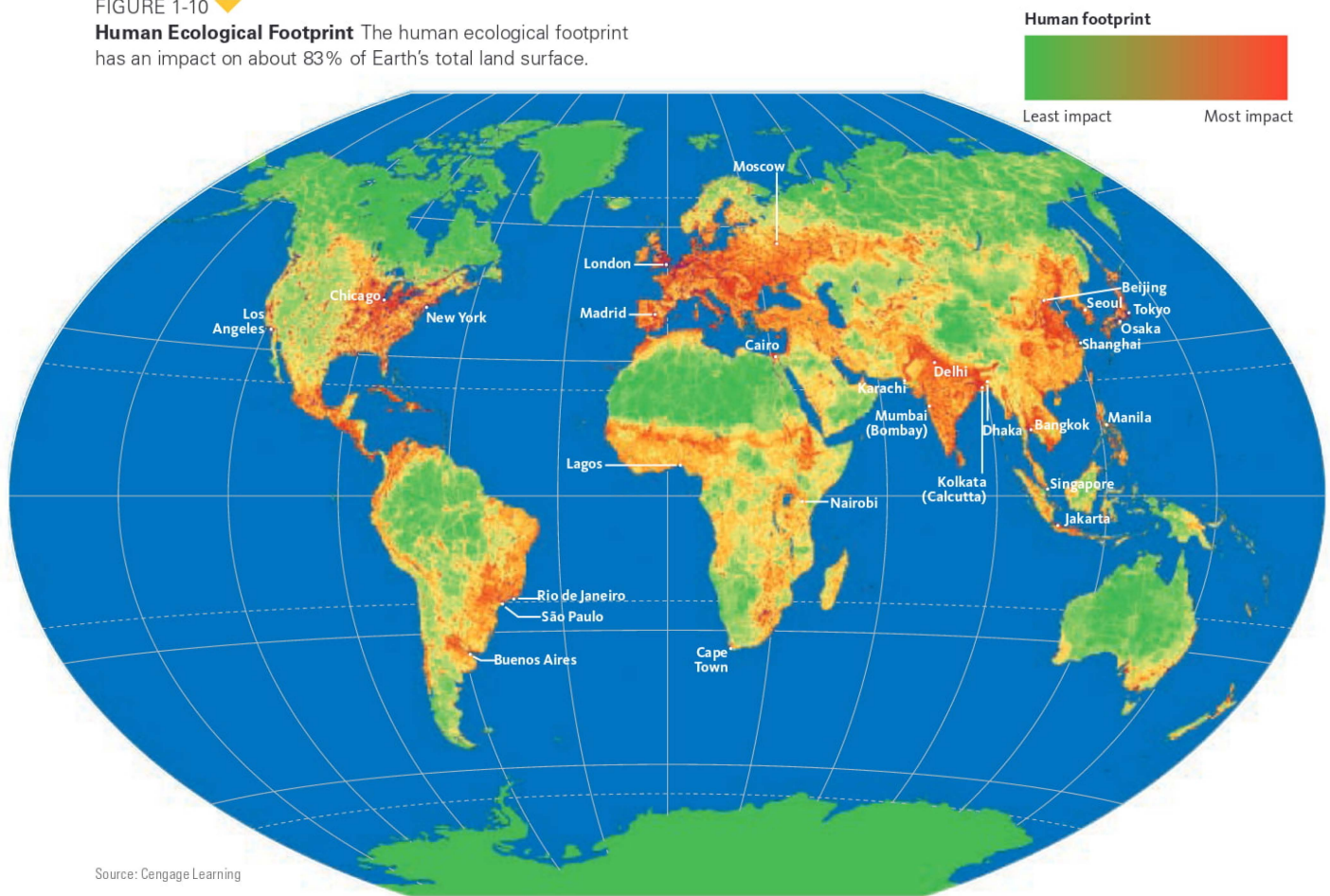
checkpoint What is the difference between point source and nonpoint source pollution?

Modeling Environmental Impacts

Overusing or misusing renewable resources can result in natural capital degradation, pollution, and waste (Figure 1-9). The extent of this harmful environmental impact is called an **ecological footprint**. This is the amount of land and water needed to supply an individual or a population with renewable resources. It is also a measure of the amount of land and water required to absorb and recycle the wastes and pollution produced by such resource use. The size of the footprint is proportional to the amount of renewable resources consumed.

FIGURE 1-10 ▼

Human Ecological Footprint The human ecological footprint has an impact on about 83% of Earth's total land surface.



Source: Cengage Learning

You can find ecological footprint models on the internet and use them to determine your own ecological footprint. The per capita ecological footprint is the average ecological footprint of an individual in a given country or area. Figure 1-10 shows the human ecological impact in different parts of the world.

If the total ecological footprint for a city, country, or the world is larger than its biological capacity to replenish resources and absorb the resulting wastes and pollution, the area is said to have an ecological deficit. In other words, an ecological deficit results when people are living unsustainably by depleting natural capital. Ecological footprint data and models have been in use since the mid-1990s. Though imperfect, they provide useful rough estimates of individual, national, and global environmental impacts. Globally, humans are running up a huge ecological deficit that is expected to increase (Figure 1-11).

Another environmental impact model was developed in the 1970s by scientists Paul Ehrlich and John Holdren. The IPAT model shows that

the environmental impact (**I**) of human activities is the product of three factors: population size (**P**), affluence (**A**), and the beneficial and harmful environmental effects of technologies (**T**). The following equation summarizes the IPAT model:

$$\text{Impact (I)} = \text{Population (P)} \times \text{Affluence (A)} \times \text{Technology (T)}$$

While the ecological footprint model emphasizes the use of renewable resources, the IPAT model includes the environmental impact of using both renewable and nonrenewable resources. The T factor can be either harmful or beneficial. Some forms of technology such as polluting factories, gas-guzzling motor vehicles, and coal-burning power plants increase our harmful environmental impact by raising the T factor. The goal is to decrease the harmful T factor with use of pollution control and prevention technologies, fuel-efficient cars, and wind turbines and solar cells that generate electricity with a low environmental impact. In doing so, the ecological footprint will be reduced.