1 Environmental Problems, Their Causes, and Sustainability

CASE STUDY

Living in an Exponential Age

Two ancient kings enjoyed playing chess, with the winner claiming a prize from the loser. After one match, the winner asked the loser to pay him by placing one grain of wheat on the first square of the chessboard, two on the second, four on the third, and so on, with the number doubling on each square until all 64 were filled.

The losing king, thinking he was getting off easy, agreed with delight. It was the biggest mistake he ever made. He bankrupted his kingdom because the number of grains of wheat he had promised was probably more than all the wheat that has ever been harvested!

This fictional story illustrates the concept of **exponential growth,** in which a quantity increases at a constant rate per unit of time such as 2% a year. Exponential growth is deceptive. It starts off slowly, but after only a few doublings, it grows to enormous numbers because each doubling is more than the total of all earlier growth.

Here is another example. Fold a piece of paper in half to double its thickness. If you could continue doubling the thickness of the paper 42 times, the stack would reach from the earth to the moon, 386,400 kilometers (240,000 miles) away. If you could double it 50 times, the folded paper would almost reach the sun, 149 million kilometers (93 million miles) away!

Between 1950 and 2004, the world's population increased exponentially from 2.5 billion to 6.4 billion and may increase to somewhere between 8 billion and 12 billion people by the end of this century (Figure 1-1).

Global economic output—some of it environmentally beneficial and some of it environmentally harmful—is a rough measure of the human use of the earth's resources. It has increased sevenfold since 1950 and is projected to continue increasing exponentially at a rapid rate.

Despite a 22-fold increase in economic growth since 1900, almost *one of every two people in the world try to survive on an income of less than $3 (U.S.) per day.*

Such poverty affects environmental quality because to survive many of the poor must deplete and degrade local forests, grasslands, soil, and wildlife.

Biologists estimate that human activities are causing premature extinction of the earth's species at an exponential rate of 0.1% to 1% a year—an irreversible loss of the earth's great variety of life forms, or *biodiversity.* In various parts of the world, forests, grasslands, wetlands, and coral reefs continue to disappear or become degraded as the human ecological footprint continues to spread exponentially across the globe.

There is growing concern that exponential growth in human activities such as burning fossil fuels and clearing forests will change the earth's climate during this century. This could ruin some areas for farming, shift water supplies, alter and reduce biodiversity, and disrupt economies in various parts of the world.

Exponential growth plays a key role in five important and interconnected environmental issues: *population growth, resource use and waste, poverty, loss of biological diversity,* and *global climate change. Great news.* We have solutions to these problems that we could implement within a few decades, as you will learn in this book.

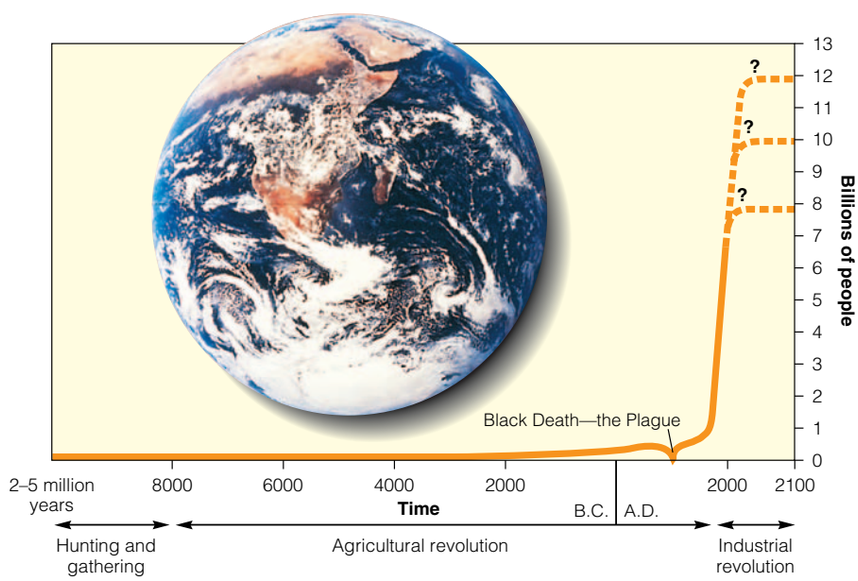

Figure 1-1 The *J*-shaped curve of past exponential world population growth, with projections to 2100. Notice that exponential growth starts off slowly, but as time passes the curve becomes increasingly steep. The current world population of 6.4 billion people is projected to reach 8–12 billion people sometime this century. (This figure is not to scale.) (Data from World Bank and United Nations; photo courtesy of NASA)

Alone in space, alone in its life-supporting systems, powered by inconceivable energies, mediating them to us through the most delicate adjustments, wayward, unlikely, unpredictable, but nourishing, enlivening, and enriching in the largest degree—is this not a precious home for all of us? Is it not worth our love?

BARBARA WARD AND RENÉ DUBOS

This chapter presents an overview of environmental problems, their causes, controversy over their seriousness, and ways we can live more sustainably. It discusses these questions:

- What keeps us alive? What is an environmentally sustainable society?
- How fast is the human population increasing? What are economic growth, economic development, and globalization?
- What are the earth's main types of resources? How can they be depleted or degraded?
- What are the principal types of pollution? What can we do about pollution?
- What are the basic causes of today's environmental problems? How are these causes connected?
- Is our current course sustainable? What is environmentally sustainable development?

1-1 LIVING MORE SUSTAINABLY

What Is the Difference between Environment, Ecology, and Environmental Science? Defining Some Basic Terms

Environmental science is a study of how the earth works, how we interact with the earth, and how to deal with environmental problems.

Environment is everything that affects a living organism (any unique form of life). **Ecology** is a biological science that studies the relationships between living organisms and their environment.

This textbook is an introduction to **environmental science,** an interdisciplinary study that uses information from the physical sciences and social sciences to learn how the earth works, how we interact with the earth, and how to deal with environmental problems. Environmental science involves integrating ideas from the *natural world* (*biosphere*) and our *cultural world* (*culturesphere*).

Environmentalism is a social movement dedicated to protecting the earth's life support systems for us and other species. Members of the environmental community include *ecologists, environmental scientists, conservation biologists, conservationists, preservationists, restorationists,* and *environmentalists.*

What Keeps Us Alive? The Sun and the Earth's Natural Capital

All life and economies depend on energy from the sun (solar capital) and the earth's resources and ecological services (natural capital).

Our existence, lifestyles, and economies depend completely on the sun and the earth, a blue and white island in the black void of space (Figure 1-1). To economists, *capital* is wealth used to sustain a business and to generate more wealth. For example, suppose you invest $100,000 of capital and get a 10% return on your money. In a year you get $10,000 in income from interest and increase your wealth to $110,000.

By analogy, we can think of energy from the sun as **solar capital. Solar energy** includes direct sunlight and indirect forms of renewable solar energy such as *wind power, hydropower* (energy from flowing water), and *biomass* (direct solar energy converted to chemical energy and stored in biological sources of energy such as wood).

Similarly, we can think of the planet's air, water, soil, wildlife, forest, rangeland, fishery, mineral, and energy resources and the processes of natural purification, recycling, and pest control as **natural resources** or **natural capital** (Figure 1-2). See the Guest Essay by Paul Hawken on the website for this chapter.

Natural capital consists of *resources* (orange in Figure 1-2) and *ecological services* (green in Figure 1-2) that support and sustain the earth's life and economies. This priceless natural capital that nature provides at no cost to us plus the natural biological income it supplies can sustain the planet and our economies indefinitely as long as we do not deplete them. Examples of *biological income* are renewable supplies of wood, fish, grassland for grazing, and underground water for drinking and irrigation.

What Is an Environmentally Sustainable Society? One That Preserves Natural Capital and Lives Off Its Income

An environmentally sustainable society meets the basic resource needs of its people indefinitely without degrading or depleting the natural capital that supplies these resources.

An **environmentally sustainable society** meets the current needs of its people for food, clean water, clean air, shelter, and other basic resources without compromising the ability of future generations to meet their needs. *Living sustainably* means living off natural income replenished by soils, plants, air, and water and not depleting or degrading the earth's natural capital that supplies this biological income.

Imagine you win $1 million in a lottery. Invest this capital at 10% interest per year, and you will have a

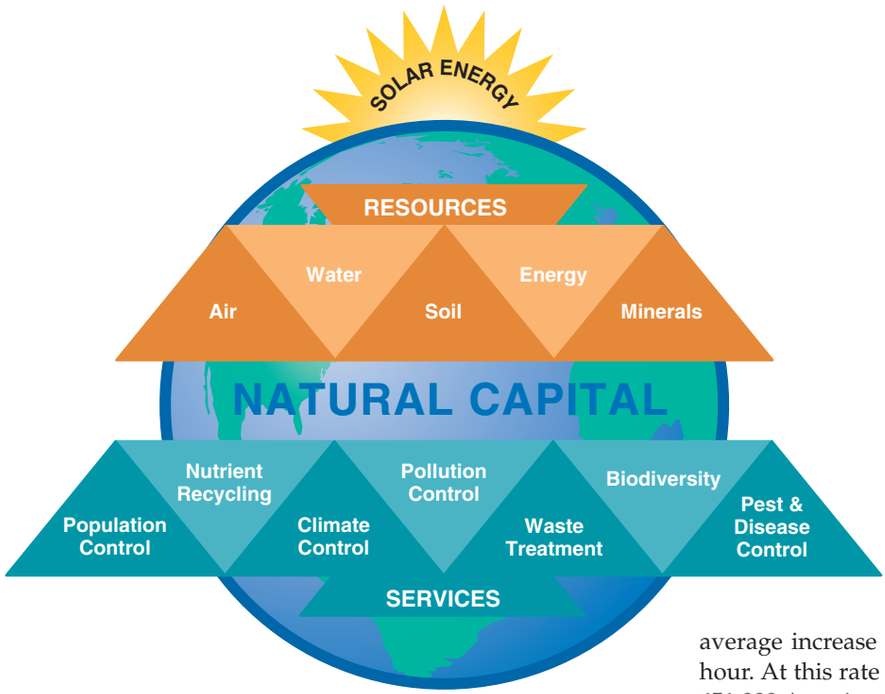

Figure 1-2 The earth's ***natural capital.*** Energy from the sun (solar capital) and the earth's natural capital provide resources (orange) and ecological services (green) that support and sustain the earth's life and economies. Wedges from this diagram will be used near the titles of various chapters to indicate the components of natural capital that are the primary focus of such chapters. This diagram also appears on the back cover of this book.

sustainable annual income of $100,000 without depleting your capital. If you spend $200,000 a year, your $1 million will be gone early in the 7th year and even if you spend only $110,000 a year, you will be bankrupt early in the 18th year.

The lesson here is an old one: *Protect your capital and live off the income it provides.* Deplete, waste, or squander your capital, and you move from a sustainable to an unsustainable lifestyle.

The same lesson applies to the earth's natural capital. According to many environmentalists and leading scientists, we are living unsustainably by wasting, depleting, and degrading the earth's natural capital at an accelerating rate.

Some people disagree. They contend that environmentalists have exaggerated the seriousness of population, resource, and environmental problems. They also believe we can overcome these problems by human ingenuity, economic growth, and technological advances.

1-2 POPULATION GROWTH, ECONOMIC GROWTH, ECONOMIC DEVELOPMENT, AND GLOBALIZATION

How Rapidly Is the Human Population Growing? Pretty Fast

The rate at which the world's population is growing has slowed but is still growing pretty rapidly.

Currently the world's population is growing exponentially at a rate of about 1.25% a year. This does not seem like a very fast rate. But it added about 80 million people (6.4 billion $\times$ 0.0125 = 80 million) to the world's population in 2004, an average increase of 219,000 people a day, or 9,100 an hour. At this rate it takes only about 3 days to add the 651,000 Americans killed in battle in all U.S. wars and only 1.6 years to add the 129 million people killed in all wars fought in the past 200 years!

How much is 80 million? Suppose you spend 1 second saying hello to each of the 80 million new people added this year for 24 hours a day—no sleeping, eating or anything else allowed. How long would this handshaking marathon take? Answer: 2.5 years. By then there would be about 192 million more people to shake hands with. Exponential growth is astonishing!

What Is the Difference between Economic Growth and Economic Development? More Stuff and Better Living Standards

Economic growth provides people with more goods and services and economic development uses economic growth to improve living standards.

Economic growth is an increase in the capacity of a country to provide people with goods and services. Accomplishing this increase requires population growth (more producers and consumers), more production and consumption per person, or both.

Economic growth is usually measured by the percentage change in a country's **gross domestic product (GDP):** the annual market value of all goods and services produced by all firms and organizations, foreign and domestic, operating within a country. Changes in a country's standard of living is measured by **per capita GDP:** the GDP divided by the total population at midyear.

Economic development is the improvement of living standards by economic growth. The United Nations

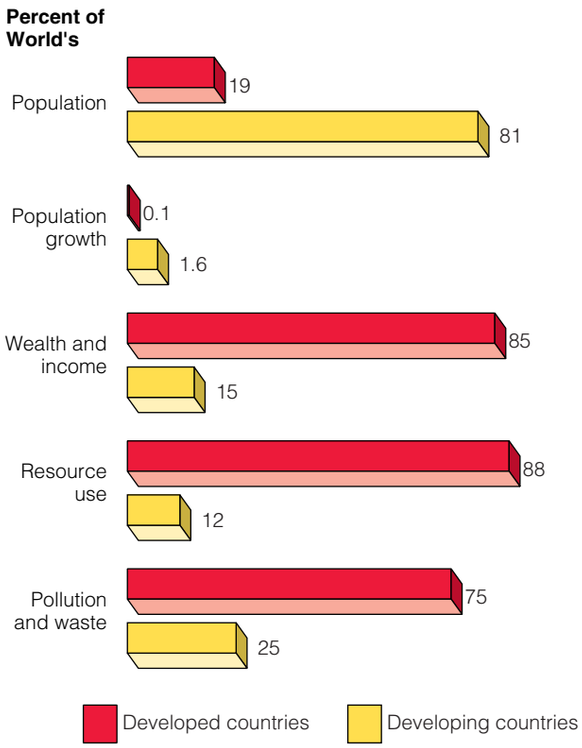

Figure 1-3 Comparison of developed and developing countries. (Data from United Nations and the World Bank)

(UN) classifies the world's countries as economically developed or developing based primarily on their degree of industrialization and their per capita GDP.

The **developed countries** (with 1.2 billion people) include the United States, Canada, Japan, Australia, New Zealand, and the countries of Europe. Most are highly industrialized and have high average per capita GDP. All other nations (with 5.2 billion people) are classified as **developing countries,** most of them in Africa, Asia, and Latin America. Some are *middle-income, moderately developed countries* and others are *low-income countries.*

Figure 1-3 compares some key characteristics of developed and developing countries. About 97% of the projected increase in the world's population is expected to take place in developing countries (Figure 1-4).

Figure 1-5 summarizes some of the benefits (*good news*) and harm (*bad news*) caused mostly by economic development. It shows effects of the wide and increasing gap between the world's haves and have-nots.

What Is Globalization? Being Connected

We live in a world that is increasingly interconnected through economic, cultural, and environmental interdependence.

You have probably heard about **globalization:** the process of social, economic, and environmental global

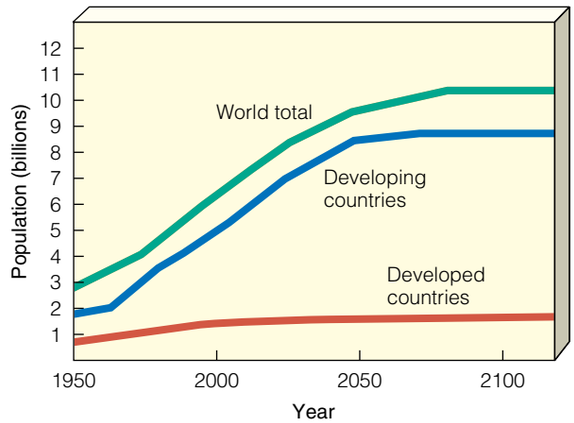

Figure 1-4 Past and projected population size for developed countries, developing countries, and the world, 1950–2100. Developing countries are expected to account for 97% of the 2.5 billion people projected to be added to the world's population between 2004 and 2050. (Data from United Nations)

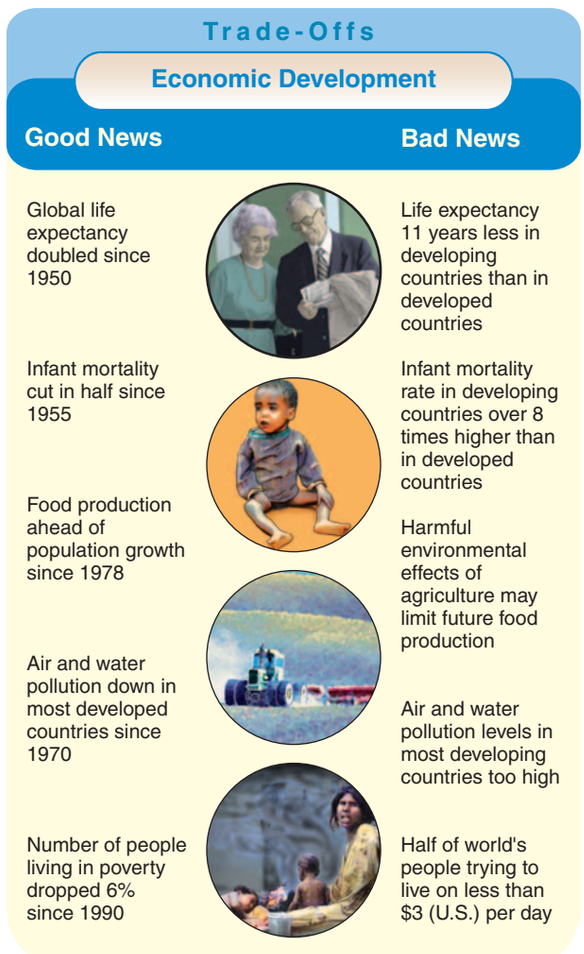

Figure 1-5 **Trade-offs:** good and bad news about economic development. Pick the single pieces of good news and bad news that you believe are the most important. (Data from United Nations and World Health Organization)

changes that lead to an increasingly interconnected world. It involves increasing exchanges of people, products, services, capital, and ideas across international borders.

Factors accelerating globalization include information and communication technologies, human mobility, and international trade and investment. Modern communication via cell phones and the Internet also allows powerless people throughout the world to share ideas and to band together to bring about change from the bottom up.

This decentralized network, where everyone has access to everyone else, represents a *democratization of learning and communication* that is unprecedented in human history. A sustainable community or country recognizes that it is part of a larger global economic and ecological system and that it cannot be sustainable unless these larger systems are also sustainable.

1-3 RESOURCES

What Is a Resource? Things We Need or Want

We obtain resources from the environment to meet our needs and wants.

From a human standpoint, a **resource** is anything obtained from the environment to meet our needs and wants. Examples include food, water, shelter, manufactured goods, transportation, communication, and recreation. On our short human time scale, we classify the material resources we get from the environment as *perpetual*, *renewable*, or *nonrenewable*, as shown in Figure 1-6.

Some resources, such as solar energy, fresh air, wind, fresh surface water, fertile soil, and wild edible plants, are directly available for use. Other resources, such as petroleum (oil), iron, groundwater (water found underground), and modern crops, are not directly available. They become useful to us only with some effort and technological ingenuity. For example, petroleum was a mysterious fluid until we learned how to find and extract it and refine it into gasoline, heating oil, and other products that we could sell at affordable prices.

What Are Perpetual and Renewable Resources? Resources That Can Last

Resources renewed by natural processes are sustainable if we do not use them faster than they are replenished.

Solar energy is called a **perpetual resource** because on a human time scale it is renewed continuously. It is expected to last at least 6 billion years as the sun completes its life cycle as a star.

On a human time scale, a **renewable resource** can be replenished fairly rapidly (from hours to several decades) through natural processes. But this works only as long as the resource is not used up faster than it is replaced. Examples of renewable resources are forests, grasslands, wild animals, fresh water, fresh air, and fertile soil.

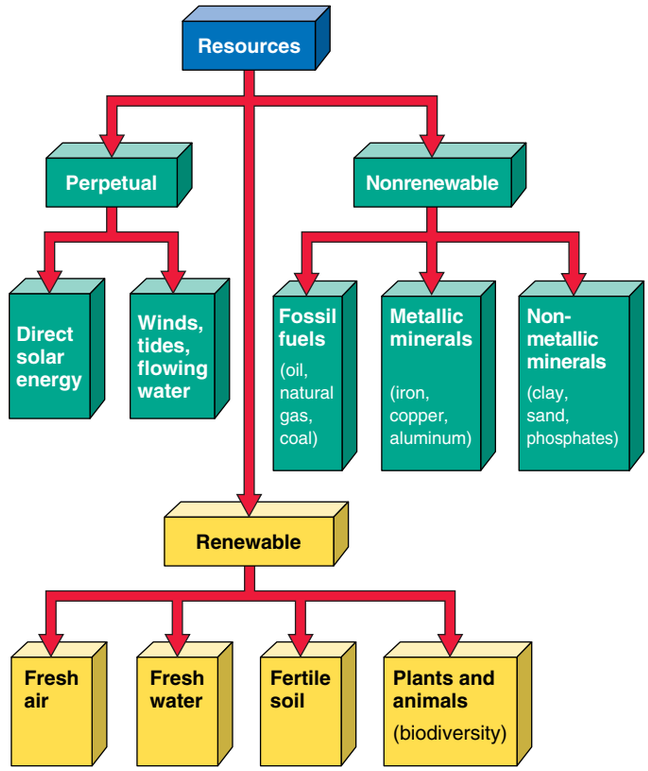

Figure 1-6 Natural capital: major types of material resources. This scheme is not fixed; renewable resources can become nonrenewable if used for a prolonged period at a faster rate than natural processes renew them.

Renewable resources can be depleted or degraded. The highest rate at which a renewable resource can be used *indefinitely* without reducing its available supply is called its **sustainable yield.**

When we exceed a renewable resource's natural replacement rate, the available supply begins to shrink, a process known as **environmental degradation.** Examples include urbanization of productive land, excessive topsoil erosion, pollution, deforestation (temporary or permanent removal of large expanses of forest for agriculture or other uses), groundwater depletion, overgrazing of grasslands by livestock, and reduction in the earth's forms of wildlife (biodiversity) by elimination of habitats and species.

Case Study: The Tragedy of the Commons—Degrading Free Renewable Resources

Renewable resources that are freely available to everyone can be degraded.

One cause of environmental degradation of renewable resources is the overuse of **common-property** or **free-access resources.** No individual owns these resources, and they are available to users at little or no charge.

Examples include clean air, the open ocean and its fish, migratory birds, wildlife species, publicly owned lands (such as national forests and national parks), gases of the lower atmosphere, and space.

In 1968, biologist Garrett Hardin (1915–2003) called the degradation of renewable free-access resources the **tragedy of the commons.** It happens because each user reasons, "If I do not use this resource, someone else will. The little bit I use or pollute is not enough to matter, and such resources are renewable."

With only a few users, this logic works. But the cumulative effect of many people trying to exploit a free-access resource eventually exhausts or ruins it. Then no one can benefit from it, and that is the tragedy.

One solution is to use free-access resources at rates well below their estimated sustainable yields by reducing population, regulating access to the resources, or both. Some communities have established rules and traditions to regulate and share their access to common-property resources such as ocean fisheries, grazing lands, and forests. Governments have also enacted laws and international treaties to regulate access to commonly owned resources such as forests, national parks, rangelands, and fisheries in coastal waters.

Another solution is to *convert free-access resources to private ownership.* The reasoning is that if you own something, you are more likely to protect your investment.

This sounds good, but private ownership is not always the answer. One problem is private owners do not always protect natural resources they own when this conflicts with protecting their financial capital or increasing their profits. For example, some private forest owners can make more money by clear-cutting the timber, selling the degraded land, and investing their profits in other timberlands or businesses.

A second problem is that this approach is not practical for global common resources—such as the atmosphere, the open ocean, most wildlife species, and migratory birds—that cannot be divided up and converted to private property.

What Is Our Ecological Footprint? Our Growing Environmental Impact

Supplying each person with renewable resources and absorbing the wastes from such resource use creates a large ecological footprint or environmental impact.

The **per capita ecological footprint** is the amount of biologically productive land and water needed to supply each person or population with the renewable resources they use and to absorb or dispose of the wastes from such resource use. It measures the average environmental impact of individuals in different countries and areas. In other words, it is a measure of how much of the earth's natural capital and biological income each of us uses.

Bad news. Humanity's ecological footprint per person exceeds the earth's biological capacity to replenish renewable resources and absorb waste by about 15% (Figure 1-7, right). If these estimates are correct, *it will*

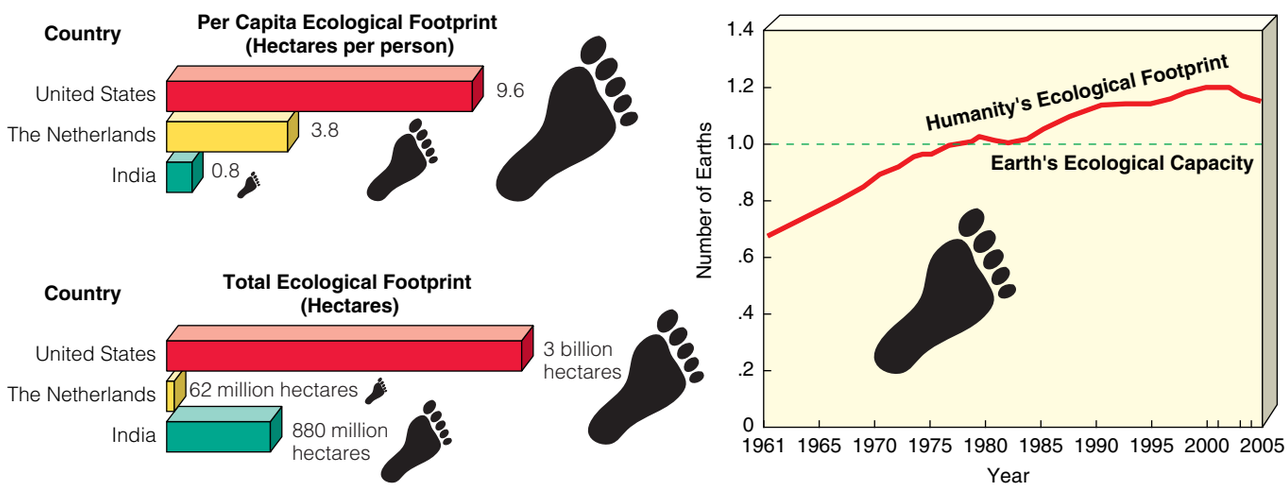

Figure 1-7 Natural capital use and degradation: total and per capita *ecological footprints* of the United States, the Netherlands, and India (left). The *ecological footprint* is a measure of the biologically productive areas of the earth required to produce the renewable resources required per person and absorb or break down the wastes produced by such resource use. Currently, humanity's average ecological footprint per person is 15% higher than the earth's biological capacity per person (right). (Data from William Rees and Mathis Wackernagel, *Redefining Progress,* 2004)

take the resources of 1.15 planet earths to indefinitely support our current use of renewable resources!

The ecological footprint of each person in developed countries is large compared to that in developing countries (Figure 1-7, left). The per capita ecological footprint of the United States is nearly double the country's biological capacity per person—explaining why the country spreads its ecological footprint by importing large quantities of renewable resources from other countries. You can estimate your ecological footprint by going to the website www.redefiningprogress.org/. Also, see the Guest Essay by Michael Cain on the website for this chapter.

This eventually unsustainable situation is expected to get worse as affluence increases in both developed and developing countries. According to William Rees and Mathis Wachernagel, developers of the ecological footprint concept, it would take the land area of about *four more planet earths* for the rest of the world to reach U.S. levels of consumption with existing technology. Clearly, such consumption patterns cannot be sustained.

A new country with a large and growing ecological footprint is emerging. China has the world's largest population and hopes to increase its total and per capita economic growth, which will increase the ecological footprints of its people. See the Guest Essay on this topic by Norman Myers on the website for this chapter.

What Are Nonrenewable Resources? Resources We Can Deplete

Nonrenewable resources can be economically depleted to the point where it costs too much to obtain what is left.

Nonrenewable resources exist in a fixed quantity or stock in the earth's crust. On a time scale of millions to billions of years, geological processes can renew such resources. But on the much shorter human time scale of hundreds to thousands of years, these resources can be depleted much faster than they are formed.

These exhaustible resources include *energy resources* (such as coal, oil, and natural gas that cannot be recycled), *metallic mineral resources* (such as iron, copper, and aluminum that can be recycled), and *nonmetallic mineral resources* (such as salt, clay, sand, and phosphates that usually are difficult or too costly to recycle).

Figure 1-8 shows the production and depletion cycle of a nonrenewable energy or mineral resource. We never completely exhaust such a resource, but it becomes *economically depleted* when the costs of extracting and using what is left exceed its economic value. At that point, we have six choices: try to find more, recycle or reuse existing supplies (except for nonrenewable energy resources, which cannot be recycled or reused), waste less, use less, try to develop a substitute, or wait millions of years for more to be produced.

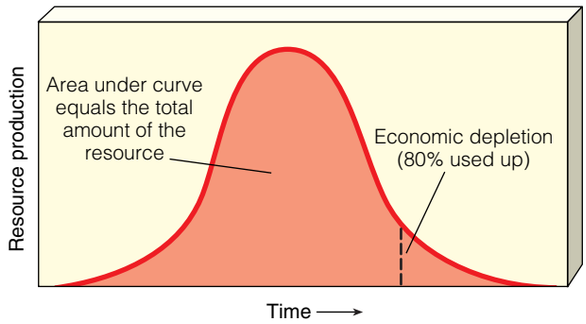

Figure 1-8 Full production and exhaustion cycle of a nonrenewable resource such as copper, iron, oil, or coal. Usually, a nonrenewable resource is considered *economically depleted* when 80% of its total supply has been extracted and used. Normally, it costs too much to extract and process the remaining 20%.

Some nonrenewable mineral resources, such as copper and aluminum, can be recycled or reused to extend supplies. **Recycling** involves collecting waste materials, processing them into new materials, and selling these new products. For example, discarded aluminum cans can be crushed and melted to make new aluminum cans or other aluminum items that consumers can buy. Recycling means nothing if we do not close the loop by buying products that are made from or contain recycled materials. **Reuse** is using a resource again in the same form. For example, glass bottles can be collected, washed, and refilled many times.

Recycling nonrenewable metallic resources takes much less energy, water, and other resources and produces much less pollution and environmental degradation than exploiting virgin metallic resources. Reusing such resources takes even less energy and other resources and produces less pollution and environmental degradation than recycling.

1-4 POLLUTION

Where Do Pollutants Come From, and What Are Their Harmful Effects? Threats to Health and Survival

Pollutants are chemicals found at high enough levels in the environment to cause harm to people or other organisms.

Pollution is the presence of substances at high enough levels in air, water, soil, or food to threaten the health, survival, or activities of humans or other organisms. Pollutants can enter the environment naturally (for example, from volcanic eruptions) or through human or anthropogenic activities (for example, from burning coal). Most pollution from human activities occurs in or near urban and industrial areas, where pollution sources such as cars and factories are concentrated. Industrialized agriculture is also a major source of

pollution. Most pollutants are unintended by products of useful activities such as burning coal to generate electricity, driving cars, and growing crops.

Some pollutants contaminate the areas where they are produced and some are carried by wind or flowing water to other areas. Pollution does not respect the neat territorial political lines we draw on maps.

The pollutants we produce come from two types of sources. **Point sources** of pollutants are single, identifiable sources. Examples are the smokestack of a coal-burning power plant, the drainpipe of a factory, and the exhaust pipe of an automobile. **Nonpoint sources** of pollutants are dispersed and often difficult to identify. Examples are pesticides sprayed into the air or blown by the wind into the atmosphere and runoff of fertilizers and pesticides from farmlands, golf courses, and suburban lawns and gardens into streams and lakes. It is much easier and cheaper to identify and control pollution from point sources than from widely dispersed nonpoint sources.

Pollutants can have three types of unwanted effects. *First,* they can disrupt or degrade life-support systems for humans and other species. *Second,* they can damage wildlife, human health, and property. *Third,* they can be nuisances such as noise and unpleasant smells, tastes, and sights.

Solutions: What Can We Do about Pollution? Prevention Pays

We can try to clean up pollutants in the environment or prevent them from entering the environment.

We use two basic approaches to deal with pollution. One is **pollution prevention,** or **input pollution control,** which reduces or eliminates the production of pollutants. The other is **pollution cleanup,** or **output pollution control,** which involves cleaning up or diluting pollutants after they have been produced.

Environmentalists have identified three problems with relying primarily on pollution cleanup. *First,* it is only a temporary bandage as long as population and consumption levels grow without corresponding improvements in pollution control technology. For example, adding catalytic converters to car exhaust systems has reduced some forms of air pollution. But increases in the number of cars and in the distance each travels have reduced the effectiveness of this approach.

Second, cleanup often removes a pollutant from one part of the environment only to cause pollution in another. For example, we can collect garbage, but the garbage is then *burned* (perhaps causing air pollution and leaving toxic ash that must be put somewhere), *dumped* into streams, lakes, and oceans (perhaps causing water pollution), or *buried* (perhaps causing soil and groundwater pollution).

Third, once pollutants have entered and become dispersed into the environment at harmful levels, it usually costs too much to reduce them to acceptable levels.

Both pollution prevention (front-of-the-pipe) and pollution cleanup (end-of-the-pipe) solutions are needed. But environmentalists and some economists urge us to put more emphasis on prevention because it works better and is cheaper than cleanup. As Benjamin Franklin observed long ago, "An ounce of prevention is worth a pound of cure."

1-5 ENVIRONMENTAL AND RESOURCE PROBLEMS: CAUSES AND CONNECTIONS

What Are Key Environmental Problems and Their Basic Causes? The Big Five

The major causes of environmental problems are population growth, wasteful resource use, poverty, poor environmental accounting, and ecological ignorance.

We face a number of interconnected environmental and resource problems, as listed in Figure 1-9. The first step in dealing with these problems is to identify their

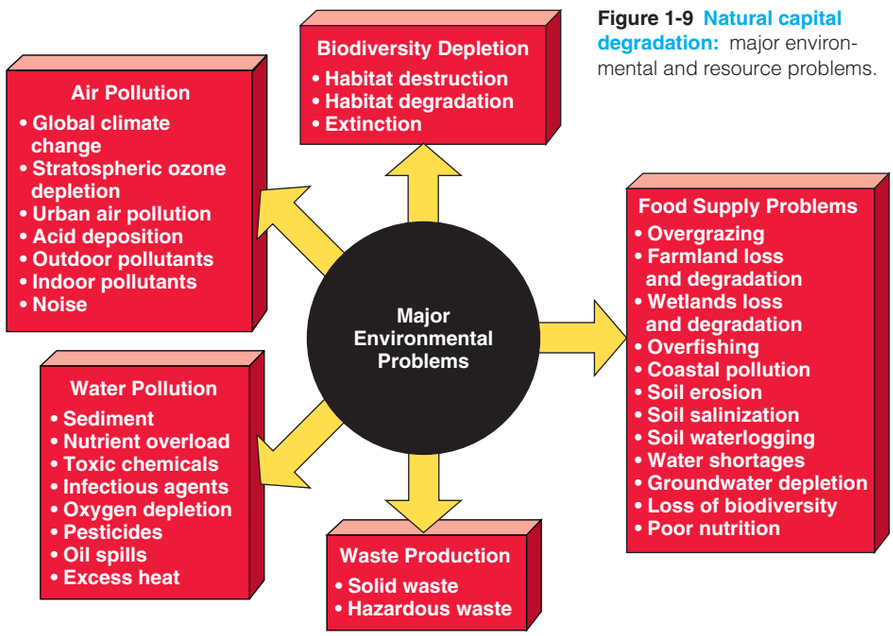

Figure 1-9 Natural capital degradation: major environmental and resource problems.

Figure 1-10 Environmentalists have identified five basic causes of the environmental problems we face.

underlying causes, listed in Figure 1-10 and sometimes known as the *big five*.

Four of these causes are rapid population growth (p. 7), poverty (discussed below), and excessive and wasteful use of resources (discussed on p. 14) A fourth is failure to include the harmful environmental costs of items in their market prices, discussed in Chapter 26. This in turn is a policy and political failure to address this issue. The fifth, inadequate understanding of how the earth works, is discussed throughout this book.

What Is the Relationship between Poverty and Environmental Problems? Being Poor Is Bad for People and the Earth

Poverty is a major threat to human health and the environment.

Many of the world's poor do not have access to the basic necessities for a healthy, productive, and decent life, as listed in Figure 1-11. Their daily lives are focused on getting enough food, water, and fuel (for cooking and heat) to survive. Desperate for land to grow enough food, many of the world's poor people deplete and degrade forests, soil, grasslands, and wildlife for short-term survival. They do not have the luxury of worrying about long-term environmental quality or sustainability.

Another problem for the poor is living in areas with high levels of air and water pollution and with a great risk of natural disasters such as floods, earthquakes, hurricanes, and volcanic eruptions. And they usually must take jobs—if they can find them—with unhealthy and unsafe working conditions at very low pay.

Poverty also affects population growth. Poor people often have many children as a form of economic security. Their children help them grow food, gather fuel (mostly wood and dung), haul drinking water, tend livestock, work, and beg in the streets. The children also help their parents survive in their old age before they die, typically in their 50s in the poorest countries. The poor do not have retirement plans, social security, or government-sponsored health plans.

Many of the world's desperately poor die prematurely from four preventable health problems. One is *malnutrition* from a lack of protein and other nutrients needed for good health (Figure 1-12). The second is increased susceptibility to normally nonfatal infectious diseases, such as diarrhea and measles, because of their weakened condition from malnutrition. A third factor is lack of access to clean drinking water. A fourth factor is severe respiratory disease and premature death from

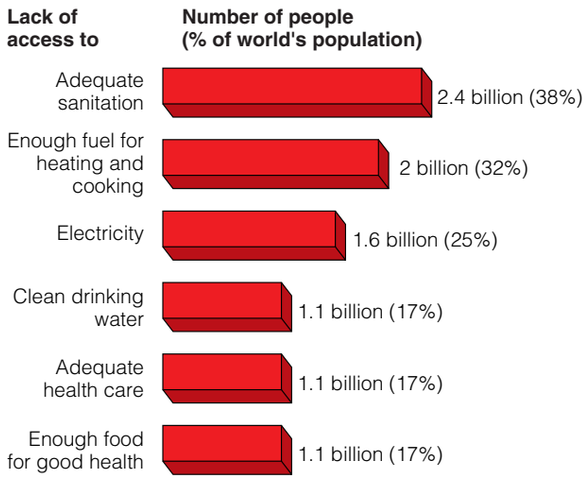

Figure 1-11 **Natural capital degradation:** some harmful effects of poverty. Which two of these effects do you believe is the most harmful? (Data from United Nations, World Bank, and World Health Organization)

John Bryson/Photo Researchers, Inc.

Figure 1-12 One in every three children under age 5, such as this Brazilian child, suffers from malnutrition. According to the World Health Organization, each day at least 13,700 children under age 5 die prematurely from malnutrition and infectious diseases from drinking contaminated water and other causes.

inhaling indoor air pollutants produced by burning wood or coal for heat and cooking in open fires or in poorly vented stoves. According to the World Health Organization, these four factors cause premature death for at least 7 million of the poor a year.

This premature death of about 19,200 human beings per day is equivalent to 48 fully loaded 400-passenger jumbo jet planes crashing every day with no survivors! Two-thirds of those dying are children under age 5.

What Is the Relationship between Resource Consumption and Environmental Problems? Affluenza

Many consumers in developed countries have become addicted to buying more and more stuff in their search for fulfillment and happiness.

Affluenza ("af-loo-EN-zuh") is a term used to describe the unsustainable addiction to overconsumption and materialism exhibited in the lifestyles of affluent consumers in the United States and other developed countries. It is based on the assumption that buying more and more things can, should, and does buy happiness.

Most people infected with this contagious *shop-till-you-drop virus* have some telltale symptoms. They feel overworked, have high levels of debt and bankruptcy, suffer from increasing stress and anxiety, have declining health, and feel unfulfilled in their quest to accumulate more and more stuff. As humorist Will Rogers said, "Too many people spend money they haven't earned to buy things they don't want, to impress people they don't like." For some, shopping until you drop means shopping until you go bankrupt. Between 1998 and 2001, more Americans declared bankruptcy than graduated from college.

Globalization and global advertising are now spreading the virus throughout much of the world. Affluenza has an enormous environmental impact. It takes about 27 tractor-trailer loads of resources per year to support one American. This amounts to 7.9 billion truckloads of resources a year to support the U.S. population. Stretched end-to-end, these trucks would more than reach the sun!

What can we do about affluenza? The first step for addicts is to admit they have a problem. Then they begin steps to kick their addiction by going on a stuff diet. For example, before buying anything a person with the affluenza addiction should ask: Do I really need this or merely want it? Can I buy it secondhand (reuse)? Can I borrow it from a friend or relative? Another withdrawal strategy: Do not hang out with other addicts. Shopaholics should avoid malls as much as they can.

After a lifetime of studying the growth and decline of the world's human civilizations, historian Arnold Toynbee summarized the true measure of a civilization's growth in what he called the *law of progressive simplification:* "True growth occurs as civilizations transfer an increasing proportion of energy and attention from the material side of life to the nonmaterial side and thereby develop their culture, capacity for compassion, sense of community, and strength of democracy."

How Can Affluence Help Increase Environmental Quality? Another Side of the Story

Affluent countries have more money for improving environmental quality.

Some analysts point out that affluence need not lead to environmental degradation. Instead, it can lead people to become more concerned about environmental quality, and it provides money for developing technologies to reduce pollution, environmental degradation, and resource waste. This explains why most of the important environmental progress made since 1970 has taken place in developed countries.

In the United States, the air is cleaner, drinking water is purer, most rivers and lakes are cleaner, and the food supply is more abundant and safer than in 1970. Also, the country's total forested area is larger than it was in 1900 and most energy and material resources are used more efficiently. Similar advances have been made in most other affluent countries. Affluence financed these improvements in environmental quality.

How Are Environmental Problems and Their Causes Connected? Exploring Connections

Environmental quality is affected by interactions between population size, resource consumption, and technology.

Once we have identified environmental problems and their root causes, the next step is to understand how they are connected to one another. The three-factor model in Figure 1-13 is a starting point.

According to this simple model, the environmental impact (**I**) of a population on a given area depends on three factors: the number of people (**P**), the average resource use per person (affluence, **A**), and the beneficial and harmful environmental effects of the technologies (**T**) used to provide and consume each unit of resource and to control or prevent the resulting pollution and environmental degradation.

In developing countries, population size and the resulting degradation of renewable resources as the poor struggle to stay alive tend to be the key factors in total environmental impact (Figure 1-13, top). In such countries per capita resource use is low.

In developed countries, high rates of per capita resource use and the resulting high levels of pollution and environmental degradation per person usually are the key factors determining overall environmental impact (Figure 1-13, bottom) and a country's ecological

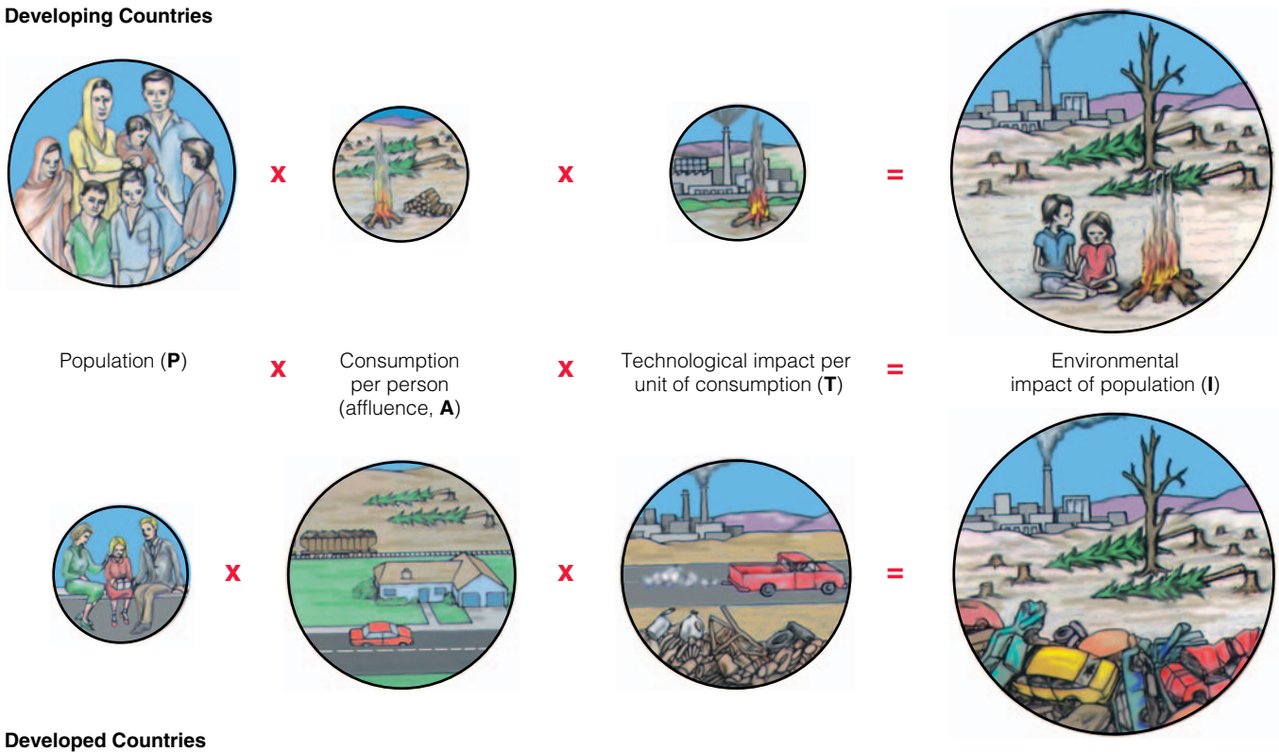

Figure 1-13 **Connections:** simplified model of how three factors—number of people, affluence, and technology—affect the environmental impact of the population in developing countries (top) and developed countries (bottom).

footprint per person (Figure 1-7). For example, the average U.S. citizen consumes about 35 times as much as the average citizen of India and 100 times as much as the average person in the world's poorest countries. *Thus poor parents in a developing country would need 70 to 200 children to have the same lifetime resource consumption as 2 children in a typical U.S. family.*

Some forms of technology, such as polluting factories and motor vehicles and energy-wasting devices, increase environmental impact by raising the T factor in the equation. But other technologies, such as pollution control and prevention, solar cells, and energy-saving devices, lower environmental impact by decreasing the T factor. In other words, some forms of technology are *environmentally harmful* and some are *environmentally beneficial.*

The three-factor model in Figure 1-13 can help us understand how key environmental problems and some of their causes are connected. It can also guide us in seeking solutions. However, these problems involve a number of poorly understood interactions between many more factors than those in this simplified model, as outlined in Figure 1-14. Look at the interactions shown in this figure.

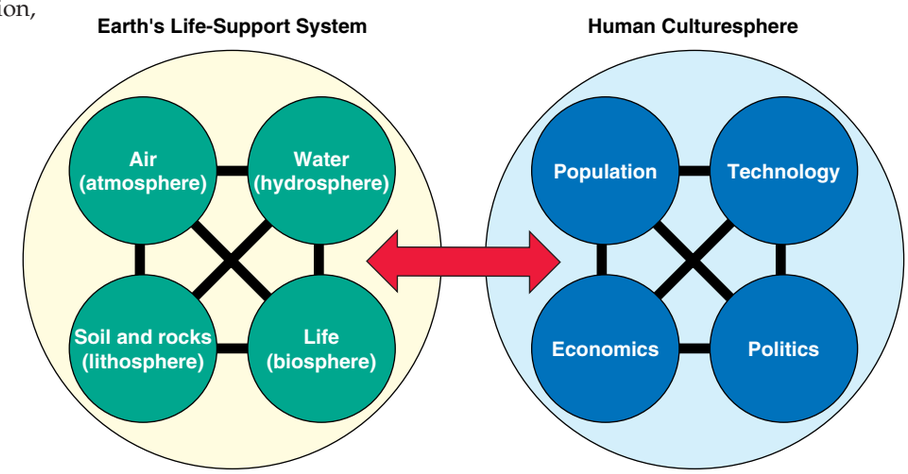

Figure 1-14 **Connections:** major components and interactions within and between the earth's life-support system and the human sociocultural system (culturesphere). The goal of environmental science is to learn as much as possible about these complex interactions.

1-6 IS OUR PRESENT COURSE SUSTAINABLE?

Are Things Getting Better or Worse? The Answer Is Both

There is good and bad environmental news.

Experts disagree about how serious our environmental problems are and what we should do about them. Some analysts believe human ingenuity, technological advances, and economic growth and development will allow us to clean up pollution to acceptable levels, find substitutes for resources that become scarce, and keep expanding the earth's ability to support more humans, as we have done in the past. They accuse many scientists and environmentalists of exaggerating the seriousness of the problems we face and failing to appreciate the progress we have made in improving quality of life and protecting the environment.

Environmentalists and many leading scientists disagree with this view. They cite evidence that we are degrading and disrupting many of the world's life-support systems for us and other species at an accelerating rate. They are greatly encouraged by the progress we have made in increasing average life expectancy, reducing infant mortality, increasing food supplies, and reducing many forms of pollution—especially in developed countries. But they point out that we need to use the earth in a way that is more sustainable for present and future human generations and other species that support us and other forms of life.

The most useful answer to the question of whether things are getting better or worse is *both.* Some things are getting better, some worse.

Our challenge is not to get trapped into confusion and inaction by listening primarily to either of two groups of people. One group consists of *technological optimists.* They tend to overstate the situation by telling us to be happy and not worry, because technological innovations and conventional economic growth and development will lead to a wonderworld for everyone. Leave the driving to us because we know best.

The second group consists of *environmental pessimists* who overstate the problems to the point where our environmental situation seems hopeless. According to the noted conservationist Aldo Leopold, "I have no hope for a conservation based on fear."

How Would You Vote?* Is the society you live in on an unsustainable path? Cast your vote online at http://biology.brookscole.com/miller14.

*To cast your vote, go to the website for the book listed above and then go to the appropriate chapter (in this case Chapter 1). In most cases you will be able to compare how you voted with others using this book throughout the United States and the world.

How Should We Live? A Clash of Environmental Worldviews

The way we view the seriousness of environmental problems and how to solve them depends on our environmental worldview.

The differing views about how serious our environmental problems are and what we should do about them arise mostly out of differing environmental worldviews. Your **environmental worldview** is how you think the world works, what you think your role in the world should be, and what you believe is right and wrong environmental behavior (**environmental ethics**).

People who have widely differing environmental worldviews can take the same data, be logically consistent, and arrive at quite different conclusions because they start with different assumptions and values.

Some people in today's industrial consumer societies have a **planetary management worldview.** Here are the basic environmental beliefs of this worldview:

- As the planet's most important species, we are in charge of nature.
- We will not run out of resources because of our ability to develop and find new ones.
- The potential for global economic growth is essentially unlimited.
- Our success depends on how well we manage the earth's life-support systems, mostly for our own benefit.

A second environmental worldview, known as the **stewardship worldview,** consists of the following major beliefs:

- We are the planet's most important species but we have an ethical responsibility to care for the rest of nature.
- We will probably not run out of resources but they should not be wasted.
- We should encourage environmentally beneficial forms of economic growth and discourage environmentally harmful forms of economic growth.
- Our success depends on how well we can manage the earth's life-support systems for our benefit and for the rest of nature.

Another environmental worldview, known as the **environmental wisdom worldview,** is based on the following major beliefs, which are the opposite of those making up the planetary management worldview:

- Nature exists for all species, not just for us and we are not in charge of the earth.
- The earth's resources are limited, should not be wasted, and are not all for us.

- We should encourage earth-sustaining forms of economic growth and discourage earth-degrading forms.
- Our success depends on learning how the earth sustains itself and integrating such lessons from nature (environmental wisdom) into the ways we think and act.

What Are the Greatest Environmental Problems We Face Now and in the Future? The Big Picture

Poverty and malnutrition, smoking, infectious diseases, water shortages, biodiversity loss, and climate changes are the most serious environmental problems we face.

Figure 1-15 ranks major environmental problems on a time scale in terms of the estimated number of people prematurely killed annually today and over the next hundred years.

From this diagram you can see that we should focus our money, minds, and hearts on reducing the environmental risks from *poverty, malnutrition, unsafe drinking water, smoking, air pollution, infectious diseases (AIDS, TB, malaria, and hepatitis B), water shortages, climate changes, and loss and degradation of biodiversity.* The poor in developing countries bear the brunt of most of these serious problems.

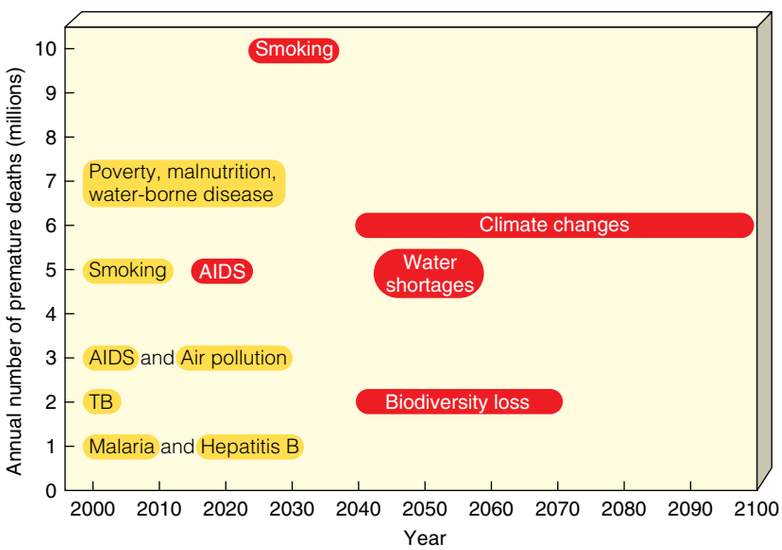

Figure 1-15 Priorities: ranking of major environmental risks in terms of the estimated number of people prematurely killed annually now (yellow) and over the next hundred years (red). Some scientists consider biodiversity loss and climate change the two most serious ecological risks to humans and other species. Estimates of deaths from biodiversity loss and climate change 50 or more years into the future are difficult to make and could be higher or lower than those shown here. (Data from UN Food and Agriculture Organization, World Health Organization, United Nations Environment Program, U.S. Centers for Disease Control and Prevention, and the World Bank)

How Would You Vote? What do you think is our most serious environmental problem? Cast your vote online at http://biology.brookscole.com/miller14.

What Is Environmentally Sustainable Economic Development? Rewarding Environmentally Beneficial Activities

Environmentally sustainable economic development rewards environmentally beneficial and sustainable activities and discourages environ-mentally harmful and unsustainable activities.

During this century, many analysts call for us to put much greater emphasis on **environmentally sustainable economic development.** Figure 1-16 (p. 18) lists some of the shifts involved in implementing such an *environmental,* or *sustainability, revolution* during this century based on this concept. Study this figure carefully.

This type of development uses economic rewards (government subsidies and tax breaks) to *encourage* environmentally beneficial and more sustainable forms of economic growth and economic penalties (government taxes and regulations) to *discourage* environmentally harmful and unsustainable forms of economic growth.

Throughout this book I try to give you a balanced view of good and bad environmental news. Try not to be overwhelmed or immobilized by the bad environmental news, because there is also some *great environmental news.* We have made immense progress in improving the human condition and dealing with many environmental problems. We are learning a great deal about how nature works and sustains itself. And we have numerous scientific, technological, and economic solutions available to deal with the environmental problems we face.

The challenge is to make creative use of our economic and political systems to implement such solutions. One key is to recognize that most economic and political change comes about as a result of individual actions and individuals acting together to bring about change by grassroots action from the bottom up. *Good news.* Social scientists suggest it takes only about 5–10% of the population of a country or of the world to bring about major social change. Anthropologist Margaret Mead summarized our potential for change: "Never doubt that a small group

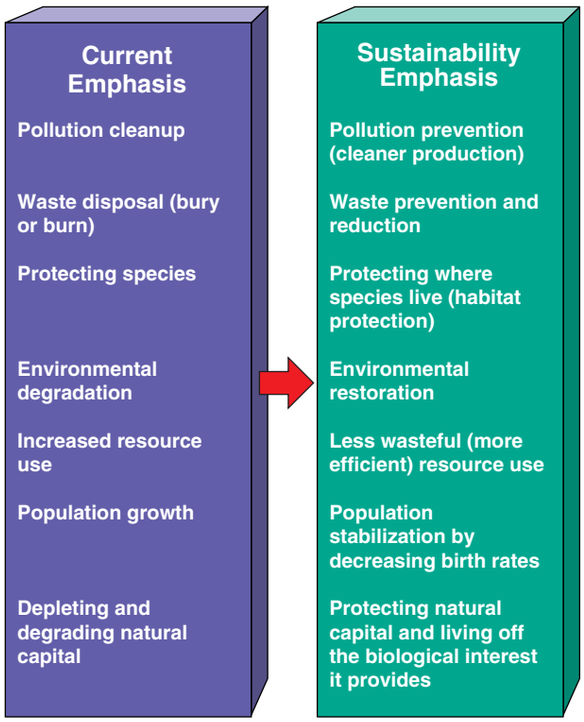

Figure 1-16 Solutions: some shifts involved in the *environmental* or *sustainability revolution.*

of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has."

We live in exciting times during what might be called a *hinge of cultural history.* Indeed, if I had to pick a time to live, it would be the next 50 years as we face the challenge of developing more environmentally sustainable societies.

What's the use of a house if you don't have a decent planet to put it on?

HENRY DAVID THOREAU

CRITICAL THINKING

1. Do you favor instituting policies designed to reduce population growth and stabilize **(a)** the size of the world's population as soon as possible and **(b)** the size of the U.S. population (or the population of the country where you live) as soon as possible? Explain. If you agree that population stabilization is desirable, what three major policies would you implement to accomplish this goal?

2. List **(a)** three forms of economic growth you believe are environmentally unsustainable and **(b)** three forms you believe are environmentally sustainable.

3. Give three examples of how you cause environmental degradation as a result of the tragedy of the commons.

4. When you read that about 19,200 human beings die prematurely each day (13 per minute) from preventable malnutrition and infectious disease, do you **(a)** doubt whether it is true, **(b)** not want to think about it, **(c)** feel hopeless, **(d)** feel sad, **(e)** feel guilty, or **(f)** want to do something about this problem?

5. How do you feel when you read that **(1)** the average American consumes about 35 times more resources than the average Indian citizen, **(2)** human activities lead to the premature extinction of at least 10 species per day, and **(3)** human activities are projected to make the earth's climate warmer: **(a)** skeptical about their accuracy, **(b)** indifferent, **(c)** sad, **(d)** helpless, **(e)** guilty, **(f)** concerned, or **(g)** outraged? Which of these feelings help perpetuate such problems, and which can help alleviate them?

6. See if you are infected by the affluenza bug by indicating whether you agree or disagree with the following statements.

a. I am willing to work at a job I despise so I can buy lots of stuff.
b. When I am feeling down, I like to go shopping to make myself feel better.
c. I would rather be shopping right now.
d. I owe more than $1,000 on my credit cards.
e. I usually make only the minimum payment on my monthly credit card bills.
f. I am running out of room to store my stuff.

If you agree with three of these statements, you are infected with affluenza. If you agree with more than three, you have a serious case of affluenza. Compare your answers with those of your classmates and discuss the effects of the results on the environment and your feelings of happiness.

7. Explain why you agree or disagree with each of the following statements: **(a)** humans are superior to other forms of life, **(b)** humans are in charge of the earth, **(c)** all economic growth is good, **(d)** the value of other species depends only on whether they are useful to us, **(e)** because all species eventually become extinct we should not worry about whether our activities cause the premature extinction of a species, **(f)** all species have an inherent right to exist, **(g)** nature has an almost unlimited storehouse of resources for human use, **(h)** technology can solve our environmental problems, **(i)** I do not believe I have any obligation to future generations, and **(j)** I do not believe I have any obligation to other species.

8. What are the basic beliefs of your environmental worldview? Are the beliefs of your environmental worldview consistent with your answers to question 7? Are your environmental actions consistent with your environmental worldview?

PROJECTS

1. What are the major resource and environmental problems where you live? Which of these problems affect you directly? Have these problems gotten better or worse during the last 10 years?

2. Write two-page scenarios describing what your life and that of any children you may have might be like 50 years from now if **(a)** we continue on our present path; **(b)** we shift to more sustainable societies throughout most of the world.

3. Make a list of the resources you truly need. Then make another list of the resources you use each day only because you want them. Finally, make a third list of resources you want and hope to use in the future. Compare your lists with those compiled by other members of your class, and relate the overall result to the tragedy of the commons (p. 9).

4. Use the library or the Internet to find out bibliographic information about *Barbara Ward, René Dubos,* and *Henry David Thoreau,* whose quotes appear at the beginning and end of this chapter.

5. Make a concept map of this chapter's major ideas using the section heads, subheads, and key terms (in boldface type). Look on the website for this book for information about making concept maps.

LEARNING ONLINE

The website for this book contains study aids and many ideas for further reading and research. They include a chapter summary, review questions for the entire chapter, flash cards for key terms and concepts, a multiple-choice practice quiz, interesting Internet sites, references, and a guide for accessing thousands of InfoTrac® College Edition articles. Log on to

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Then click on the Chapter-by-Chapter area, choose Chapter 1, and select a learning resource.