Pearson New International Edition

Environmental Science
Toward a Sustainable Future

Richard T. Wright   Dorothy F. Boorse

Twelfth Edition

ALWAYS LEARNING

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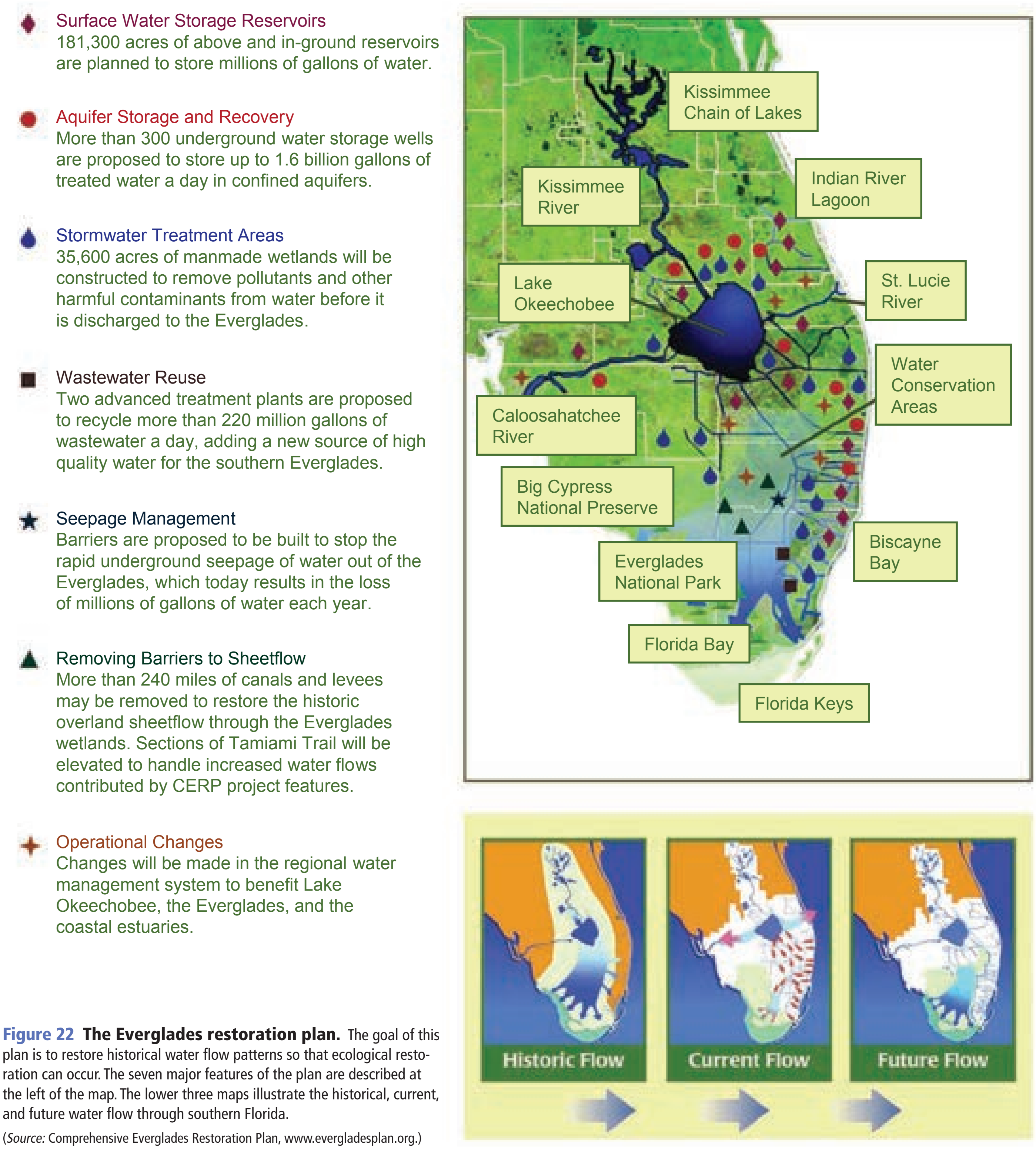


Figure 22 The Everglades restoration plan. The goal of this plan is to restore historical water flow patterns so that ecological restoration can occur. The seven major features of the plan are described at the left of the map. The lower three maps illustrate the historical, current, and future water flow through southern Florida.

(*Source:* Comprehensive Everglades Restoration Plan, www.evergladesplan.org.)

continues to rise. These pressures must be met with increasingly effective protective measures if we want to continue to enjoy the goods and services provided by ecosystems. The problems are most difficult in the developing world, where poverty forces people to take from nature in order to survive. If natural areas are to be preserved, the needs of people must be met in ways that do not involve destroying ecosystems. People must be provided with alternatives to overexploitation, a situation requiring both wise leadership and effective international aid.

In April 2000, when he was UN Secretary-General, Kofi Annan included in his millennium report to the General Assembly a stern warning that far too little concern was being given to the sustainability of our planet: "If I could sum it up in one sentence, I should say that we are plundering our children's heritage to pay for our present unsustainable practices. . . . We must preserve our forests, fisheries, and the diversity of living species, all of which are close to collapsing under the pressure of human consumption and destruction. . . . in short," Annan stated, "we need a new ethic of stewardship." Indeed, under UN sponsorship, the Billion Tree Campaign, begun in 2006, overran its goal in 18 months and has now become the Seven Billion Tree Campaign. From individuals to heads of states, people in 155 countries are planting trees, acting in stewardship concern for the climate and for peoples' needs.

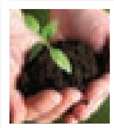
REVISITING THE THEMES

Sound Science

Calculating a total allowable catch (TAC) requires solid scientific data on fish populations and an understanding of the MSY model. These limits are difficult, if not impossible, to accomplish for mobile creatures such as fish and whales. Fisheries scientists are constantly challenged to assess fish stocks accurately, and their recommendations can often be trumped by political and economic decisions, as is well illustrated in the plight of the New England fisheries. Ensuring sustainable harvests in forests requires thorough scientific assessments of tree growth and a balancing of the needs of ecosystems with those of the harvesters. The restoration of ecosystems requires a great deal of sound science in the form of species and ecosystem ecology. It also requires the ability to make midcourse corrections, which projects like the Everglades restoration will require in the future. Scientists at the Curtic prairie set the stage for the discipline of restoration ecology. Scientists today use not only experiments, but also data collected by citizen scientists to test hypotheses, as the example of the REEF data collection showed.

Sustainability

The protection of forests, reefs, and other ecosystems requires intelligent policies and practices. Often this requires coordination, as an unregulated commons almost always tends to overuse. This is why we have the International Whaling Commission, for example. Unfortunately, there are many cases of unsustainable use: the taking of "bush meat" by commercial hunters, the cyanide poisoning of coral reefs, the exploitation of a commons where there is open access to all, and the deforestation in tropical rain forests, to name a few. The principle of sustainability is built into the model of the maximum sustainable yield, but for fisheries it turns out to be harder to accomplish in practice than in theory. For this reason, it is wise to use the precautionary principle in attempting to set such a threshold for a resource. Sustainable forestry, however, is not so difficult, as long as it is focused on managing the forests as functioning ecosystems and as long as biodiversity is respected. Where resources are being exploited in much of the developing world, sustainability is unworkable without taking into account the needs of local people and involving them in management decisions. Incorporating ecosystem services into our calculations will make protection of ecosystems more economically viable. Such an approach requires a knowledge of the value of ecosystem capital.



Stewardship

Stewardship care of ecosystems means consciously managing them so as to benefit both present and future generations. Sustainable consumptive and productive use of ecosystem resources involves tenurial rights over them; exercising these rights should be a matter of stewardship embodied in rules and policies. Table 3 presents a set of principles that promote such stewardship. When forests and fisheries are under the control of the people who most directly depend on their use, stewardship can flourish. Management of the fisheries exhibits both good and poor stewardship in different regions: Compare the Pacific Northwest and Georges Bank fisheries. Individuals can show stewardship by acting as citizen scientists or informed consumers or helping nonprofits such as land trusts.

Finally, it is heartening to see the former UN secretary-general endorsing a stewardship ethic as an important step in preserving the natural resources that are under tremendous pressure from present generations. The Seven Billion Tree Campaign is a tangible demonstration of that ethic.

REVIEW QUESTIONS

1. How did individuals act to help scientists in the Caribbean Sea?
2. What are some goods and services provided by natural ecosystems?
3. Compare the concept of ecosystem capital with that of natural resources. What do the two reveal about values?
4. Compare and contrast the terms *conservation* and *preservation*.
5. Differentiate between consumptive use and productive use. Give examples of each.
6. What does maximum sustainable yield mean? What factors complicate its application?
7. What is the tragedy of the commons? Give an example of a common-pool resource, and describe ways of protecting such resources.
8. When are restoration efforts needed? Describe efforts under way to restore the Everglades.
9. Describe some of the findings of the most recent FAO Global Forest Resources Assessments. What are the key elements of sustainable forest management?

10. What is deforestation, and what factors are primarily responsible for deforestation of the tropics?
11. What is the global pattern of exploitation of fisheries? Compare the yield of the capture fisheries with that of aquaculture.
12. Compare the objectives of the original Magnuson Act with those of the 2006 Magnuson-Stevens Fishery Conservation and Management Reauthorization Act.
13. What is the current status of the large whales? Discuss the controversy over continued whaling by some countries.
14. How are coral reefs and mangroves being threatened, and how is this destruction linked to other environmental problems?
15. Compare the different levels of protection versus use for the different categories of federal lands in the United States.
16. Describe the progression of the management of our national forests during the past half century. What are current issues, and how are they being resolved?
17. How do land trusts work, and what roles do they play in preserving natural lands?

THINKING ENVIRONMENTALLY

1. It is an accepted fact that both consumptive use and productive use of natural ecosystems are necessary for high-level human development. To what degree should consumptive use hold priority over productive use? Think about more than one resource (lumber, bush meat, etc.).
2. Consider the problem presented by Hardin of open access to the commons without regulation. To what degree should the freedom of the use of these areas be limited by the authorities? Make use of Table 3 when you defend your position.
3. Consider the benefits and problems associated with coastal and open-ocean aquaculture. Is aquaculture a useful practice overall? Justify your answer.
4. Kofi Annan stated that we are in need of a "new ethic of stewardship." What principles should this new ethic be built on?

MAKING A DIFFERENCE

1. To determine the impact you have on the ecosystems around you, calculate your ecological footprint (several sites on the Internet can help with this). What can you do to lower your ecological footprint?
2. Consider Michael Pollan's work *The Omnivore's Dilemma*. The book deals with America's eating habits, government regulations regarding food production, farming techniques, and similar topics. Decide which eating habits are ecologically sustainable and which are not. Go to the Internet and search for sites that offer ecosystem-friendly recipes.
3. By transporting firewood from its native area, you may run the risk of spreading diseases and alien insect species that can damage trees and overrun whole areas of forest. You can avoid this by using firewood harvested locally or, if you need to carry firewood a distance, by finding wood marked with a U.S. Department of Agriculture (USDA) tag confirming that the logs are safe to move.
4. Organize a volunteer tree-planting group. You can purchase young trees at a nursery, college agricultural department, or city government. To raise money for a large project, try to find individual or corporate sponsors.
5. When you visit parks and other natural areas, stay on the designated trails. Avoid making new trails that might lead to erosion, and never disturb nesting birds and wild animals raising their young.

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Table 2: Source: Data from "Living Beyond Our Means: Natural Assets and Human Well-Being," from Millennium Ecosystem Assessment (Statement of the Millennium Ecosystem Assessment Board, 2005); Figure 8: Source: based on "Global Forest Resources Assessment 2010" from Food and Agriculture Organization of the United Nations; Figure 10: Source: based on "Global Forest Resources Assessment 2010" from Food and Agriculture Organization of the United Nations; "A Global Map of Human Impacts to Marine Ecosystems," from *National Center for Ecological Analysis and Synthesis* website, 2010. Copyright © 2010 by The Regents of the University of California. Reprinted with permission. All Rights Reserved.; Figure 19: Source: National Atlas website.

GLOSSARY

carrying capacity The maximum population of a given species that an ecosystem can support without being degraded or destroyed in the long run. Represented symbolically by *K*.

catch shares See **individual quota system**.

clear-cutting In harvesting timber, the practice of removing an entire stand of trees, leaving an ugly site that takes years to recover.

Comprehensive Everglades Restoration Plan (CERP) Multi-billion-dollar plan to restore the Florida Everglades by addressing water flow and storage.

conservation The management of a resource in such a way as to ensure that it will continue to provide maximum benefit to humans over the long run. *Energy*: Saving energy by cutting back on the use of heating, air conditioning, lighting, transportation, and so on and also by increasing the efficiency of energy use.

consumptive use The harvesting of natural resources in order to provide for people's immediate needs for food, shelter, fuel, and clothing.

coral bleaching A condition, usually brought on by excessively high temperatures, in hard corals where the coral animals expel their symbiotic algae and become white in appearance.

deforestation The process of removing trees and other vegetation covering the soil and converting the forest to another land use, often leading to erosion and loss of soil fertility.

easement In reference to land protection, an arrangement whereby a landowner gives up development rights into the future but retains ownership of the land.

ecosystem capital The sum of goods and services provided by natural and managed ecosystems, both free of charge and essential to human life and well-being.

fishery Fish species being exploited, or a limited marine area containing commercially valuable fish.

Forest Stewardship Council An alliance of organizations directed toward the certification of sustainable wood products.

maximum sustainable yield (MSY) The maximum amount of a renewable resource that can be taken year after year without depleting the resource. The maximum sustainable yield is the maximum rate of use or harvest that will be balanced by the regenerative capacity of the system.

national parks Lands and coastal areas of great scenic, ecological, or historical importance administered by the National Park Service, with the dual goals of protecting them and providing public access.

national wildlife refuges Administered by the U.S. Fish and Wildlife Service, these lands are maintained for the protection and enhancement of wildlife and for the provision of public access.

natural goods The food, fuel, wood, fibers, oils, alcohols, and the like derived from the natural world, on which the world economy and human well-being depend.

natural resources Features of natural ecosystems and species that are of economic value and that may be exploited. Also, features of particular segments of ecosystems, such as air, water, soil, and minerals.

new forestry Now part of the U.S. Forest Service's management practice, a forestry management strategy that places priority on protecting the ecological health and diversity of forests rather than maximizing the harvest of logs.

ocean acidification An outcome of the rise in atmospheric carbon dioxide; as the oceans take up more and more of the CO_2, the carbonate ion concentration is reduced, making it more difficult for coral animals to build their calcium carbonate skeletons.

optimal population The population of a harvested biological resource that yields the greatest harvest for exploitation; according to maximum-sustained-yield equations, the optimal population is half the carrying capacity.

precautionary principle The principle that says that where there are threats of serious or irreversible damage, the absence of scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

preservation In protecting natural areas, the objective of preservation is to ensure the continuity of species and ecosystems, regardless of their potential utility.

private land trust See **land trust**.

productive use The exploitation of ecosystem resources for economic gain.

public good A category of ecosystem services that is not used up when people use it and cannot be marketed, like the air we breathe.

renewable resources Biological resources, such as trees, that may be renewed by reproduction and regrowth. Conservation to prevent overcutting and to protect the environment is still required, however. (Contrast **nonrenewable resources**.)

restoration ecology The branch of ecology devoted to restoring degraded and altered ecosystems to their natural state.

selective cutting In forestry, the practice of cutting some mature trees from a stand but leaving enough to maintain normal ecosystem functions and a diverse biota.

shelter-wood cutting In forestry practice, the strategy of cutting the mature trees in groups over a period of years, leaving enough trees to provide seeds and give shelter to growing seedlings.

silviculture A term used to denote the practice of forest management.

sustainable forest management The management of forests as ecosystems wherein the primary objective is to maintain the biodiversity and function of the ecosystem.

sustained yield In forestry, the objective of managing a forest to harvest wood continuously over time without destroying the forest.

tenure Property rights over land and water resources that involve different patterns of use of those resources.

total allowable catch (TAC) In fisheries management, a yearly quota set for the harvest of a species by managers of fisheries.

wetlands Areas that are constantly wet and are flooded at more or less regular intervals—especially marshy areas along coasts that are regularly flooded by tides.

wilderness Land that is undeveloped and wild; in the U.S., land that is protected by the Wilderness Act.

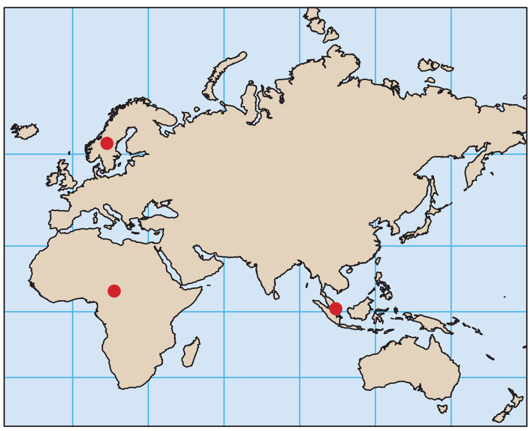
zooxanthellae Photosynthetic algae that live within the tissues of coral species and enable them to grow productively in warm, shallow coastal areas.

The Human Population

LEARNING OBJECTIVES

1. **Humans and Population Ecology: Explain how humans, like other organisms, are subject to natural laws and ecological processes. Describe some significant differences between humans and other creatures in their ability to change their own world.**
2. **Population and Consumption—Different Worlds: Explain the relationship between income and fertility in countries around the world.**
3. **Consequences of Population Growth and Affluence: Describe the likely outcome of unlimited population growth or unlimited use of natural resources. Explain ways in which both population growth and consumption patterns must be addressed for stewardship of resources to occur.**
4. **Projecting Future Populations: Explain how age structure, population momentum, and the demographic transition help social scientists understand populations and predict future population trends in developing and developed countries.**

SWEDEN. The cold winter wind cuts through the streets of Stockholm, Sweden, as Anje, a 19-year-old university student, hurries home to the warmth of her apartment, where she will settle in for an evening at her computer and books, studying for a degree in banking. She will stop for a fast-food meal on the way. Like many Swedes, Anje plans to travel extensively when her studies are over and then work for an international firm. While she is dating, Anje has no plans to marry in the near future. She is likely to marry late, if she does, and have children later than many people in the world. Like many in the European Union (EU), Anje gets a free university education. She works hard because jobs will be scarce and she wants, someday, to be established. When she is ready to have children, Anje is likely to have good benefits, with medical care and maternity leave. She is likely to care for her elderly parents in a society in which the number of elderly people is increasing, but good social and medical services will keep them active long into their seventies, maybe their eighties.



INDONESIA. A world away, in the heat of bustling Jakarta, Indonesia, 19-year-old

From Chapter 8 of *Environmental Science: Toward a Sustainable Future*, Twelfth Edition. Richard T. Wright, Dorothy F. Boorse.
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Atin rides a motorcycle home with her brother. They will stop at a market for chicken and noodles and come home to the small house they share with their parents and three siblings. Atin and her family have a small television and a few other luxuries. A medical emergency could set them back, though, and Atin is worried about her father's coughing. Like millions of Indonesian men, he smokes local clove and tobacco cigarettes. Their family, like many others, was hurt by the Asian financial crisis in the 1990s. Atin's father lost a stable job and took a series of temporary jobs, and their mother began to work part-time. Atin dropped out of high school to help her family. Now Atin and her brother are working to help support the family. Atin hopes to marry a young man her family knows, if they can get enough money together. Like many Indonesians, she will most likely have a smaller family than her parents did.

BURKINA FASO. In the dry season, Burkina Faso (in West Africa) is a place of dust and sun. Awa, 19-year-old married mother of two, walks with her children along a dusty road toward her home. She is carrying a large container of water on her head. Awa's husband works in agriculture in neighboring Côte d'Ivoire (Ivory Coast), where he makes a small amount of money and sends it home. Neither Awa nor her husband can read, and there is no nearby medical facility. She is worried because she is pregnant and has been feeling very ill. Awa and her husband had another child who died shortly after birth, and Awa is afraid that this coming baby will not survive either because she is sick and still nursing another child. Her feet ache and she is very tired, but there is little to be done about it. She sometimes cares for her mother and for the children of her sister, who died of AIDS. Her four surviving siblings have similar lives and live nearby. They all farm during the rainy season—growing cassava, yams, peanuts, and maize—and a few members of the extended family work on a cotton farm or have other relatives working in the Ivory Coast.

Anje, Atin, and Awa are three of millions of young people living around the world. Their life circumstances give them different health concerns, access to education, and medical care. They are also likely to have different family sizes and to use natural resources differently. In the 20th century, the global human population experienced an unprecedented explosion, more than tripling its numbers. Now, the rate of growth is slowing down, but the increase in absolute numbers continues to be substantial—and in some parts of the world, there isn't much slowing.

Remarkable changes in technology and substantial improvements in human well-being have accompanied this growth. In just the past 50 years (1960–2010), average income per capita has more than tripled, global economic output has risen more than sevenfold (from $10 trillion to $76 trillion), life expectancy has risen from 53 to 69 years, and infant mortality has been cut to one-tenth (from 40 to 4 deaths per thousand live births). Even so, Anje, Atin, and Awa do not live in a world where people experience average conditions. The remarkable improvements in living conditions are not experienced equally. Extreme poverty is still widespread. An estimated 1.2 billion people live on less than $1 per day, and the income gap between the richest and the poorest countries is enormous.

Humans are animals, and population ecologists can study human populations and ask many of the same questions they would if they were studying wolves or elk. But humans are also exceptional. They can think about and make decisions about their own fertility, they have ethical systems that inform their decisions, and they can use technology to prolong life and increase food production. Even more unusual, humans have cultural constructs, such as money. Money and its economic institutions mean that survival is driven not only by evolutionary fitness, but also by the economic circumstances into which people are born.

In this chapter, we will put the stories of people like Anje, Atin, and Awa into the context of the dynamics of population growth and the related context of consumption and its social and environmental consequences. A continually growing population is unsustainable, as is a continually increasing consumption of natural resources, so the focus in this chapter is population and consumption stability—and what is required to get there.

1 Humans and Population Ecology

Humans are part of the natural world, and human populations are subject to processes such as birth and death. **Figure 1** shows human population growth over the past 2,000 years. The long, slow incline is followed by a rapid rise, giving what looks like a *J*-shaped curve. However, on closer inspection, the past few decades have shown decreasing population growth rates, and projections (possible future scenarios determined by assumptions about changes we will see) suggest that the global human population may level off, so that the pattern in 2100 will be more like the *S*-shaped curve that characterizes logistic growth.

The field of collecting, compiling, and presenting information about human populations like that presented in Figure 1 is called **demography**; the people engaged in this work are **demographers**. Demographers may study population processes such as migration or changes in fertility and mortality. In environmental science, biological science quickly becomes intertwined with other fields, so some social demographers include economic, cultural, social, and biological factors in their analyses of populations. Consequently, we cannot discuss human population ecology without quickly discussing differences in wealth or health care.

Demographers use a set of specialized terms, described in Table 1, which we will use throughout the chapter.