FOURTH EDITION

PLACES AND REGIONS IN GLOBAL CONTEXT

Human Geography

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2007

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Upper Saddle River, New Jersey 07458

Brief Contents

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MAIN POINTS

- Nature and society constitute a complex relationship. It is our view in this text that nature is both a physical realm and a social creation.
- Because in this text we regard nature as a social creation, it is important to understand the many views of nature in society today as well as the history of those views. The most prominent view of nature in Western culture is derived from the Judeo-Christian tradition, which is founded on a belief that humans should dominate nature.
- Humankind's relationships with nature have developed over the course of human history, beginning with the early Stone Age. The early human history included people who revered nature, as well as those who abused it. Urbanization and industrialization have had extremely degrading impacts on the environment.
- The globalization of the political economy has meant that environmental problems are also global in scope. Deforestation, acid rain, and nuclear fallout affect us all. Many new ways of understanding nature have emerged in the last several decades in response to global environmental crises.
- Sustainability has recently become a predominant way of approaching global economic development and environmental change. In addition, new institutional frameworks, including conventions, protocols, and organizations, are rapidly emerging to promote global sustainability.

In addition to the spread of people, ideas, money and goods, globalization, from its earliest beginnings to the present, is also about the spread of disease. Within the Old World, diseases carried by insects, rodents and people spread from one region to another fairly regularly. An outbreak of the bubonic plague occurred in China in the 1330s and spread to western Asia and Europe and finally into Britain through the rats in the hulls of ships that carried the traders who travelled across these regions. After killing over a third of Europe's population, the disease recurred regularly in epidemic proportions until the seventeenth century. The contact between the Old World and the New, in the sixteenth and seventeenth centuries, geographically extended the spread of diseases that wiped out entire, previously insulated native populations in the New World. The Arawac, an indigenous group in the Carribbean, was completely wiped out by a flu carried by pigs on Columbus's ships.

During the twentieth century, developments in international public health enabled a wide range of diseases affecting people around the globe either to be eradicated completely or largely controlled, at least in some parts of the world. For example, malaria and typhoid have disappeared from western Europe, North America, Australia and Japan but still affect populations throughout the periphery. Tuberculosis still kills about two million people a year and sickens another eight million; malaria causes one million deaths a year with more than 41 percent of the world's population at risk of acquiring it. Both of these diseases affect populations in the periphery because of deteriorating health systems, growing drug and insecticide resistance, and war. But it is also the case that global climate change is increasingly being seen as playing a role in the resurgence of diseases, once thought to be eradicated, not only in the periphery but also in the core.

Climate change is increasingly drawing the attention of scientists, environmental groups, and health professionals world wide because it points to changing environmental conditions as the cause of the spread of a range of infectious diseases once restricted to the periphery. One of the diseases of the twentieth century thought to have been wiped out but recurring recently in the United States is West Nile Virus (WNV). The disease was first isolated in the West Nile District of Uganda in 1937 and began to appear in Europe, the Middle East, west and central Asia, Oceania, and most recently North America in the 1990s. Transmitted to humans by mosquitoes and birds, the most serious manifestation of WNV infection is encephalitis (inflammation of the brain) which is fatal in humans as well as in certain domestic and wild birds. WNV cases in human populations have now occurred in all fifty states of the United States except for Alaska, Hawai'i, and Oregon.

Climate scientists and epidemiologists in the United States and elsewhere have begun to collaborate in order to better understand the conditions that produce the disease. They believe the climate factors that accelerate the disease's life cycle—mild winters coupled with prolonged droughts and heat waves—are the result of global climate change, which is a long-term transformation in Earth's atmosphere. The conditions producing climate change are thought to be caused by human activity such as

West Nile Virus Arizona Health Department Campaign

deforestation and fossil fuel burning which lead to alterations in the atmosphere resulting in warmer temperatures, a decline in sea ice and snow cover in the Northern Hemisphere, a retreat of mountain glaciers, and an increase in precipitation in high latitudes. Climate change is one of the results of the interaction of nature and society, a change that is likely to have long term consequences that may be difficult to reverse.

The relationship between people and the environment is perhaps the most central of all relationships within the discipline of geography. Indeed, the discipline consists of those who study natural systems and those who study human systems. In this chapter we explore the ways that society has used technology to transform and adapt to nature, together with the impact of those technological adaptations on humans and the environment.

NATURE AS A CONCEPT

As discussed in Chapter 2, a simple model of the nature-society relation is that nature, through its awesome power and subtle expressions, limits or shapes society. This model is known as environmental determinism. A second model posits that society also shapes and controls nature, largely through technology and social institutions. This second model, explored in this chapter, emphasizes the complexity of nature-society interactions.

Interest in the relationship between nature and society has experienced a resurgence over the last two or three decades largely because the scope of environmental problems seems to have increased from those that are locally or regionally defined to those that have implications for the whole planet. The single most dramatic manifestation of this interest occurred in the summer of 1992, when more than 100 world leaders and 30,000 other participants attended the second Earth Summit in Rio de Janeiro (the first Earth Summit was held in Stockholm in 1972). The central focus of the agenda was to ensure a sustainable future for Earth by establishing treaties on global environmental issues, such as climate change and biodiversity. The signatories to the 1992 Earth Summit conventions created the Commission on Sustainable Development to monitor and report on implementation. A five-year review of Earth Summit progress was made in 1997 through a U.N. General Assembly meeting in special session. In July 2002, world leaders and other environmentally concerned individuals met for another Earth Summit, this time in Johannesburg, South Africa (**Figure 4.1**).

Some very important and significant, though not necessarily dramatic, changes have occurred since Rio. One change has been the emergence of international institutions to facilitate and monitor environmental improvements. Another has been real progress on the global phase-out of leaded gasoline. A third has been rising scientific and popular interest in global environmental issues.

Renewed interest in the nature-society relationship is the result of the persistence, increasing number, and wider impact of environmental crises. This interest has led to attempts to rethink the relationship. For example, at the beginning of the twentieth century, Gifford Pinchot, as an influential citizen and later as director of the National Conservation Commission, advocated environmental conservation as the nation's forests and wild lands were increasingly given over to development. In 1962 Rachel L. Carson, in a groundbreaking book, *Silent Spring*, warned of the dangers of agricultural pesticides to ecosystems. Yet as the new century begins, the pesticide problem persists in both peripheral and core countries. In the past, technology emerged as the apparent solution to most environmental problems, but today's technological progress seems often to aggravate rather than to solve such problems (**Figure 4.2**). As a result, researchers and activists have begun to ask different questions and abandon the assumption that technology is the *only* solution. For instance, 2004 Nobel Laureate and scientist Wangari Maathai has led a movement advocating tree-planting as a way of addressing the linkage between environmental conservation and economic development (**Figure 4.3**). The Green Belt Movement, as it is known, works to conserve local biodiversity, prevent soil erosion, and increase the forest cover of Kenya. At present Kenya's forest cover is less than 2 percent. The GBM is therefore fully engaged in a reforestation campaign aimed at preserving and improving local biological diversity. The purchase of seedlings

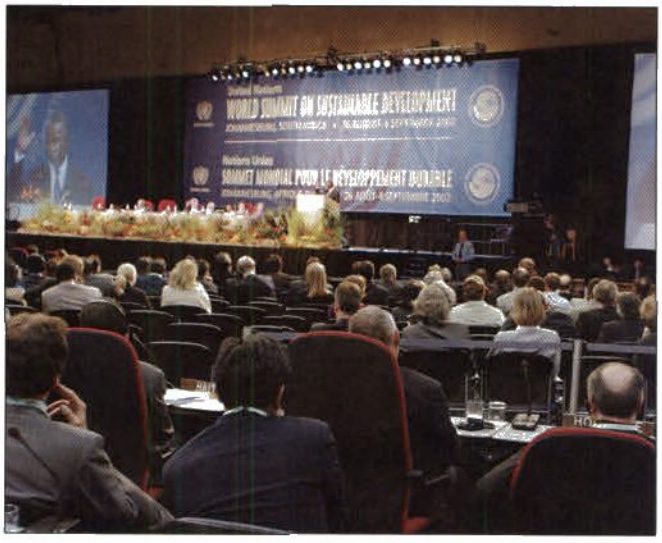


Figure 4.1 2002 Earth Summit, Johannesburg, South Africa
Global concern about environmental issues persists as the new century unfolds. Pictured here are attendees at the 2002 Earth Summit, with U.N. Secretary General Kofi Annan at the podium.

for the campaign helps to generate income for local groups at the same time that reforestation is advanced.

The GBM and others like it have influenced environmental experts, including a number of geographers, to conceptualize nature not as something apart from humans but as inseparable from us. These experts believe that nature and questions about the environment need to be considered in conjunction with society, which shapes our attitudes toward nature and how we identify sources of and solutions to environmental problems. Such an approach—uniting nature and society as interactive components of a complex system—enables us to ask new questions and consider new alternatives to current practices with respect to nature.

But before asking new questions about nature, this text examines the nature-society relationship by looking first at different approaches to it. We then examine how changing conceptions of nature have translated into very different uses of, and adaptations to, it. We conclude with an examination of sustainable development as a way of addressing global environmental problems and the new institutional frameworks and activist organizations that are emerging to promote sustainability.

Figure 4.3 Wangari Maathai In 2004, environmental activist, scientist, and Assistant Minister for Environment and Natural Resources in Kenya became the first African woman to receive a Nobel Prize. Dr. Maathai received the prize for her work in the Green Belt Movement (GBM) in Kenya and the pan-GBM. The GBM is a grass-roots organization involved in tree planting/biodiversity conservation, civic and environmental education, advocacy and networking, food security, and capacity building for women and girls. The aim of the organization is to address issues of sustainable development through environmental alternatives to technology.

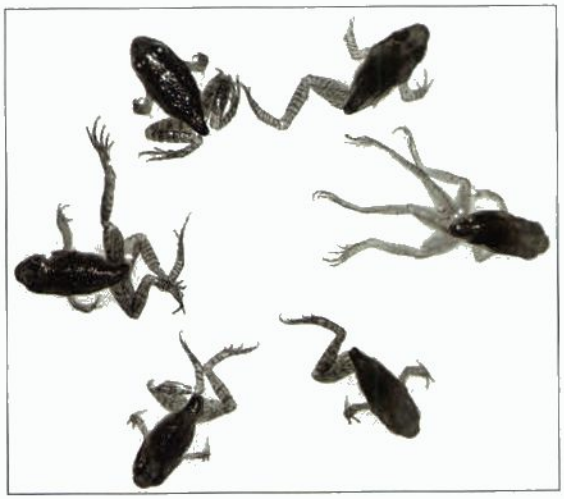


Figure 4.2 Deformities in frogs A 2005 study by a Pennsylvania State University scientist and published in the *Proceedings of the National Academy of Sciences* found that the combination of pesticide contamination and parasite infection has caused missing legs and extra legs in wood frogs in 43 states in the United States and five provinces in Canada. Both factors acting together are thought to be responsible for the mutations. It is believed that exposure to agricultural chemicals may weaken amphibian immune systems, making the frogs more vulnerable to parasitic infection leading to limb deformities. World-wide, amphibians have been decreasing at an alarming rate and scientists like this one believe that global climate change and other human induced factors are responsible for this decline.

Nature and Society Defined

The central concepts of this chapter—nature and society—have very specific meanings. Although we discuss the changing conceptions and understandings of nature in some detail, we hold to one basic conception here, that **nature** is a social creation as much as it is the physical universe that includes human beings. Therefore, understandings of nature are the product of different times and different needs. Nature is not only an object, it is a reflection of society in that philosophies, belief systems, and ideologies shape the way people think about and use nature. The relationship between nature and society is two-way: society shapes people's understandings and uses of nature at the same time that nature shapes society. The

amount of shaping by society is dependent to a large extent on the state of technology and the constraints on its use at any given time.

Society is the sum of the inventions, institutions, and relationships created and reproduced by human beings across particular places and times. Society's relationship with nature is just one of its relationships, and the social relationship to nature varies from place to place among different social groups.

The relationship between society and nature is usually mediated through technology. Knowledge, implements, arts, skills, and the sociocultural context all are components of technology. If we accept that all of these components are relevant to technology, then we can provide a definition that has three distinguishable though equally important aspects. **Technology** is defined as:

- physical objects or artifacts (for example, the plow);
- activities or processes (for example, steelmaking);
- knowledge or know-how (for example, biological engineering).

This definition recognizes tools, applications, and understandings as critical components of the human production of technology. The manifestations and impacts of technology can be measured in terms of concepts, such as level of industrialization and per capita energy consumption.

The definitions provided in this section reflect current thinking on the relationship between society and nature. For centuries humankind, in response to the constraints of the physical environment, has been as much influenced by prevailing ideas about nature as by its realities. In fact, prevailing ideas about nature have changed over time, as evidence from literature, art, religion, legal systems, and technological innovations makes abundantly clear.

A recent attempt to conceptualize the relationship between social and environmental changes has emerged from concern with global environmental changes. Based on the premise that individual societal changes can be both subtly and dramatically related to environmental changes, a formula for distinguishing the sources of social impacts on the environment has been advanced and is now widely used. The formula, known as $I = PAT$, relates human population pressures on environmental resources to the level of affluence and access to technology in a society. More specifically, the formula states that $I = PAT$, where I (impact on Earth's resources) is equal to P (population) times A (affluence, as measured by per capita income) times T (a technology factor). For example, the differential impact on the environment of two households' energy use in two different countries would equal the number of people per household times the per capita income of the household times the type of technology used to provide energy for that household (**Figure 4.4**).

Each of the variables in the formula—population, affluence, and technology—is complex. For example, with regard to population numbers, it is generally believed that fewer people on the planet will result in fewer direct pressures on resources. Some argue, however, that increased world population is quite desirable, since more people

Figure 4.4 Affluence differences in Iceland and Guatemala As the $I = PAT$ formula suggests, the level of affluence of households plays an important role in their impact on the global environment. Pictured here are two families, one from the core and the other from the periphery. Both families are pictured outside their homes with all of their possessions arrayed around them. The extensive range of possessions shows the Icelandic family, composed of two parents and four children, to be far more affluent than the Guatemalan family, composed of two parents and three children. Iceland ranks eighth in affluence among the 183 members of the United Nations; Guatemala's rank is 114. The Icelandic family possesses two radios, one stereo, two televisions, one VCR, one home computer, two automobiles, and a private airplane. The Guatemalan family possesses one battery-operated radio and no telephone, but would like to acquire a television set.

means more labor coupled with more potential for the emergence of innovation to solve present and future resource problems. Clearly there is no simple answer to the question of how many people are too many.

Affluence also cannot simply be assessed in terms of "less is better." Certainly, increasing affluence—a measure of per capita consumption multiplied by the number of consumers and the environmental impacts of their technologies—is a drain on Earth's resources and a burden on Earth's ability to absorb waste. Yet how much affluence is too much is difficult to determine. Furthermore, evidence shows that the core countries, with high levels of affluence, are more effective than the poor countries of the periphery at protecting their environments. Unfortunately, core countries often do so by exporting their noxious industrial processes and waste products to peripheral countries. By exporting polluting industries and the jobs that go with them, however, core countries may also be contributing to increased affluence in the receiving countries. Given what we know about core countries, such a rise fosters a set of social values that ultimately leads to better protection of the environment in a new place. It is difficult to identify just when environmental consciousness goes from being a luxury to a necessity. The role of affluence in terms of environmental impacts is, in short, like population, difficult to assess.

Not surprisingly, the technology variable is no less complicated. Technologies affect the environment in three ways:

- through the harvesting of resources;
- through the emission of wastes in the manufacture of goods and services;
- through the emission of waste in the consumption of goods and services.

A technological innovation can shift demand from an existing resource to a newly discovered, more plentiful one. In addition, technology can sometimes be a solution and sometimes a problem. Both principles can be seen in the case of nuclear energy, widely regarded as cleaner and more efficient than coal or oil as energy sources. Producing this energy creates hazards, however, which scientists are still unable to prevent.

It is therefore clear that increases in human numbers, in levels of wealth, and in technological capacity are key components of social and economic progress whose impact on the environment has been extremely complex. In the last 100 years this complexity has increasingly come to be seen as a triple-barreled threat to the quality of the natural world and the availability and quality of environmental resources. Before we look more carefully at the specific impacts of populations, affluence, and technology on nature, we need to look first at how differing social attitudes toward nature shape the human behaviors that are a basis for $I = PAT$.

Nature-Society Interactions

The concept of *adaptation* to the natural environment is part of the geographical subfield of cultural ecology most closely associated with the work of Carl Sauer and his students. Cultural ecology is the study of how human society has adapted to environmental challenges such as aridity and steep slopes through technologies such as irrigation and terracing and the organization of people to construct and maintain these systems. These adaptations can be seen clearly in the landscape, such as the rice terraces of Southeast Asia or the canals and reservoirs of the southwestern United States. More recent adaptations include the use of biotechnology and agricultural chemicals to increase agricultural production and the development of new pharmaceuticals to cope with diseases.

Human adaptation has gone far beyond responses to natural constraints to produce widespread modification of environment and landscapes. In some cases, the human use of nature has resulted in environmental degradation or pollution. For example, overcultivation of steep slopes can result in erosion of the soil needed for subsequent agricultural production, and the use of agricultural chemicals has caused the contamination of adjacent rivers and lakes by chemicals that are toxic to fish and humans. The Industrial Revolution produced a dramatic growth in the emissions of waste material to land, water, and atmosphere, and resulted in serious air pollution and health problems in many areas.

The massive transformation of nature by human activity led geographers such as Neil Smith and Margaret Fitzsimmons to claim that we can no longer talk about "natural" environments or untouched wilderness. They use the phrase *social production of nature* to describe the refashioning of landscapes and species by human activity, especially capitalist production and labor processes.

Geographers have played a major role in highlighting the global scope of this transformation in their discussions of the human dimensions of global environmental change, in which they explore the social causes and consequences of changes in global environmental conditions. Of particular concern are global patterns of fossil-fuel use and land-use change that are producing serious changes in climate and biodiversity through carbon dioxide–induced global warming or deforestation.

Global climate change is causing sea levels to rise as polar ice caps melt and has increased the frequency of violent storms. Warmer oceans surrender greater quantities of water as evaporation. Warmer surface temperatures and more humid air masses intensify weather systems, resulting in fiercer cyclones and hurricanes. In summer 2005 the twin disasters associated with global warming—violent storms and flooding—came together in the United States as Hurricane Katrina bore down on a wide swath of the Gulf Coast the extended from Pensacola, Florida to New Orleans, Louisiana (**Figure 4.5**). The hurricane destroyed extensive sections of the built environment and caused the flooding of low lying areas, especially Greater

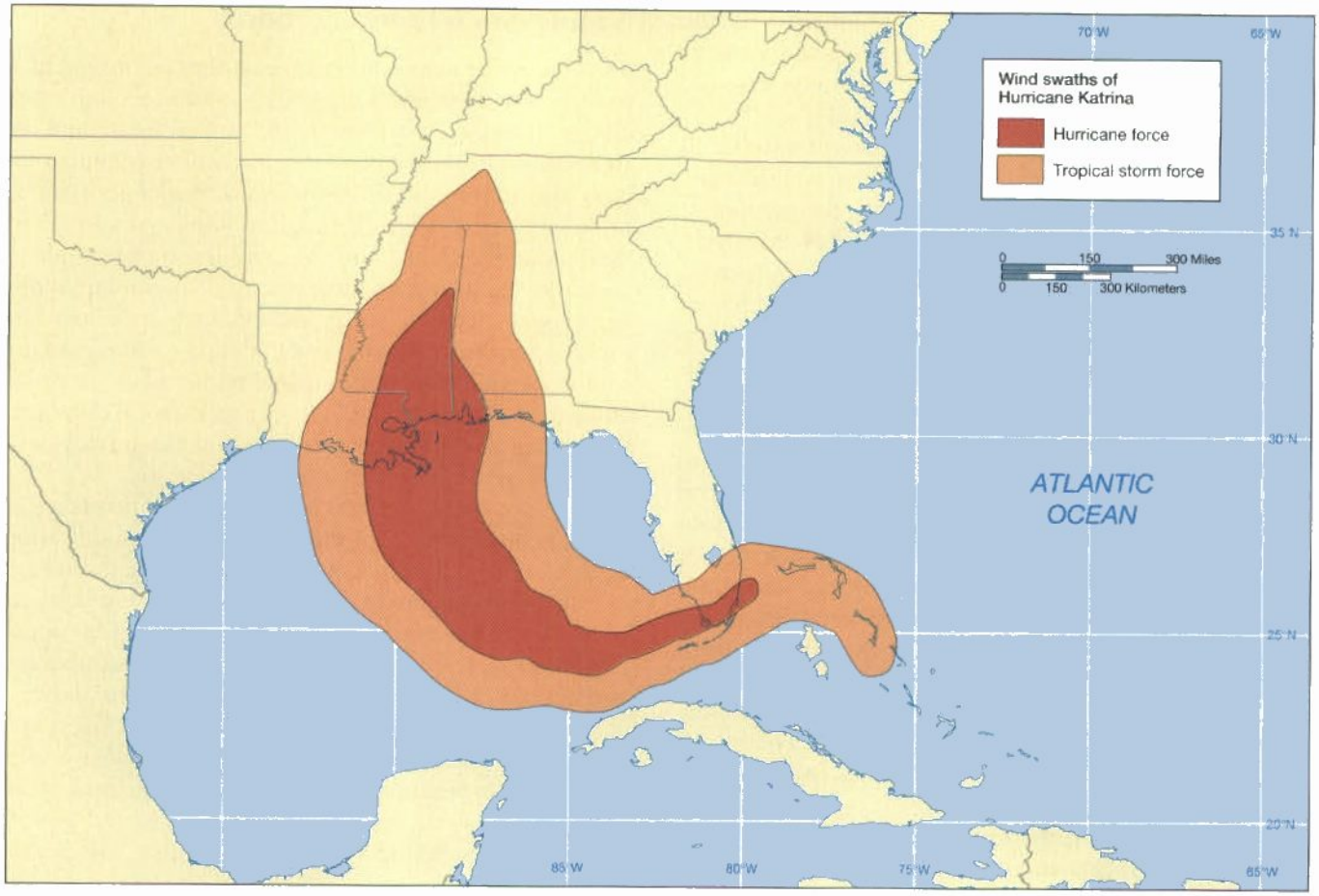


Figure 4.5 Hurricane Katrina's path This map produced by the National Oceanographic and Atmospheric Administration and the National Weather Service provides a graphic sense of the trail of Hurricane Katrina as it swept across southern Florida and then up the Gulf of Mexico making landfall a second time across the tip of the Florida panhandle, Alabama and Louisiana. (*Source:* http://www.nhc.noaa.gov/refresh/graphics_at2+shtml/084543.shtml?swath?large)

New Orleans—with a population of 1.4 million—where thousands died or were injured and more than one million people were displaced. The media, politicians, government officials, planners, and engineers labeled Hurricane Katrina the worst natural disaster the United States has ever experienced.

It is still too soon to identify definitively all the root causes of the calamity, but many scientists and public figures are arguing that Katrina was far from a "natural" disaster. While there is no doubt that the force of the winds slamming the Gulf Coast were extreme, the fact that districts and parishes in and around New Orleans (where the most dramatic impacts occurred) flooded and so many people (who had not evacuated) died was not because of the hurricane but was the result of political and social factors that could have been avoided. As with Hurricane Andrew, the violent storm that hit the Miami-Dade area in 1992, weak building codes and poor building code enforcement in New Orleans, made the wood-frame housing stock especially susceptible to damage from high winds. And critically needed improvements to the sinking levees—that hold back the Mississippi River and Lake Ponchartrain and enable various districts of the city of New Orleans to sit nearly five feet below sea level—were repeatedly postponed by the federal government. The strong winds mostly brought down power and communication lines leaving the region without electricity or phone service but the housing stock fairly in tact. But the storm surge that accompanied Katrina breached the levees and caused flooding to occur in over 80 percent of the city. Add to these technological vulnerabilities the fact that although the city's evacuation plan worked well for many, tens of thousands of people who were too poor or disabled or fearful to find their way out of the city before the storm hit and were thus put directly in harm's way. Blaming nature for the flooding and the tremendous loss of life in New Orleans, if not also in the rest of the affected Gulf region, is difficult to maintain. This is especially so when comparing Katrina's impact on the Gulf Coast of the United States in 2005 to Hurricane Ivan's impact on Cuba just a year before. Ivan was a Category 5 storm with 160-mile per hour winds when it hit the west coast of Cuba; Katrina a Category 4 storm with winds of 125–140 miles per hour when it hit the Gulf Coast. Yet 1.5 million Cubans successfully evacuated to higher ground ahead of the storm. They also evacuated pets, TVs, and refrigerators so people weren't reluctant to leave because their belongings would be unprotected. And though

20,000 houses were destroyed, no one died, no curfews were imposed, and no looting or violence took place. After Hurricane Ivan, the United Nations International Secretariat for Disaster Reduction cited Cuba as a model for hurricane preparation. Atmospheric scientists have been arguing for over a decade that global warming is putting Atlantic and Gulf coastal cities in the United States in a very vulnerable position as higher than normal ocean temperatures help to intensify hurricanes and tropical storms. Many believe that Hurricane Katrina is not an example of a "perfect storm" where essential meteorological elements combine to produce an extreme and devastating event, but the perfect example of how global climate change in combination with human practices, is transforming Earth's environment in dramatic and devastating ways.

During the twentieth century, global sea level rose by 20 centimeters (7.9 inches), and a recent report by Britain's Meteorological Office warned that flooding will increase more than ninefold over the twenty-first century, with four-fifths of the increase coming in South and Southeast Asia. A rising sea level would be disastrous for some countries. About 70 percent of Bangladesh, for example, is at sea level, as is much of Egypt's most fertile land in the Nile delta. In contrast, farmers in much of Europe and North America would welcome a local rise in mean temperatures, since it would extend their options for the kinds of crops that they could profitably raise.

The causes and consequences of these global climate changes vary considerably by world region. For example, the industrial countries have higher carbon dioxide emissions. Increased carbon dioxide emissions are contributing to rising temperatures through the trapping of heat in Earth's atmosphere. In order to survive in many of the world's peripheral regions, the rural poor are often impelled to degrade and destroy their immediate environment by cutting down forests for fuelwood, leading to the destruction of forests, which help to cool Earth's surface. Thus, both the core and the periphery are contributing to the problem of global change in different but equally significant ways.

Population growth patterns and the changing geography of economic development allow us to predict with some confidence that the air and water pollution generated by low-income countries will more than double in the next 15 years, as they become more industrialized. Thus, environmental problems are becoming inseparable from processes of demographic change, economic development, and human welfare. In addition, regional environmental problems are becoming increasingly enmeshed in matters of national security and regional conflict. Since the principles of cultural ecology did not explain the political dimensions of ecological questions, cultural ecologists in the 1980s began moving away from a strict focus on particular cultural groups' relationship with the environment, instead placing that relationship within a wider context. The result is political ecology, the merging of political economy with cultural ecology. **Political ecology** stresses that human-environment relations can be adequately understood only by reference to the relationship of patterns of resource use to political and economic forces (see Box 4.1: "Understanding Cultural Ecology and Political Ecology").

U.S. Environmental Philosophies and Political Views of Nature

As mentioned, nature is a construct that is very much shaped by social ideas and values. As a result, different societies and different cultures have very different views of nature. In the contemporary world, views of nature are dominated by the Judeo-Christian tradition, which understood Man to be superior to nature, such that nature is something to be tamed or dominated. But other views of nature have emerged and departed dramatically from the Judeo-Christian tradition, especially the environmental philosophies that became popular in the nineteenth and early twentieth centuries and the more radical political views of nature that gained prominence in the late twentieth century. We examine both of these approaches in this section in terms of changing U.S. philosophies and views of nature, which are largely representative of the core of the world economy.

Henry David Thoreau (1817–1862), an American naturalist and activist, perhaps best illustrates the Western incorporation of North American Indian conceptions of nature into ecological approaches that began emerging in the mid-nineteenth century in the United States. Thoreau lived and studied the natural world around the town of his birth, Concord, Massachusetts. He is most famous for his book *Walden*, which chronicles the two years he spent living and observing nature in solitude in a house he built on Walden Pond, a mile and a half from the village green of Concord. Thoreau represents a significant alternative to the "Man-over-nature" approach that characterized his times. Many people credit him as the originator of a U.S. ecological philosophy.

Thoreau was impressed with the power of nature. He often described its unrestrained and sometimes explosive capacity, which he thought had the potential to overthrow Man's dominion if left unchecked. He also emphasized the interrelatedness of the natural world, where birds depended upon worms, fish depended upon flies, and so on, along the food chain (**Figure 4.6**). Most notably, however, Thoreau regarded the natural world as an antidote to the negative effects of technology on the landscape and the American character. Concord was just 20 miles west of Boston and an equal distance south of the booming mill towns of Lowell and Lawrence. Although he spent his life in a more or less rural setting, the Industrial Revolution was in full force all around Thoreau, and he was keenly aware of its impacts. In fact, Thoreau's approach to the natural world was very much a response to the impacts on nature of the early forces of globalization. His research into the animals and plants that surrounded Concord was an attempt to reconstruct the landscape as it had existed before colonization and massive European immigration.

GEOGRAPHY MATTERS

Understanding Cultural Ecology and Political Ecology

The impact of Spanish agricultural innovations on the culture of the indigenous people of the Central Andes region of South America (an area encompassing the mountainous portions of Peru, Bolivia, and Ecuador) presents an excellent case study in cultural ecology. The transformation of Andean culture began when Pizarro arrived in Peru from Spain in 1531 and set about vanquishing the politically, technologically, and culturally sophisticated Incas. The Spaniards brought with them not only domestic plants and animals (mainly by way of Nicaragua and Mexico) but also knowledge about how to fabricate the tools they needed and a strong sense of what was necessary for a "civilized" life.

By the 1590s a bundle of Spanish cultural traits had been integrated into the Central Andean rural culture complex, creating a hybridized rural culture. The hybridized culture—and cultural landscape—combined a much simplified version of Spanish material life with important (though altered) Incan practices of crop growing, herding, agricultural technology, and settlement patterns. That this hybrid culture complex remains identifiable today, even after four centuries and in the face of contemporary globalizing forces, is due to the peasants' strong adherence to custom, geographic isolation, and poverty.

By 1620 the indigenous Andean people had lost 90 percent of their population and had been forced to make significant changes in their subsistence lifestyles (an illustration of demographic collapse as discussed on pages 144–148). The Inca empire, with its large population base, had once engaged in intensive agriculture practices, including building and maintaining irrigation systems, terracing fields, and furrowing hillsides. With the severe drop in population and consequent loss of labor power, the survivors turned to pastoralism because herding requires less labor than intensive agriculture. Ultimately, it was the introduction of Old World domesticated animals that had the greatest impact on the Central Andes (**Figure 4.A**).

Cultural ecologists study the material practices (food production, shelter provision, levels of biological reproduction) as well as the nonmaterial practices (belief systems, traditions, social institutions) of cultural groups. Their aim is to understand how cultural processes affect groups' adaptation to the environment. Whereas the traditional approach to the cultural landscape focuses on human impacts on the landscape or its form or history, cultural ecologists seek to explain how cultural processes affect adaptation to the environment. Cultural adaptation involves the complex strategies human groups employ to live successfully as part of a natural system. Cultural ecologists recognize that people are components of complex ecosystems and that the way they manage and consume resources is shaped by cultural beliefs, practices, values, and traditions, as well as by larger institutions and power relationships.

The cultural ecology approach incorporates three key points:

- Cultural groups and the environment are interconnected by systemic interrelationships. Cultural ecologists examine how people manage resources

Figure 4.A Andean woman weaving Though sheep are not indigenous to the Andes, they have been widely adopted in this region since the colonial period. Sheep are well adapted to high altitudes and provide wool and meat. Shown here is a woman weaving accompanied by another woman.

through a range of strategies to comprehend how the environment shapes culture, and vice versa.

- Cultural behavior is examined as a function of the cultural group's relationship to the environment through both material and nonmaterial cultural elements. Such examinations are conducted through intensive fieldwork.
- Most studies in cultural ecology investigate food production in rural and agricultural settings in the periphery in order to understand how change affects the relationship between cultural groups and the environment.[1]

Cultural ecologists look at food production, demographic change and its impacts on ecosystems, and ecological sustainability. The scale of analysis is not on cultural areas or cultural regions, but on small groups' adaptive strategies to a particular place or setting.

In the Andean example above, cultural ecologists have been able to understand complex relationships between two cultural groups and their environment, showing how the groups' choices were shaped by both culture and environmental conditions. Some critics have argued, however, that cultural ecology leaves out other intervening influences of the relationship between culture and the environment: the impact of political and economic institutions and practices.

During the 1980s cultural ecologists began moving away from a strict focus on a particular group's interactions with the environment, instead placing that relationship within a wider context. The result is political ecology, the merging of political economy with cultural ecology. Political ecology stresses that human-environment relations can be adequately understood only by reference to the relationship of patterns of resource use to political and economic forces. Just as with the study of agriculture, industrialization, urbanization, and comparable geographical phenomena, this perspective requires an examination of the impact of the state and the market on the ways in which particular groups utilize their resource base.

Political ecology incorporates the same human-environment components analyzed by cultural ecologists. However, because political ecologists frame cultural ecology within the context of political and economic relationships, they go beyond what cultural ecologists seek to understand.

A case study of the banana industry on St. Vincent and the Grenadines, an island nation in the Caribbean, illustrates the difference (**Figure 4.B**).[2] Beginning in the 1980s, agriculturalists in the main island of St. Vincent shifted to banana production for export at the same

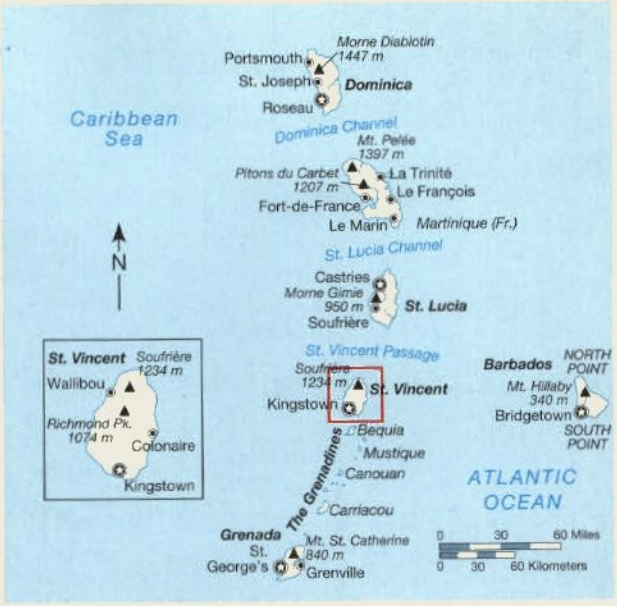


Figure 4.B St. Vincent and the Grenadines These island and island groupings are part of the chain of the Lesser Antilles in the Caribbean Sea. The total population is about 115,000, occupying about 390 square kilometers (150 square miles).

time that local food production began to decline. Without recognizing the impacts of politics and the wider economy, it would be impossible to understand why these two processes have been occurring simultaneously. Disincentives and incentives have both played a role. Disincentives to maintain local food production include marketing constraints, crop theft, competition from inexpensive food exports, and inadequate government assistance. Incentives to produce for export include state subsidies to export-oriented agriculture and access to credit for banana producers, as well as a strong British market for Caribbean bananas. As a result, local food production, although faced with the same environmental conditions as banana production, does not enjoy the same political and economic benefits. Because production for export is potentially more lucrative and an economically safer option, and to some extent because of changing dietary practices, local food production is a less attractive option for agriculturalists.

As the St. Vincent case illustrates, the political ecology approach provides a framework for understanding how the processes of the world economy affect local cultures and practices. It also indicates how state policies and practices and economic demand in the global economy shape local decision making. Furthermore, local cultural practices (especially dietary) are being abandoned as people develop a taste for low-cost and convenient imported agricultural commodities such as flour and rice. Unfortunately, however, production for export also opens up the local economy to the fluctuations of the wider global economy. Recent changes in European Union policy on banana imports, for example, are having negative effects on banana production in St. Vincent.

[1]K. Butzer, "Cultural Ecology," in G. L. Gaile and C. J. Wilmot (eds.), *Geography in America*. Columbus, OH: Merrill Publishing Co., 1989, p. 192.

[2]Adapted from L. Grossman, "The Political Ecology of Bananas: Contract Farming, Peasants, and Agrarian Change in Eastern Caribbean." Chapel Hill, NC: University of North Carolina Press, 1998.

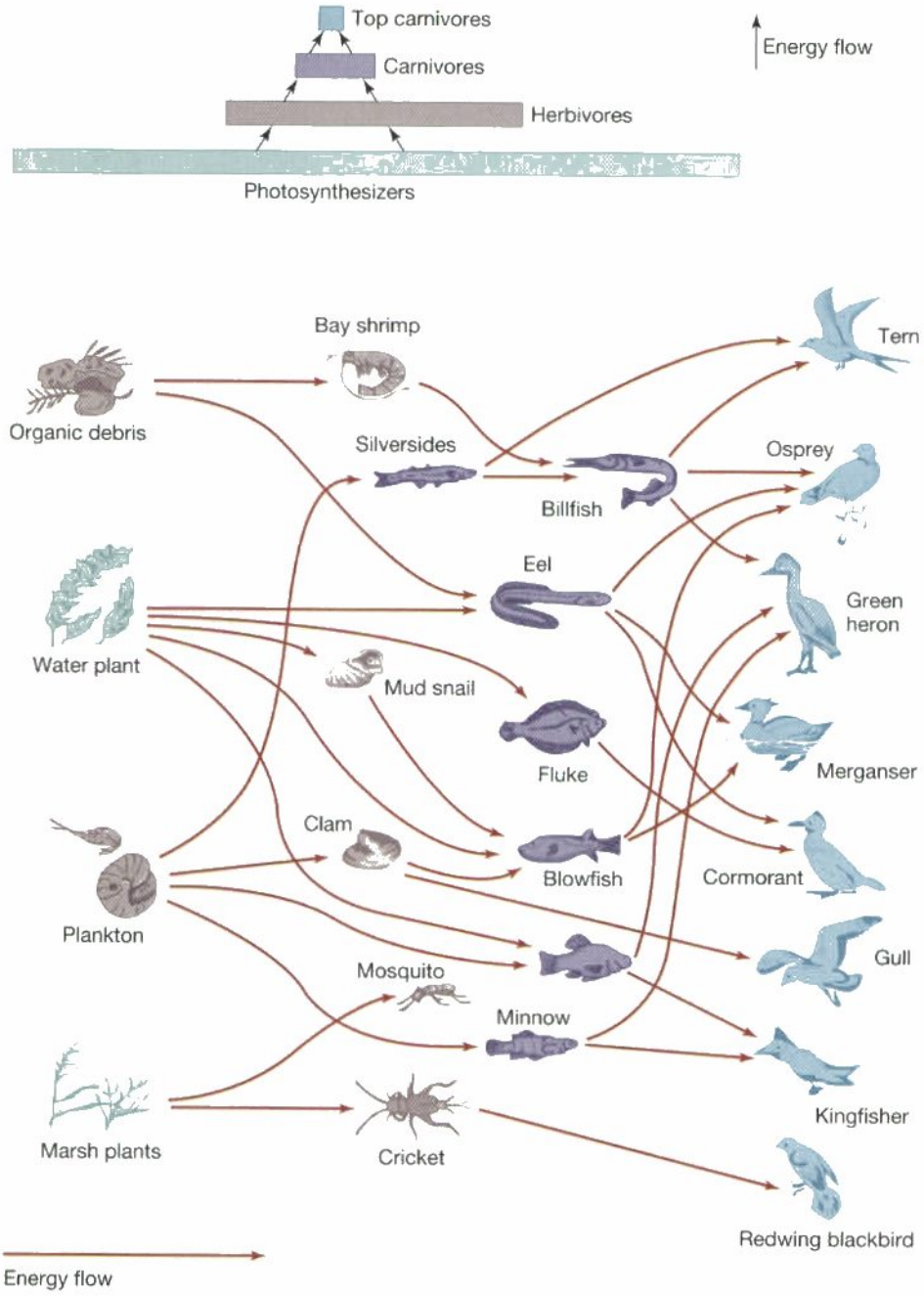


Figure 4.6 Generalized food chain Although a contemporary diagram, this illustration of the food chain in a Long Island estuary demonstrates the nineteenth-century naturalist's view. Plants, animals, and insects are all seen to be part of a complex whole, such that elimination or injury to one element affects the entire system. Although most ecosystems have complex food chains containing numerous relationships among the different parts, one rule holds for all: The higher the animal is in a food chain, the fewer there are of that animal. This rule is illustrated in the bar graph at the top of the illustration, which shows that the photosynthesizers (those at the bottom) are numerous whereas the carnivores (at the top) are much less so. The photosynthesizers are the most numerous because they are the most energy efficient. The farther you go up the chain from the photosynthesizers—who are also known as primary producers—the less energy efficient the animal is. (After C. Ponting, *A Green History of the World*. London: Sinclair-Stevenson, 1991, p. 13.)

Thoreau was also a primary force behind romanticism, a movement that originated in Europe. **Romanticism** is a philosophy that emphasizes the interdependence of humans and nature. In direct revolt against those who espoused a Judeo-Christian understanding of nature, the romantics believed that *all* creatures—human and otherwise—were infused with a divine presence that commanded respect and that humans were not exceptional in this scheme. Rather, their divinity issued from humble participation in the natural community.

A branch of American romanticism known as **transcendentalism** has also influenced contemporary understandings of nature. Transcendentalism was espoused most eloquently by Unitarian minister turned poet and philosopher Ralph Waldo Emerson, a neighbor and contemporary of Thoreau's. It encourages people to attempt to rise above nature and the limitations of the body to the point where the spirit dominates the flesh, where a mystical and spiritual life replaces a primitive and savage one. Thoreau and Emerson are two of the most important influences on contemporary ideas about the human-nature relationship.

Another major influence on U.S. environmentalism derives from the writings of George Perkins Marsh, a native Vermonter who in 1864 wrote a treatise entitled *Man and Nature, or Physical Geography as Modified by Human Action* (heavily revised and republished in 1874 as *The Earth as Modified by Human Action*). As

the first work to suggest that human beings are significant agents of environmental change, it is considered one of the most important advances in geography, ecology, and resource management in the nineteenth century. Marsh's ideas served as the foundation of the U.S. environmental movement in the twentieth century. Early in that century, writers like Gifford Pinchot and politicians like Theodore Roosevelt drew on the ideas of Thoreau, Emerson, and Marsh to advocate the wise use of natural resources and the conservation of natural environments. Their view that nature should be conserved has persisted to the present. **Conservation** holds that natural resources should be used wisely and that humans should serve as stewards, not exploiters, of the natural world. Conservation implies responsibility to future generations as well as to the natural world itself in the utilization of resources.

The writings of all these individuals eventually helped to inspire a wide range of environmental organizations, including the Environmental Defense Fund, World Watch Institute, Nature Conservancy, and the Sierra Club. The Environmental Defense Fund brings together experts in science, law, and economics to address complex environmental issues and to educate governments and the public about them. World Watch is a nonprofit public-policy research organization whose goal is also to inform policymakers and the public about emerging global problems and trends, and the complex links between the world economy and its environmental support systems. The mission of the Nature Conservancy is: "To preserve the plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive." The Sierra Club is an organization founded in the late nineteenth century, which has a similar mission of promoting and protecting Earth's wild places, diverse ecosystems, and resources. All of these organizations are considered mainstream in their approaches in that they work within the political and economic system to achieve their ends.

For those who espouse a more radical approach to nature, the conservation approach described previously is seen as too passive to be truly effective in protecting the environment. These individuals believe that conservation leaves intact the political and economic system that drives the exploitation of nature. They believe that nature is sacred and should be preserved, not used at all. This more extreme position, **preservation**, advocates that certain habitats, species, and resources should remain off limits to human use, regardless of whether the use maintains or depletes the resource in question. The philosophy of groups such as Earth First! is closely aligned with the preservationist perspective. Earth First!, unlike the Sierra Club, operates outside the bounds of mainstream institutional frameworks. Whereas the Sierra Club takes its opponents into the courtroom, Earth First! employs extralegal tactics—often called *ecoterrorist* tactics—such as driving spikes into trees to discourage logging. These "quick strike" actions are intended to halt what are regarded as government or corporate environmental abuses (which may, in fact, be perfectly legal though counter to the Earth First! philosophy).

Greenpeace is yet another environmental organization different from either Earth First! or the Sierra Club. Greenpeace is global in its reach, meaning that both its membership and its areas of emphasis are international (**Figure 4.7**). (We talk more about global environmental organizations later in this chapter.) Focusing on environmental polluters and combining the strategies of both the Sierra Club and Earth First!, Greenpeace utilizes oppositional tactics as well as formal international legal actions. In its membership—with the world headquarters in

Figure 4.7 Greenpeace protest in Europe The sign attached to the Brandenburg Gate in Berlin is displayed by Greenpeace, Europe, one of the many regional branches of the organization. Activists like these and in other environmental organizations throughout Europe and North America were among those who opposed the war in Iraq for humanitarian as well as environmental reasons. The Persian Gulf War (1991) was an environmental disaster as Iraqi troops released oil into the Persian Gulf and ignited 732 oil wells in Kuwait as they fled the country. These protesters and others like them would like to see a different energy source than oil fueling the global economy.

Amsterdam and regional offices in most major industrial countries—as well as its objectives—halting environmental pollution worldwide—Greenpeace articulates the belief that places are interdependent, and what happens in one part of the globe affects us all.

Organizations such as Earth First! and Greenpeace are practical illustrations of new approaches to understanding human interactions with nature that have developed since the publication of *Silent Spring* over 40 years ago. These, as well as other new approaches—environmental ethics, ecofeminism, deep ecology, and environmental justice—take the view that nature is as much a physical universe as it is a product of social thought. All provide different ways of understanding how society shapes our ideas about nature.

Environmental ethics is a philosophical perspective on nature that prescribes moral principles as guidance for our treatment of it. Environmental ethics insists that society has a moral obligation to treat nature according to the rules of moral behavior that exist for treating human beings. An aspect of environmental ethics that has caused a great deal of controversy is the perspective that animals, trees, rocks, and other elements of nature have rights in the same way that humans do. If the moral system of our society insists that humans are to have the right to a safe and happy life, then it is argued that the same rights should be extended to nonhuman nature.

Ecofeminism shares much of this philosophical perspective. Ecofeminists hold that patriarchy—a system of social ideas that values men more highly than women—is at the center of our present environmental malaise. Because patriarchy has equated women with nature, it has promoted the subordination and exploitation of both. The many varieties of ecofeminism range from nature-based spirituality oriented toward a goddess to more political approaches that emphasize resistance and opposition to the dominant masculine models that devalue what is not male. Some ecofeminists are also environmental ethicists. Not only a movement of the core, ecofeminism has also been widely embraced in the periphery, where women are primarily responsible for the health and welfare of their families in environments that are being rapidly degraded. The unifying objective in all of ecofeminism is to dismantle the patriarchal biases in Western culture and replace them with a perspective that values social, cultural, and biological diversity.

Deep ecology, which shares many points with ecofeminism, is an approach to nature revolving around two key components: self-realization and biospherical egalitarianism. Self-realization embraces the view that humans must learn to recognize that they are part of the nonhuman world, whereas biospherical egalitarianism insists that Earth, or the biosphere, is the central focus of all life and that all components of nature, human and nonhuman, deserve the same respect and treatment. Deep ecologists, like environmental ethicists, believe that there is no absolute divide between humanity and everything else, and that a complex and diverse set of relations constitutes the universe. The belief that all things are internally related could enable society to treat the nonhuman world with respect and not simply as a source of raw materials for human use.

Activists in the **environmental justice** movement consider the pollution of their neighborhoods through such elements as nearby factories and hazardous-waste dumps to be the result of a structured and institutionalized inequality that is pervasive in both the capitalist core and periphery. They see their struggles as distinct from the more middle-class and mainstream struggles of groups such as the Sierra Club or even Earth First! and Greenpeace. These activists view their struggles as rooted in their economic status. Thus, these struggles are not about quality-of-life issues, such as whether any forests will be left for recreation, but about sheer economic and physical survival. As a result, the questions raised by environmental justice activists involve the distribution of economic and political resources. Such questions are not easily resolved in courts of law, but speak to more complex issues such as the nature of racism and sexism, and of capitalism as a class-based economic system.

The environmental justice movement is not restricted to the core. Indeed, poor people throughout the world are concerned that the negative impacts of economic development consistently affect them more than the rich. Furthermore, although most people support improving the lives of people throughout the globe who are currently living in poverty, many have serious reservations about trying to raise all living standards to the level that core regions and the elite enjoy. In fact, some globalization experts argue that some of the highest standards of living around the globe will have to be lowered in order to raise others up, because the widespread economic development that universally high standards would require is not environmentally sustainable. In short, because of the limitations set by Earth's resources—both in terms of the amount and quality of key resources—improvements in social well-being at the level now enjoyed by the core cannot be sustained over the long term and may not even be possible to begin with. As a result, discussions of the future of economic globalization are increasingly being accompanied by discussions about sustainability and the ways economic development might proceed without continuing to damage the environment. (We discuss sustainability in greater detail later in this chapter.)

All of these approaches to the environment attest to a growing concern regarding the effects of globalization. Acid rain, deforestation, the disappearance of species, nuclear accidents, and toxic waste have all been important stimuli for newly emerging philosophies about the preferred relationships between society and nature within a globalizing world. While none of these philosophies is a panacea, each has an important critique to offer. More than anything, however, each serves to remind us that environmental crises are not simple, and simple solutions will no longer suffice.

The Concept of Nature and the Rise of Science and Technology

Let us return to the point made earlier: that the most widespread ideas of nature current in Western thought—and ones that have persisted under different labels for thousands of years—are that humans are the center of all creation and that nature in all its wildness was meant to be dominated by humans. This Judeo-Christian belief insists that Man, made in the image of God, was set apart from nature and must be encouraged to control it.

While Christianity held that nature was to be dominated, that idea existed more in the religious and spiritual realm than in the political and social realm. In terms of the conduct of everyday life, it was not until the sixteenth century that Christian theology was conscripted to aid the goals of science. Before 1500 in Europe there existed a widely held view of Earth as a living entity such that human beings conducted their daily lives in an intimate relationship with the natural order of things. The prevailing image was that of an organism, which emphasized interdependence among human beings and between them and Earth. Yet even within this organic idea of nature, we can find two opposing conceptions. One was of a nurturing Earth that provided for human needs in a beneficent way; the other was of a violent and uncontrollable nature that could threaten human lives. In both views Earth and nature were regarded as female.

Francis Bacon (1561–1626) and Thomas Hobbes (1588–1679) were English philosophers who, as prominent promoters of science and technology, were influential in changing the prevailing organic view of nature. Borrowing from Christian theology, they advanced a view of nature as something subordinate to Man. Bacon and Hobbes sought to rationalize benevolent nature as well as to dominate disorderly and chaotic nature.

As feminist environmental historian Carolyn Merchant writes:

> The change in controlling imagery was directly related to changes in human attitudes and behavior toward the earth. Whereas the nurturing earth image can be viewed as a cultural constraint restricting the types of socially and morally sanctioned human actions allowable with respect to the earth, the new images of mastery and domination functioned as cultural sanctions for the denudation of nature. Society needed these new images as it continued the process of commercialization and industrialization, which depended on activities directly altering the earth—mining, drainage, deforestation, and assarting [grubbing up stumps to clear fields]. The new activities used new technologies—lift and force pumps, cranes, windmills, geared wheels, flap valves, chains, pistons, treadmills, under- and overshot watermills, fulling mills, flywheels, bellows, excavators, bucket chains, rollers, geared and wheeled bridges, cranks, elaborate block and tackle systems, worm spur, crown, and lantern gears, cams and eccentrics, ratchets, wrenches, presses, and screws in magnificent variation and combination.[1]

Figure 4.8 illustrates Merchant's point, that by the sixteenth and seventeenth centuries the power of science was too great for the organic idea of nature. Subsequently, a view that nature was the instrument of Man became dominant in Western culture.

Figure 4.8 Commodification of nature This sixteenth-century woodcut illustrates the various uses of wood and water with respect to the mining industry of the late Middle Ages and Renaissance. This scene illustrates the exploitation of nature, in contrast to the view of it as a bountiful mother. (After Georg Agricola woodcut: Georgius Agricola, *De Re Metallica*, translated from the first Latin edition of 1556 by Herbert Clark Hoover/Lou Henry Hoover, p. 337.)

[1]C. Merchant, *The Death of Nature*. San Francisco: Harper and Row, 1979, pp. 2–3.

THE TRANSFORMATION OF EARTH BY ANCIENT HUMANS

Although the previous discussion might suggest that Earth remained relatively unaffected by human action until well into the early modern period, the Paleolithic and Neolithic peoples altered the environment even without machines or elaborate tools. Considerable evidence exists that early humans were very active agents of change. People's perceptions of nature were usually quite influential in shaping their environmental behaviors, although many examples exist of contradictions between attitudes and actions. In this section we see that contemporary humans have inherited an environment that was significantly affected even by the practices of our very earliest ancestors.

Paleolithic Impacts

Although humans are thought to have first inhabited Earth approximately 6 million years ago, almost no evidence exists of how the very earliest hominids, as they are called, used the natural world around them to survive. What is known is that their numbers were not large and that they left little behind in the way of technology or art to help us understand their relationship to nature. The earliest evidence about the environmental relationships of our ancestors comes from the **Paleolithic period** (about 1.5 million years ago), a cultural period also known as the early Stone Age, because this was the period when chipped-stone tools first began to be used.

Hunters and gatherers living on the land in small groups, the early Stone Age people mainly foraged for wild food and killed animals and fish for their survival. Hunting under early Stone Age conditions could not support a growing population, however. It is estimated that on the African grassland, where humans are believed to have first evolved, only two people could survive on the vegetation and wildlife available within about a 2.5-square-kilometer (1-square-mile) area. To help ensure survival, early Stone Age people constantly moved over great distances, which ultimately made them a dispersed species, creating the foundation for the world's population distribution of today (**Figure 4.9**).

Evidence also exists of early Stone Age tools, as well as of the importance of hunting to human existence. The cave paintings of Vallon-pont-d'arc, France, for example, illustrate that hunting was the primary preoccupation of the Stone Age mind (**Figure 4.10**). Because these early peoples lived in small bands and moved frequently in wider and wider ranges, it is tempting to conclude that they had very little impact on their environment. It does appear, however, that Stone Age people frequently used the powerful tool of fire. They used it to attract game, to herd and hunt game, to deflect predators, to provide warmth, and to encourage the growth of vegetation that would attract grazing animals like antelope and deer.

The impact of frequent and widespread fire on the environment can be dramatic. Fire alters or destroys vegetation—from entire forests to vast grasslands (**Figure 4.11**). Fire can encourage the growth and survival of some species, while eliminating others. When fire destroys the vegetation that anchors the soil, however, and is followed by heavy rains, it can lead to soil erosion and, in areas with a steep slope, to the total denudation of the landscape. The use of fire by early Stone Age peoples certainly had all these impacts on the environment.

Archaeologists believe that many large North American animal species disappeared around 11,000 years ago. At the end of the Pleistocene—the geologic and climatic age immediately preceding the one in which we now live—large, slow animals such as the mastodon, mammoth, cave bear, woolly rhino, and giant deer became extinct. These species constituted over two-thirds of the megafauna, or large animals, of the region. A great deal of controversy exists about why these megafauna became extinct and others did not. Climate change or large-scale natural dis-

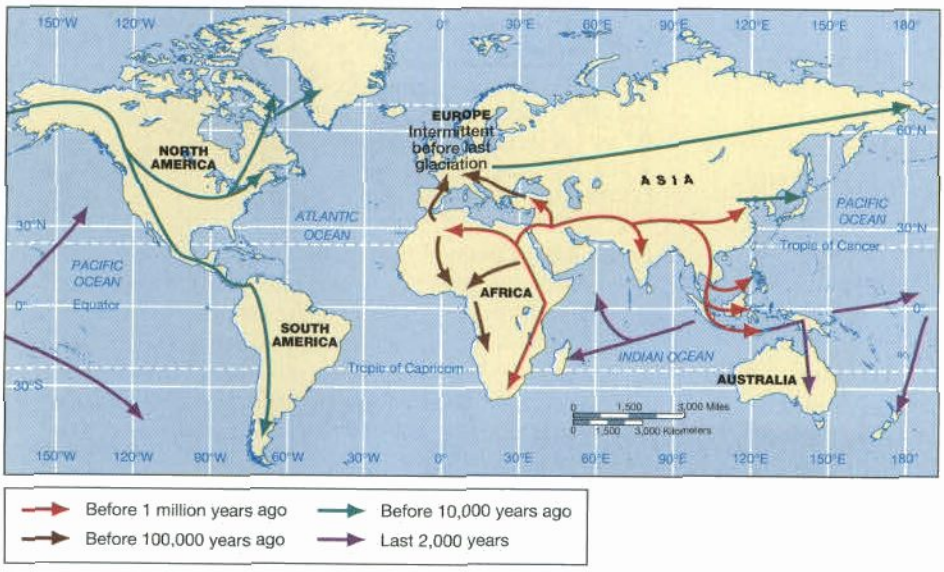


Figure 4.9 The settlement of the world This map shows one theory of the direction and timing of movement of early humans. The constant search for food promoted such movement. The map represents over 1 million years of migration. (After C. Ponting, *A Green History of the World*. London: Sinclair-Stevenson, 1991, p. 25.)

Figure 4.10 Cave paintings Cave paintings are an important record of the imagination of early hunter-gatherers. Some regard these paintings as clear evidence of the development of forward thinking or anticipation among humans. This cave painting from Vallon-pont-d'Arc in southern France portrays large animals hunted for their meat and skins.

asters are not satisfying explanations because neither is particularly selective such that megafauna would be eliminated but not other animals.

Another explanation for the extinction of the larger, slower megafauna is that early Stone Age peoples were directly responsible. While it might seem implausible that primitive hunting techniques could have such a devastating impact, consider the point made earlier that 2.5 square kilometers (one square mile) of vegetation and wildlife were adequate for the survival of only two people. As population sizes increased, more pressure was placed on animal populations to satisfy human food requirements. Those animals easiest to bring down were certainly the slowest and largest—the ones that could not escape quickly.

It is also the case that early Stone Age peoples had, over time, refined their killing technologies, particularly stone blades and spearheads. The double-edged **Clovis point**, for example, increased the likelihood of a kill rather than an injury to an animal. The Clovis point (**Figure 4.12**) is a flaked, bifaced projectile whose length is more than twice its width. Used to kill large animals such as bison, the point is so named because archeologists found the first projectiles in conjunction with kill sites in Clovis, New Mexico. Some Paleolithic hunters used the natural landscape to trap or kill large numbers of animals. Driving animals into canyons where they could be contained, or over cliffs where they would be killed en masse, ensured that huge numbers could be eliminated at one time (**Figure 4.13**). Other Paleolithic groups hunted small game, such as rabbits, using traps and small projectiles.

Neolithic Peoples and Domestication

The credit for the development of agriculture—a technological triumph with respect to nature—goes to the Neolithic peoples, also known as the late Stone Age peoples. While the divide between them and the Paleolithic peoples occurred about 10,000 years ago, it is not known exactly when Neolithic peoples shifted from hunting and gathering to cultivating certain plants and taming and herding wild animals. We have termed that period the First Agricultural Revolution (described in greater detail in Chapter 8). Climatically we know that for many regions of the globe, this period coincided with the end of the last Ice Age, which means that spring slowly began to occur in

Figure 4.11 Fire and its impacts on the landscape Fires can have a devastating impact on the landscape. Especially hot fires can burn not only the surface vegetation but also the organic material in the soil. The loss of these organic materials and other nutrients hinders the regeneration of vegetation. Without vegetation to anchor the soil, heavy rains can cause massive soil erosion. Shown in the photograph is eastern Arizona, the site of the convergence of the Rodeo and Chediski fires in 2002.

Figure 4.12 The Clovis point Clovis points are named after Clovis, New Mexico, where the points were first discovered. The Clovis points in this photo were found in Southern Arizona, and they show the typical shape of the points, which were attached to spears and used to hunt game. (*Source:* Photo courtesy Arizona State Museum © Jerry Jacka Photography.)

places that had not experienced it for thousands upon thousands of years.

At this time, environmental conditions made possible the domestication of plants and animals, which also requires a sedentary lifestyle based in permanent settlements. The first domestication successes of the late Stone Age peoples were with the most docile animals (herbivores) and the hardiest plants (those with large seeds and a tolerance to drought). Once early domestication was established, it became possible for small groups of Neolithic peoples to cease to be nomads. As Chapter 2 discusses, permanent settlement enabled further refinements in domestication. Eventually Neolithic people achieved a truly dramatic innovation—the breeding of plants and animals to produce desired genetic characteristics, such as disease resistance in plants.

The emergence of agriculture changed the course of human history and had important environmental impacts—both negative and positive. One negative impact was the simplification of ecosystems as the multiplicity of wild species began to be replaced by fewer cultivable crops. An **ecosystem** is a community of different species interacting with each other and with the larger physical environment that surrounds it. Along with the vast number of wild species lost has gone the opportunity to understand their benefit to humans and the wider ecosystem. More positively, however, increased crop yields through greater control over available foodstuffs helped to improve human health and eventually increased population growth.

It is from this early period of plant domestication that we also find widespread evidence of a growing appreciation of nature through ritual, religion, and art. Human beings depended upon rain, soil fertility, and an abundance of sunlight to produce a successful harvest, and reverential attitudes toward nature appear to have been pervasive. In many places in both the Old and the New World, people worshiped Earth, Sun, and Rain, and they sacrificed deer and bear to them in an attempt to ensure survival.

Early Settlements and Their Environmental Impacts

What is perhaps the most significant aspect of plant and animal domestication is that it eventually enabled a food surplus to be produced. It also permitted the formation of human settlements in which small groups—probably craftspeople and political and religious elites—were able to live off the surplus without being responsible for its

Figure 4.13 Massive animal kills Paleolithic hunters appear to have used features of the landscape to aid them in hunting large game. Archaeologists believe that the mounds of skeletal remains of large animals found at various sites are evidence of this. It is not clear whether hunters and their kin were even able to consume all the animal flesh made available through such killing methods. It has been speculated that such gross killing methods may have led to the extinction of some species. (After Arthur Lidov/National Geographic Society Image Collection.)

production. Eventually growing numbers of people, bolstered by increasing surpluses, were able to settle in places where water was available and the land cultivable.

The invention of agricultural tools helped to further the domestication of plants and animals as well as multiply the early agriculturalists' impact on the landscape. Among the early tools that enabled humans a greater measure of control over nature were the sickle for harvesting wheat (**Figure 4.14**); the plow for preparing the soil; the yoke for harnessing draft animals, such as oxen, to pull the plow; and the wheel for grinding wheat, creating pottery, and later enabling transportation. The wheel was also used as a pulley to draw water. In Sumer and Assyria, for example, the wheel enabled the development of large-scale irrigation systems.

Irrigation is one of the most significant ways that humans have been able to alter the limits of their environment. Throughout much of the world, in fact, agriculture could not occur without irrigation. And as agriculture has spread, irrigation has increased (**Table 4.1**). Following the success of the Fertile Crescent, agriculture diffused and new settlements emerged. The food-producing minisystems of China, the Mediterranean, Mesoamerica, the Middle East, and Africa were sustained largely through irrigated agriculture. Yet despite the existence of a vast irrigation network and a whole social structure bound up with agricultural production and attendant activities, the cities of the Mesopotamian region collapsed around 4,000 years ago. While there is no undisputed explanation for why this occurred, many researchers believe—based on archaeological evidence—that it was due to environmental mismanagement. The irrigation works became clogged with salt, resulting in increasingly saline soils. To counteract the effect of salt on production, agriculturalists switched to barley, which is more salt-resistant than wheat, but the ultimate result was a significant drop in yields. **Siltation** (the buildup of sand and clay in a natural or artificial waterway) associated with **deforestation** (the removal of trees from a forested area without adequate replanting) also occurred, filling up the deltas for nearly 200 miles (322 kilometers). Eventually the canals filled with salt and the soils became too saline to support cultivation.

TABLE 4.1 World Irrigated Area Since 1700

Date (A.D.)	Area (in thousands of square kilometers/ square miles)
1700	50/19
1800	80/31
1900	480/185
1949	920/355
1959	1490/575
1980	2000/772
1981	2130/822
1984	2200/849
2000	2740/1057

Source: W. Meyer, *Human Impact on the Earth*, 1990. Cambridge: Cambridge University Press, p. 59. *Original source:* B. G. Rozanov, V. Targulian, and D. S. Orlov, "Soils" in *The Earth Transformed by Human Action*, B. L. Turner II, W. L. Clark, R. W. Kates, J. F. Richards, J. T. Matthews, and W. B. Meyer (eds.), *1990*. Cambridge: Cambridge University Press. Updated from FAOSTAT Agricultural Database. 2001. Irrigation. 10 July 2001. Web site: http://apps.fao.org/page/form? collection=Irrigation&Domain=Land&servlet=1&language=EN&hostname=apps.fao.org&version=default

While it may seem that poorly informed management led to the demise of Mesopotamian cities, increasingly saline soils currently plague agriculture in California and southwestern Arizona (**Figure 4.15**). And it was not only the Mesopotamians who made environmental mistakes. Other early urban civilizations, such as the Mayans in Central America and the Anasazi of Canyon de Chelly in Arizona, are also thought to have collapsed due to environmental mismanagement of water.

In the following section we examine the period of European expansion and globalization. Although many other important cultures and civilizations affected the environment in the intervening periods, the impacts of their technological developments were much the same as those we have already described. The period of European colonialism, however, had a profoundly different impact from preceding periods in extent, magnitude, and kind. Furthermore, it set the stage for the kinds of environmental problems contemporary society has inherited, perpetuated, and magnified.

Figure 4.14 Wheat and flint sickle blade Perhaps the most significant factor in the spread of agriculture from Mesopotamia was the occurrence of hybrid forms of wheat, one of many wild grasses found in the area. Even before a fertile hybrid emerged, however, people were harvesting the wild forms. Sickle blades made from flint and set into a horn handle were the most common harvesting tools.

EUROPEAN EXPANSION AND GLOBALIZATION

The history of European expansion provides a powerful example of how a society with new environmental attitudes was able to transform nature in radically new ways.

Figure 4.15 Irrigation system near El Centro, Southern California This photo illustrates a large irrigation system in one of the driest areas of the United States. Much of the remaining cultivable land in the United States lies in dry areas such as in the Southwest. Large-scale irrigation is required there to sustain agricultural productivity. Under these circumstances, the application of water to crops is an expensive undertaking—it has to be pumped some distance and is subject to rapid evaporation during the dry, hot season of summer. Irrigation in the Southwest also contributes to the depletion of groundwater supplies. The systems that supply such irrigation are expensive to build and maintain. Much of the water delivered to the agricultural sector in the U.S. Southwest is heavily subsidized by the federal government in order to protect agricultural producers from the negative impact that high water prices would have on the number of farms as well as overall productivity. The agricultural sector is often the largest water user among all sectors (including residential, commercial, and government) in the Southwest.

These new attitudes drew from a newly emerging science and its contribution to technological innovation; the consolidation of the population around Judeo-Christian religious beliefs; and, most important, the development of a capitalist political and economic system.

Initially European expansion was internal—largely contained within its continental boundaries. The most obvious reason for this expansion was population increase: from 36 million in 1000 to over 44 million in 1100, nearly 60 million in 1200, and about 80 million by 1300 (**Figure 4.16**). As population continued to increase, more land was brought into cultivation. In addition, more forest land was cleared for agriculture, animals killed for food, and minerals and other resources exploited for a variety of needs. Forests originally covered upward of 90 percent of Western and Central Europe. At the end of the period of internal expansion, however, around 1300, the forested area was only 20 percent.

The bubonic plague, also known as the Black Death, had temporarily slowed population growth by wiping out over a third of Europe's population in the mid-fourteenth century. By then agricultural settlement had been extended to take up all readily available land and then some. In England, Italy, France, and the Netherlands, for example, marshes and fens had been drained and the sea pushed back or the water table lowered to reclaim and create new land for agriculture and settlement.

In the fifteenth century, Europe initiated its second phase of expansion—external—which not only changed the global political map but launched a period of environmental change that continues to this day. European external expansion—colonialism—was the response to several impulses, ranging from self-interest to altruism. Europeans were fast running out of land, and as we saw in Chapter 2, explorers were being dispatched by monarchs to conquer new territories and enlarge their empires while collecting tax revenues from the monarch's new subjects. Many of these adventurous individuals were also searching for fame and fortune or avoiding religious persecution. Behind European external expansion was also the Christian impulse to bring new souls into the kingdom of God. Other forces behind European colonialism included the need to expand the emerging system of trade, which ultimately meant increased wealth and power for a new class of people—the merchants—as well as for the aristocracy.

Over the centuries, Europe came to control increasing areas of the globe. Two cases illustrate how the introduction of European people, ideologies, technologies, plant species, pathogens, and animals changed not only the environments into which they were introduced but also the societies they encountered.

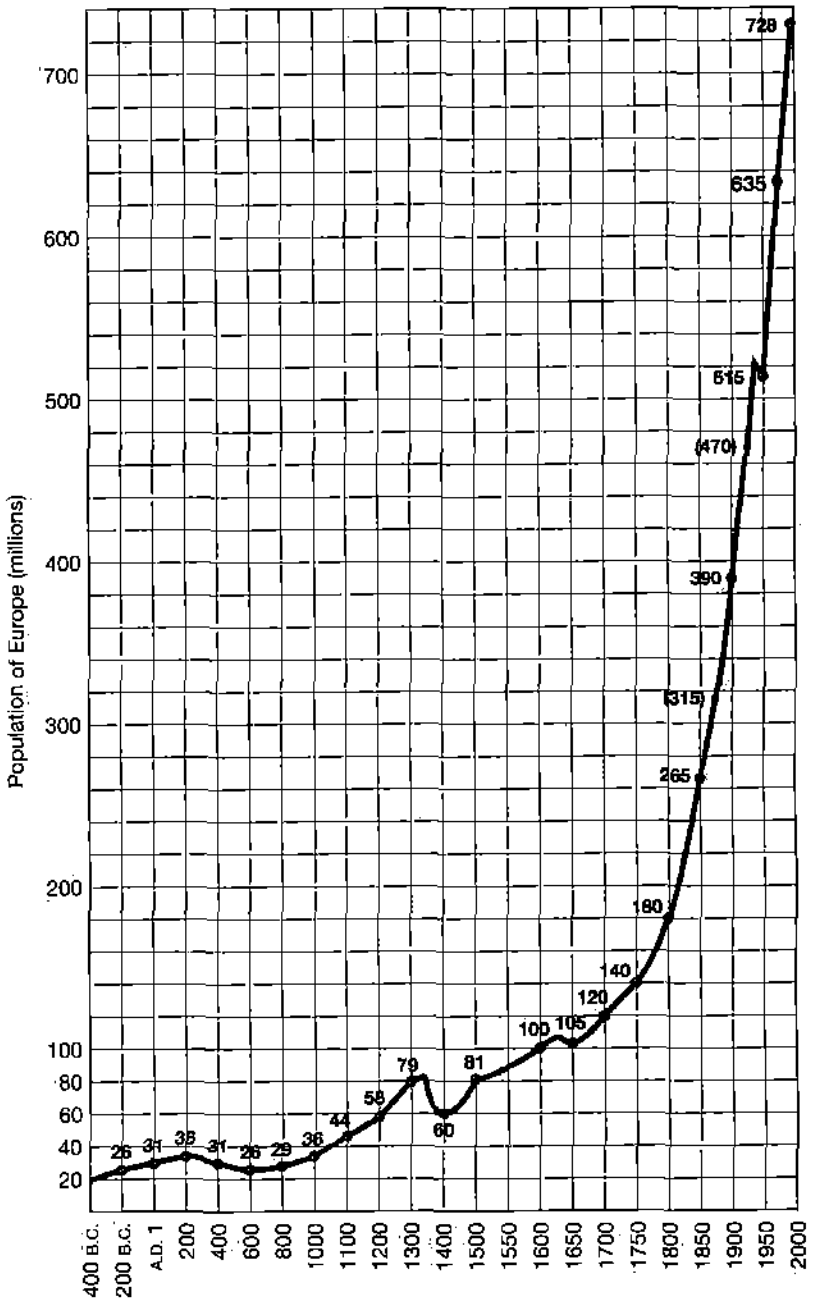


Figure 4.16 Population growth in Europe This graph shows the growth in the European population from 400 B.C. to A.D. 2000. As is apparent from the graph, the growth in European population has been especially dramatic in the last 500 years as a result of capitalist globalization. The increase in human numbers at the beginning of the 1500s was an important push to exploration and colonization beyond the confines of the continent. The dip in the graph from 1300 to 1500 is partially explained by the bubonic plague epidemic called the Black Death, but food shortages also played a significant role in this population decline. Another dip during the middle of the *twentieth century* shows the effects of two world wars. (After C. McEvedy and R. Jones, *Atlas of World Population History*, London: Allen Lane, 1978, Fig. 1.2, p. 18.)

Disease and Depopulation in the Spanish Colonies

Little disagreement exists among historians that the European colonization of the New World was eventually responsible for the greatest loss of human life in history. Moreover, very little disagreement exists that the primary factor responsible for that loss was disease. New World populations, isolated for millennia from the Old World, possessed immune systems that had never encountered some of the most common European diseases. **Virgin soil epidemics**—where the population at risk has no natural immunity or previous exposure to the disease within the lifetime of the oldest member of the group—were common in the so-called Columbian Exchange, though the exchange in this case was mostly one-way. The **Columbian Exchange** was the interaction between the Old World (Europe) and the New World (the Americas) initiated by the voyages of Columbus. For example, diseases such as smallpox, measles, chicken pox, whooping cough, typhus, typhoid fever, bubonic plague, cholera, scarlet fever, malaria, yellow fever, diphtheria, influenza, and others were unknown in the pre-Columbian New World.

Geographer W. George Lovell has examined the role disease played in the depopulation of some of Spain's New World colonies from the point of initial contact until the early seventeenth century, using several cases to illustrate his point.[2] The first case is Hispaniola (present-day

[2]W. G. Lovell, "Heavy Shadows and Black Night": Disease and Depopulation in Colonial Spanish America. *Annals, Association of American Geographers*, 82:426–443, 1992.

Haiti and the Dominican Republic), where Columbus's 1493 voyage probably brought influenza through the introduction of European pigs carrying swine fever. Subsequent voyages brought smallpox and other diseases, which eventually led to the extinction of the island's Arawak population.

In a second example, in Central Mexico, Lovell writes of Hernán Cortés's contact with the Aztec capital of Tenochtitlán in the first decades of the sixteenth century, which led to a devastating outbreak of smallpox among a virgin soil population. A native Aztec text provides a graphic description of the disease:

> While the Spaniards were in Tlaxcala, a great plague broke out here in Tenochtitlán. It began to spread during the thirteenth month [September 30–October 19, 1520] and lasted for seventy days, striking everywhere in the city and killing a vast number of our people. Sores erupted on our faces, our breasts, our bellies; we were covered with agonizing sores from head to foot.
>
> The illness was so dreadful that no one could walk or move. The sick were so utterly helpless that they could only lie on their beds like corpses, unable to move their limbs or even their heads. They could not lie face down or roll from one side to the other. If they did move their bodies, they screamed with pain.
>
> A great many died from this plague, and many others died of hunger. They could not get up and search for food, and everyone else was too sick to care for them, so they starved to death in their beds.[3]

In a third example, Lovell described the Jesuits' missionizing efforts in northern Mexico during a slightly later period. Because these efforts gathered dispersed population groups into single locations, conditions for the outbreak of disease were created. Contact with Spanish conquistadors in advance of the missionaries had already reduced native populations by perhaps 30 to 50 percent. When groups were confined to smaller areas organized around a mission, mortality rates climbed to 90 percent. Eventually the disease was diffused beyond the initial area of contact as traders carried it across long-distance trade routes to the periphery of the Mayan empire in advance of the Spanish armies and missionaries. The Mayans were not defeated by European technological superiority, but by the ravages of a new disease against which they possessed no natural defenses.

Lovell provides similar descriptions of disease impacts in Mayan Guatemala and the Central Andes of South America that led to devastating depopulation. Scholars refer to the phenomenon of near genocide of native populations as **demographic collapse**. The ecological effect of the population decline caused by the high rates of mortality was the transformation of many regions from productive agriculture to abandoned land. Many of the Andean terraces, for example, were abandoned, and dramatic soil erosion ensued. In contrast, large expanses of cleared land eventually returned to forests in areas such as the Yucatán in present-day Mexico.

[3]W. G. Lovell, 1992, p. 429, quoting from M. León-Portilla, *The Broken Spears: The Aztec Account of the Conquest of Mexico*. Boston: Beacon Press, 1962, pp. 92–93.

Old World Plants and Animals in the New World

A second case study of the environmental effects of European colonization involves the introduction of Old World plants and animals in the New World, and vice versa. The introduction of exotic plants and animals into new ecosystems is called **ecological imperialism**, a term now widely used by geographers, ecologists, and other scholars of the environment. The interaction between the Old and the New World resulted in both the intentional and unintentional introduction of new crops and animals on both sides of the Atlantic. Europeans brought from their homelands many plants and animals that were exotics, that is, unknown to American ecosystems. For example, the Spanish introduced wheat and sugarcane, as well as horses, cattle, and pigs.

These introductions altered the environment, particularly as the emphasis on select species led to a reduction in the variety of plants and animals that constituted local ecosystems. Inadvertent introductions of hardy exotic species included rats, weeds such as the dandelion and thistle, and birds such as starlings, which crowded out the less hardy indigenous species. As with the human population, the indigenous populations of plants, birds, and animals had few defenses against European plant and animal diseases and were sometimes seriously reduced or made extinct through contact.

Contact between the Old and the New Worlds was, however, an exchange—a two-way process—and New World crops and animals as well as pathogens were likewise introduced into the Old World, sometimes with devastating implications. Corn, potatoes, tobacco, cocoa, tomatoes, and cotton were all brought back to Europe; so was syphilis, which spread rapidly throughout the European population.

Contacts between Europe and the rest of the world, though frequently violent and exploitative, were not uniformly disastrous. There are certainly examples of beneficial contacts for both sides. The largely beneficial impacts of the Columbian Exchange were mostly knowledge-based or nutritional. Columbus's voyages (**Figure 4.17**) added dramatically to global knowledge, expanding understanding of geography, botany, zoology, and other rapidly growing sciences. It has been argued that the availability of American gold bullion and silver enlarged Europe's capacity for trade and may even have been indirectly responsible for creating the conditions that launched the Industrial Revolution.

The encounter also had significant nutritional impacts for both sides by bringing new plants to each. European

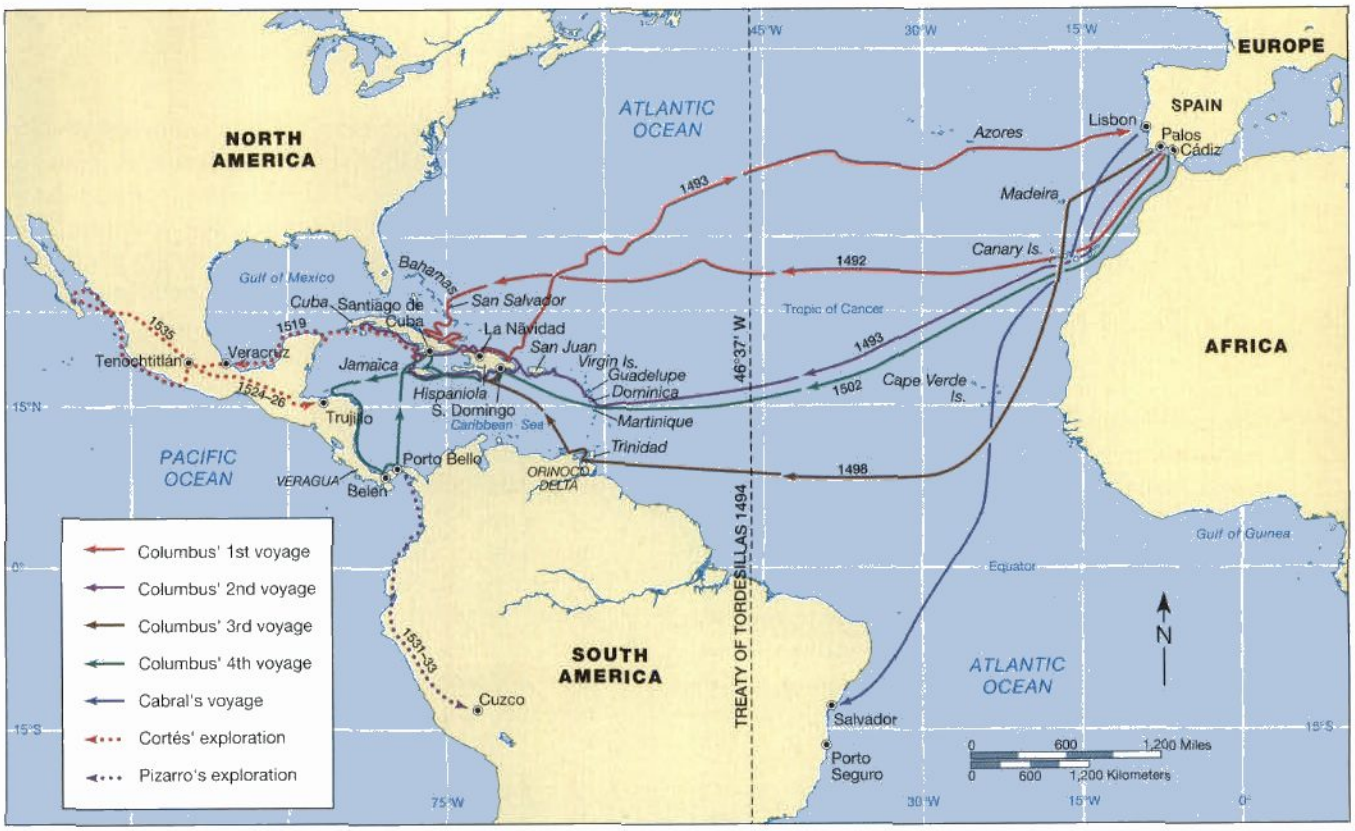


Figure 4.17 European voyages of exploration This maps shows the voyages and missions of Columbus, Pizarro, Cabral, and Cortés. Departing from Portugal and Spain, Columbus encountered several of the islands of the Caribbean, as well as the coastal area of present-day Honduras and Venezuela. (After *The Penguin Atlas of the Diasporas,* by Gerard Chaliand and Jean-Pierre Rageau, translated by A. M. Berrett. Translation copyright © 1995 by Gerard Chaliand and Jean-Pierre Rageau.)

colonization, although responsible for the extermination of hundreds of plant and animal species, was also responsible for increasing the types and amounts of foods available worldwide. It is estimated that the Columbian Exchange may have tripled the number of cultivable food plants in the New World. It certainly enabled new types of food to grow in abundance where they never had grown before, and it introduced animals as an important source of dietary protein. The advantages of having a large variety of food plants are several. For instance, if one crop fails, another more than likely will succeed because not all plants are subject to failure from the same set of environmental conditions.

The introduction of animals provided the New World not only with additional sources of protein but also with additional animal power. Before the Columbian Exchange, the only important sources of animal energy were the llama and the dog. The introduction of the horse, the ox, and the ass created a virtual power revolution in the New World. These animals also provided fibers and, after death or slaughter, hides and bones to make various tools, utensils, and coverings. Most significant in its environmental impact, however, was the ox.

Land that had escaped cultivation because the indigenous digging sticks and tools were unable to penetrate the heavy soil and matted root surface became available to an ox-drawn plow. The result was that the indigenous form of intensive agricultural production (small area, many laborers) was replaced by extensive production (large area, fewer laborers). This transformation, however, was not entirely without negative impacts, such as soil destabilization and erosion.

It is also important to explore the impact of native New World peoples on their environment. The popular image of indigenous peoples living in harmony with nature, having only a minimal impact on their environment, is flawed. In reality, different groups had very different impacts, and it is erroneous to conflate the thousands of groups into one romanticized caricature.

In New England, for example, prior to European contact, groups existed who hunted for wild game and gathered wild foods. More sedentary types also existed, living in permanent and semipermanent villages, clearing and planting small areas of land. Hunter-gatherers were mobile, moving with the seasons to obtain fish, migrating birds, deer, wild berries, and plants. Agriculturalists planted corn, squash, beans, and tobacco and used a wide range of other natural resources. The economy was a fairly simple one based on personal use or on barter (trading corn for fish, for example). The idea of a surplus was foreign here: People cultivated or exploited only as much land and resources as they needed to survive. Land and

Uranium Mining and the Impacts on Oceania

Oceania is a region encompassing Australia, New Zealand, and more than 20,000 other islands—including 11 independent nation islands or island clusters—located in the southern Pacific Ocean. Like oil in the Middle East, the extraction and use of uranium links Oceania to the global hunger for cheap energy and to geopolitical conflicts beyond the region (**Figure 4.C**). Uranium is a radioactive element that can be split in a process of nuclear fission to produce a chain reaction that releases large amounts of energy. Controlled reactions can be used to generate electricity in nuclear power plants, whereas uncontrolled reactions can be used in atomic bombs that release enormous amounts of thermal energy and radioactivity. Uranium first became a desirable commodity after the bombs dropped on Japan at Nagasaki and Hiroshima during World War II demonstrated the power of the atomic weapons, and its desirability increased after the potential of nuclear-powered electrical generation became apparent.

This interest in uranium had important impacts on the South Pacific. The United States, Britain, and France all joined the Cold War arms race and the effort to develop even more powerful weapons based on uranium and related elements, such as plutonium. They chose to test many of the weapons in the Pacific, with devastating implications for local residents and environments. The United States tested its bombs in the Marshall Islands after first relocating the residents of Bikini and Enewetak atolls to other islands, and exploded several types of nuclear weapons between 1946 and 1958. Although the prevailing winds were supposed to carry the radioactive fallout from bomb testing away from inhabited islands, in 1954 radioactive ash dusted the island of Rongelap and its almost 100 residents, including several relocated from Bikini. Radioactive exposure can have serious short- and long-term effects, including acute poisoning, leukemia, and birth defects, so the U.S. government

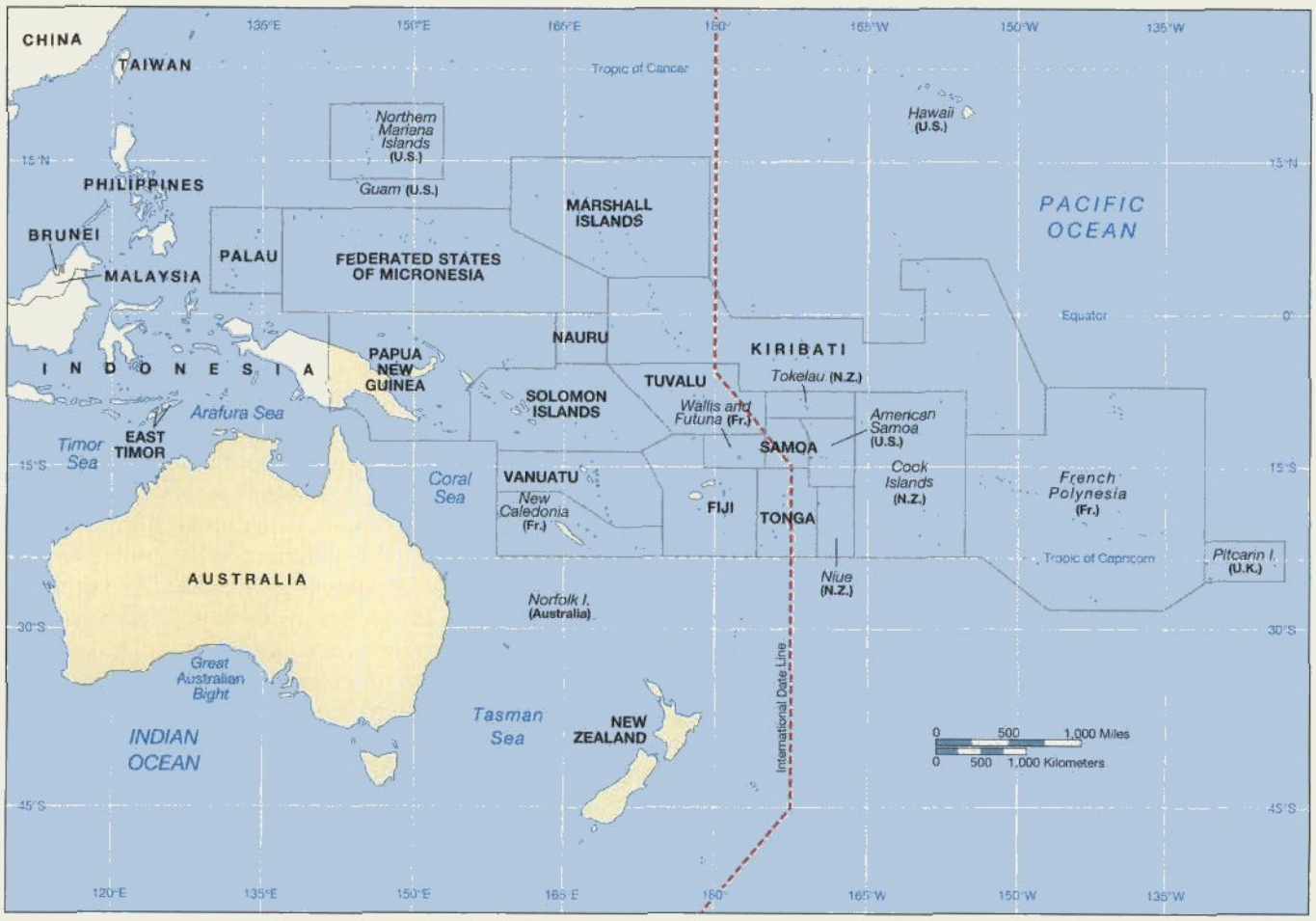


Figure 4.C **Oceania** This region of the world is made up of more than 20,000 islands and a continent located in the Pacific Ocean. The majority of the islands are located in the southeastern Pacific, including the large countries of Papua New Guinea and New Zealand, as well as the continent of Australia.

evacuated the residents of Rongelap on short notice with little information about the hazard they had been exposed to or warning that they would not be able to return to their homelands. In 1968 the residents of Rongelap and Bikini were told it was safe to return, but those on Bikini later had to be re-evacuated when scientists discovered that dangerous levels of radioactivity persisted in food gathered on the islands. Although the United States has monitored the health of the islanders and established a $90 million trust fund, many residents of the islands remain angry about the experiments that disrupted their lives.

France conducted more than 150 bomb tests on the tiny atolls of Moruroa and Fangataufa in French Polynesia beginning in 1966. The first bombs showered the surrounding regions with radioactivity, reaching as far as Samoa and Tonga hundreds of miles to the west. Opposition from other Pacific islands, including New Zealand and Australia, culminated in boycotts of French products, including wine and cheese, during the 1970s. France moved to underground testing and refused to release information about accidents and monitoring of radioactive pollution or health in French Polynesia. While locals have used the bomb tests as a reason to seek independence from France, international activists have tried to stop the tests. In 1985 the environmental group Greenpeace planned to protest tests by sailing its ship *Rainbow Warrior* to Moruroa, but French intelligence agents scuttled the ship while it was moored in the harbor of Auckland, New Zealand.

The resulting international scandal prompted New Zealand to take a strong stand against nuclear proliferation, banning all nuclear-powered and nuclear-armed vessels from its harbors, breaking off diplomatic relations with France, and taking a leadership role in the antinuclear movement in the Pacific. This created a long-term strain on relations between New Zealand and the United States because U.S. military vessels, which will not admit or deny nuclear capability, were therefore banned from New Zealand. However, New Zealand's actions contributed to the announcement by France in 1996 that it would end nuclear testing after riots in Tahiti and declines in tourism.

The British tested their bombs on Christmas Atoll, now within the nation of Kiribati, and also at several locations in Australia, including the Monte Bello islands off the coast of Western Australia and Maralinga in Southern Australia. Critics now claim that neither the Australian government nor its people were made fully aware of the risks of these tests and that the local Aborigines were heavily exposed to radiation and continue to wander into the contaminated test sites.

The consumption of uranium has also threatened Australian Aborigines through the mining of uranium on or near their lands in northern Australia. The Ranger mine commenced operations in the Northern Territory in 1980 within the boundary of Kakadu National Park, a region of great natural beauty listed as a World Heritage site for both natural and cultural values (**Figure 4.D**). The mine has produced more than 16 million tons (35 billion pounds) of radioactive mine waste and has created serious water-pollution problems in the area. Australia produces 27 percent of the world's uranium, exported to fuel nuclear power stations in the United States, Japan, Europe, Canada, and South Korea, even though Australia itself does not produce electricity from uranium. Great controversy has arisen over proposals to open another mine at Jabiluka on land belonging to the Mirrar Aboriginal Group. Activists have blockaded the mine road, and protests have occurred around Australia.

Thus, uranium links the countries of the Oceania to the global geography of energy consumption and to the desire for geopolitical supremacy in a multitude of ways. Though nuclear testing has been halted in the Pacific, radioactivity persists for thousands of years and will continue to pose risks to people and ecosystems. However, since uranium prices are currently low because few new nuclear power stations are under construction in the aftermath of the Chernobyl accident in Russia in 1986, many countries are seeking to purchase uranium as other supplies become scarce or create different sorts of environmental problems.

Figure 4.D The Ranger uranium mine This mine is located in Kakadu National Park in Australia's Northern Territory. The area is sacred to the Aborigine population and has striking landscapes and ecosystems. Moves to expand the mine have resulted in protests by Aboriginal groups and environmental activists.

resources were shared, without concepts such as private property or land ownership. Fire was used to clear land for planting as well as for hunting. Although vegetation change did occur, it was minimal and not irreversible.

The relationship between some of the the Indians of South and Central America altered their environment as well, though in more dramatic ways. The Aztecs of Mexico and the Incas of Peru had developed complex urban civilizations dependent on dense populations employing intensive agricultural techniques (**Figure 4.18**). These groups were responsible for dramatic environmental modifications through cultivation techniques that included the irrigation of dry regions and the terracing of steep slopes. As we have seen, irrigation over several centuries results in the salinization of soils. In the lowland tropics, intensive agricultural practices resulted in widespread deforestation as people cut and set fire to patches of forest, planted crops, and then moved on when soil fertility declined. A surplus was key to the operations of both societies, as tribute by ordinary people to the political and religious elite was required in the form of food, animals, labor, or precious metals. The construction of the sizable Inca and Aztec empires required the production of large amounts of building materials in the form of wood and mortar. Concentrated populations and the demands of urbanization meant that widespread environmental degradation existed prior to European contact.

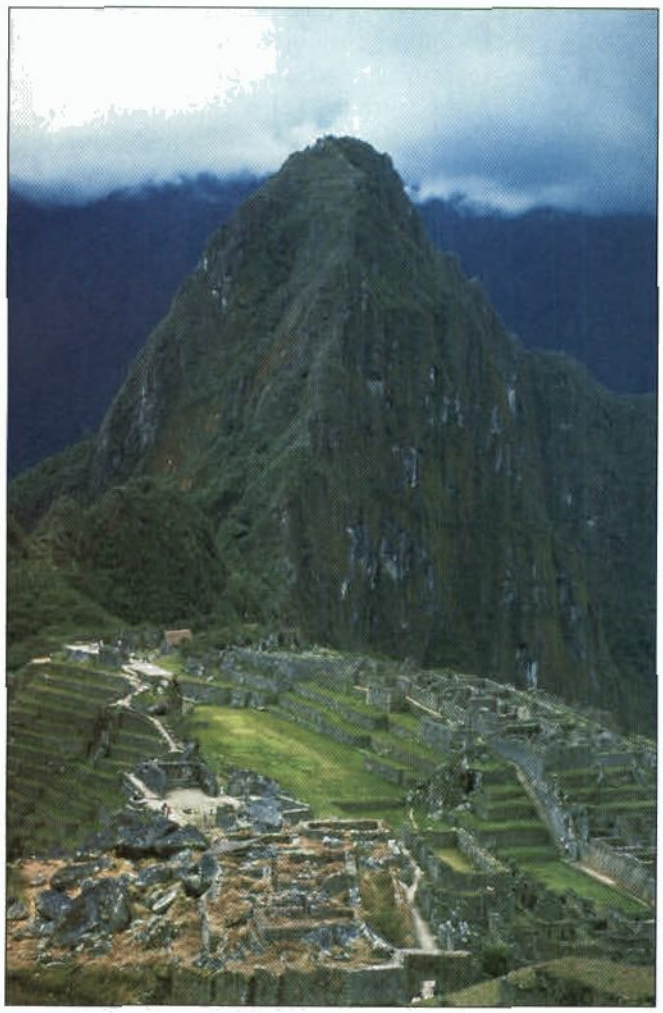


Figure 4.18 Machu Picchu Pictured is one of the most important sites of ancient Incan civilization, located in highland Peru on the so-called *ceja de selva,* or "eyebrow of the jungle." Machu Picchu was probably an important ceremonial center but was also a large-scale residential center, as evidenced by the extensive agricultural terraces. Archaeologists, geographers, and other scholars believe Machu Picchu was probably one of the last sites of fierce Incan resistance to the Spanish conquistadors. As the photograph suggests, natural terrain helped in the fortification of the city. Machu Picchu is one of the best-preserved ruins of the Incan empire.

HUMAN ACTION AND RECENT ENVIRONMENTAL CHANGE

No other transition in human history has had the impact on the natural world that industrialization has. When we couple industrialization with its frequent companion, urbanization, we have the two processes that, more than any others, have revolutionized human life and affected far-reaching ecological changes. The changes wrought by industrialization and urbanization have moved beyond a local or a regional scale to affect the entire globe. In this section we explore some of the dramatic contemporary environmental impacts that industrial technology and urbanization have produced. In doing so, we highlight the two issues most central to environmental geography today: energy-use and land-use change.

The Impact of Energy Needs on the Environment

Certainly the most central and significant technological breakthrough of the Industrial Revolution was the discovery and utilization of fossil fuels: coal, oil, and natural gas. Although the very first factories in Europe and the United States relied on waterpower to drive the machinery, hydrocarbon fuels provided a more constant, dependable, and effective source of power. A steady increase in power production and demand since the beginning of the Industrial Revolution has been paralleled, not surprisingly, by an increase in resource extraction and conversion.

At present, the world's population relies most heavily for its energy needs on nonrenewable energy resources that include fossil fuels and nuclear ones, as well as renewable resources such as solar, hydroelectric, wind, and geothermal power. Fossil fuels are derived from organic materials and are burned directly to produce heat. Nuclear energy originates with isotopes, which emit radiation. Most commercial nuclear energy is produced in reactors fueled by uranium (see Box 4.2: "Uranium Mining and the Impacts on Oceania"). Renewable sources of energy, such as the sun, wind, water, and steam, are captured in various ways and used to drive pumps, machines, and electricity generators.

The largest proportion of the world's current consumption of energy resources, 35 percent, is from oil; 24 percent is from coal; 18 percent from gas; 6 percent from hydropower (largely from dams); 5 percent from nuclear power; and 12 percent from biomass (which includes wood, charcoal, crop waste, and dung). The production and consumption of these available resources, however, are geographically uneven, as **Figure 4.19** shows. Fifty percent of the world's oil supplies are from the Middle East, and most of the coal is from the Northern Hemisphere, mainly from the United States, China, and Russia. Nuclear reactors are a phenomenon of the core regions of the world. For example, France generates 90 percent of its electricity from nuclear sources.

The consumption side of energy also varies geographically. It has been estimated that current annual world energy consumption is equal to what it took about one million years to produce naturally. In one year, global energy consumption is equal to about 1.3 billion tons of coal. What is most remarkable is that this is four times what the global population consumed in 1950 and 20 times what it consumed in 1850. And as the $I = PAT$ formula suggests, the affluent core regions of the world far outstrip the peripheral regions in energy consumption. With nearly four times the population of the core regions, the peripheral regions account for less than one-third of global energy expenditures. Yet consumption of energy in the peripheral regions is rising *quite rapidly* as globalization spreads industries, energy-intensive consumer products such as automobiles, and energy-intensive agricultural practices into regions of the world where they were previously unknown. It is projected that within the next decade or so, the peripheral regions will become the dominant consumers of energy (**Figure 4.20**).

Most important for our discussion, however, is that every stage of the energy conversion process—from discovery to extraction, processing, and utilization—has an impact on the physical landscape. In the coal fields of the world, from the U.S. Appalachian Mountains to western Siberia, mining results in a loss of vegetation and topsoil, in erosion and water pollution, and in acid and toxic drainage. It also contributes to cancer and lung disease in coal miners. The burning of coal is associated with relatively high emissions of environmentally harmful gases, such as carbon dioxide and sulfur dioxide (**Figure 4.21**).

The burning of home heating oil, along with the use of petroleum products for fuel in internal combustion engines, launches harmful chemicals into Earth's atmosphere—causing air pollution and related health problems. The production and transport of oil have resulted in oil spills and substantial pollution to water and ecosystems. Media images of damage to seabirds and mammals after tankers have run aground and spilled oil have shown how immediate the environmental damage can be. Indeed, the oceans are acutely affected by the widespread use of oil for energy purposes. Thousands of tons of oil are spilled into the world's oceans each year from leaking ships, oil drilling, transporting oil, and from natural seeps. Oil drilling can also have other profound environmental consequences in the form of well explosions and fires (**Figure 4.22**).

Natural gas is one of the least noxious of the hydrocarbon-based energy resources because it is converted relatively cleanly. Now supplying nearly one-quarter of global commercial energy, natural gas is predicted to be the fastest-growing energy source in the new century. Reserves are still being discovered, with Russia holding the largest amount—about one-third of the world's total (**Figure 4.23**). While regarded as a preferred alternative to oil and coal, natural gas is not produced or consumed without environmental impacts. The risk of explosions at natural-gas conversion facilities is significant; leakages and losses of gas from distribution systems contribute to the deterioration of Earth's atmosphere.

At the midpoint of the twentieth century, nuclear energy for civilian use was widely promoted as a clearly preferable alternative to fossil fuels. It was seen by many as the answer to the expanding energy needs of core countries, especially as the supply of uranium worldwide was thought to be more than adequate for centuries of use. Nuclear energy was also regarded as cleaner and more efficient than fossil fuels. Although nuclear war was a pervasive threat, and there were certainly critics of nuclear energy even in the early years of its development, the civilian "atomic age" was widely seen as a triumphant technological solution to the energy needs of an expanding global economic system. It was not until serious accidents at nuclear power plants began to occur—such as at Windscale in Britain and Three Mile Island in the United States—that the voices of concerned scientists and citizens began to be heard. These voices described, with incontestable evidence, the problems associated with nuclear energy production, such as ensuring nuclear reactor safety and safely disposing of nuclear waste (which remains radioactive for tens of thousands of years). Since these accidents and the meltdown of the Chernobyl nuclear power plant in Russia in 1986, many core countries have drastically reduced or eliminated their reliance on nuclear energy. Sweden, for example, has committed to eliminate entirely its reliance on nuclear power—*from which a large portion* of its current electricity use is derived—by the year 2010.

Interestingly, while the majority of core countries have begun to move away from nuclear energy because of the possibility of environmental disaster in the absence of fail-safe nuclear reactors, a few semiperipheral—and especially populous—countries are moving in the opposite direction (**Figure 4.24**). India, South Korea, and China have fledgling nuclear energy programs. So far, no accidents have been associated with nuclear energy production in the periphery. And, because of the rising price of oil, many core countries, such as the United States, who had once abandoned nuclear energy as an acceptable alternative, are now reconsidering it.

While nuclear power problems are largely confined to the core, the periphery is not without its energy-related environmental problems. Because a large proportion of populations in the periphery rely on wood for their

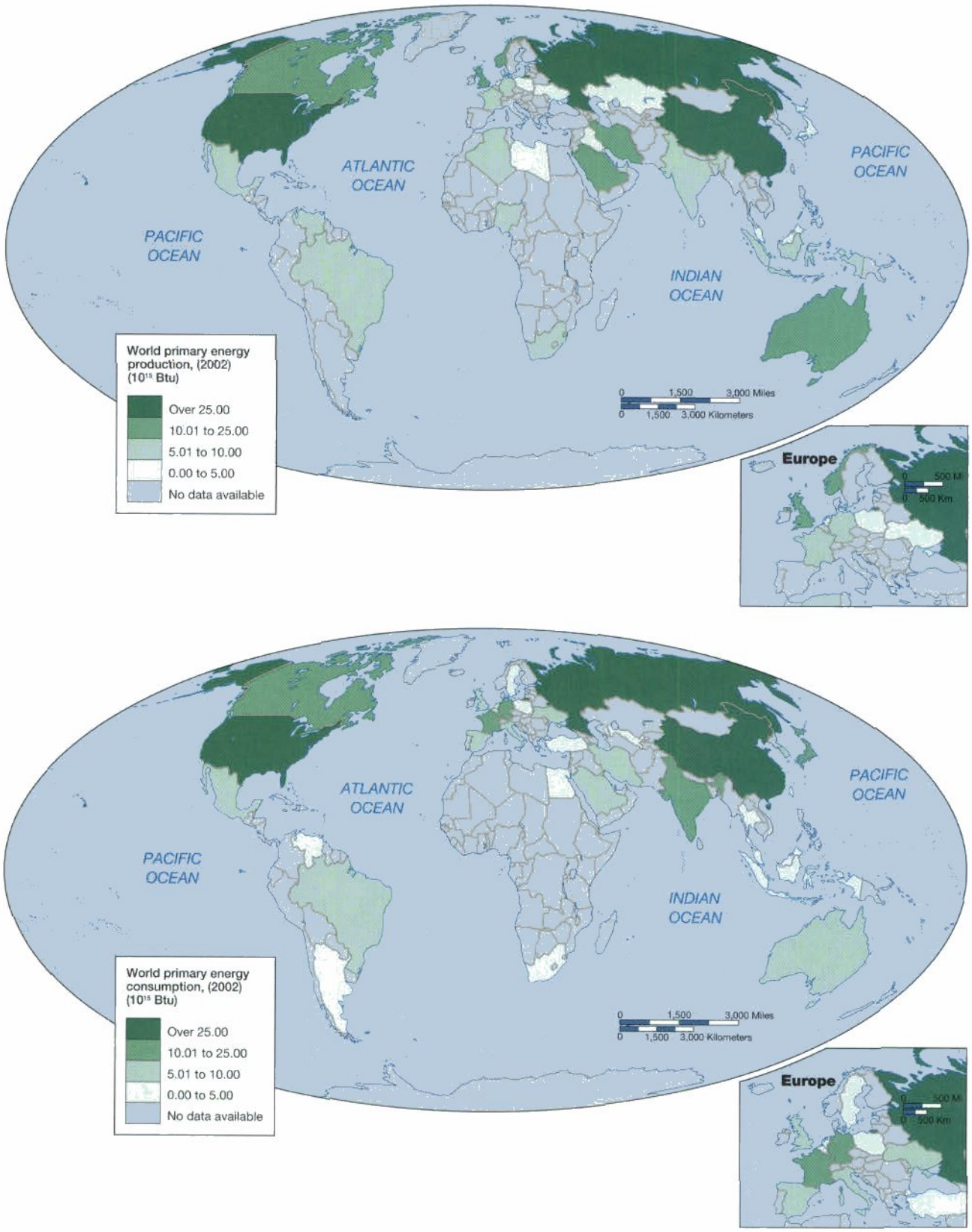


Figure 4.19 World production and consumption of energy, 1993–2002 These paired maps provide a picture of the uneven distribution of the production and consumption of energy resources around the world. The United States is the largest producer and consumer of a range of energy resources. Notice that although the Middle East and North African countries as well as Nigeria are important producers of energy resources, their consumption (as well as that of the rest of the African continent, excluding South Africa) is very low. Japan produces a negligible amount of the total of world energy resources but consumes a relatively high share. (Top map after *International Energy Annual*, 1999, Web site: http://www.eia.doe.gov/iea. Data tables "World Primary Energy Production (Btu)" and "World Primary Energy Consumption (Btu)." Bottom map reprinted with permission of Prentice Hall, from E. F. Bergman, *Human Geography: Cultures, Connections, and Landscapes* © 1995, p. 395. Data from the World Resources Institute, World Resources 1994–95. New York: Oxford University Press, 1994, pp. 334–335.)

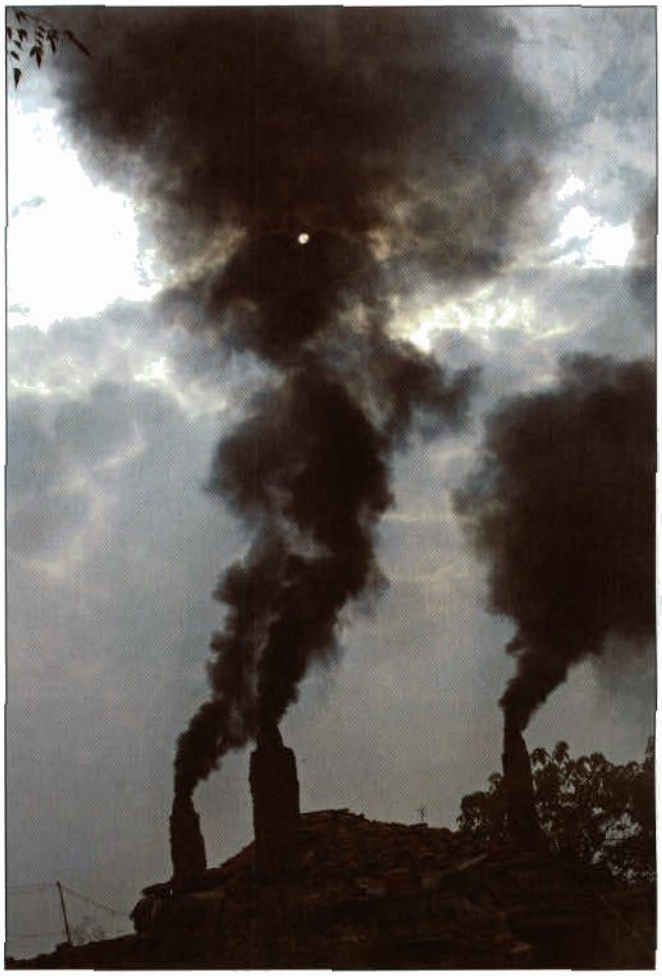


Figure 4.20 Pottery furnace, China Black smoke billows from the chimneys of an unlicensed pottery furnace on the outskirts of Wuhan in China's central province of Hubei. The workers use material like old tires and asphalt as fuel, which produces excessive pollutants. Chinese authorities are fighting an uphill battle to eliminate unlicensed factories throughout China which continue to contaminate the environment.

Figure 4.21 Coal mining This coal-mining operation in western Germany is typical of the surface-mining technologies used to exploit shallow deposits in most parts of the world. After deposits are located, the vegetation and overburden (rocks and dirt overlaying the coal seam) are removed by bulldozers and discarded as spoil (or waste material). With the coal seam exposed, heavy equipment (such as the type pictured) is used to mine the deposit. Some countries, such as the United States, require restoration of newly mined landscapes. Sites exploited before these laws were introduced remain unrestored, however. Successful restoration makes it difficult to tell that the area was once a mining site. Unfortunately, many such sites are in arid or semiarid areas where soil and climate prevent full restoration. In addition to substantial land disturbance, the mining and processing of coal resources often cause soil erosion as well as water and air pollution.

Figure 4.22 A tanker oil spill Although the international press is quick to report the disastrous oil spills into the world's oceans, most of the petroleum released into the environment every year comes from nonaccidental sources. The largest contributor to oil pollution of the oceans comes from the extraction process. A very small amount of oil released in oceans is due to major tanker accidents. Tanker spills, like the one shown here, are dramatic because huge amounts of oil end up affecting fairly small areas.

energy needs, as the populations have grown, so has the demand for fuelwood. One of the most immediate environmental impacts of wood burning is air pollution, but the most alarming environmental problem is the rapid depletion of forest resources. With the other conventional sources of energy (coal, oil, and gas) being too costly or unavailable to most peripheral households, wood or other forms of biomass—any form of material that can be used as fuel such as animal wastes, livestock operation residues, and aquatic plants—is the only alternative. The demand for fuelwood has been so great in many peripheral regions that forest reserves are being rapidly used up (**Figure 4.25**).

Figure 4.23 Natural gas processing in Russia Pictured here is a natural gas processing facility in Siberia, where the largest natural gas deposits in the world are located.

Fuelwood depletion is extreme in the highland areas of Nepal, as well as in Andean Bolivia and Peru. The clearing of forests for fuelwood in these regions has led to serious steep-slope soil erosion. In sub-Saharan Africa, where 90 percent of the region's energy needs are met with energy supplied by wood, overcutting of the forests has resulted in denuded areas, especially around rapidly growing cities. And although wood gathering is usually associated with rural life, it is not uncommon for city dwellers to use wood to satisfy their household energy needs as well. For example, in Niamey, the capital of Niger, the zone of overcutting is gradually expanding as the city itself expands. It is now estimated that city dwellers in Niamey must travel from 50 to 100 kilometers (31 to 62 miles) to gather wood. The same goes for inhabitants of Ouagadougou in Burkina Faso, where the average haul for wood is also over 50 kilometers.

Hydroelectric power was also once seen as a preferred alternative to the more obviously environmentally polluting fossil-fuel sources. The wave of dam building that occurred throughout the world over the course of the twentieth century improved the overall availability, quality, cost, and dependability of energy (**Figure 4.26**). Unfortunately, however, dams built to provide hydroelectric power (as well as water for irrigation, navigation, and drinking) for the burgeoning cities of the core and to encourage economic development in the periphery and semiperiphery have also had profound negative environmental impacts. Among the most significant of these impacts are changes in downstream flow, evaporation, sediment

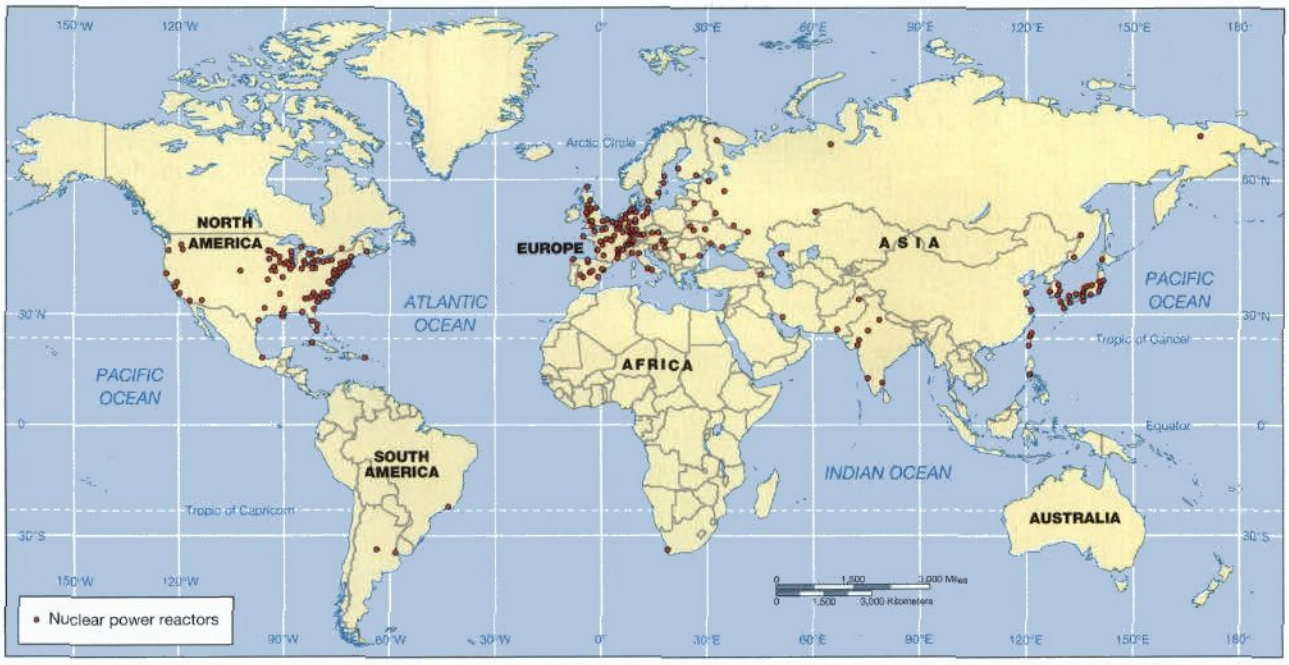


Figure 4.24 World distribution of nuclear reactors, 2000 Most of the dependence on nuclear power is concentrated in core countries. South America and Africa together contain only four nuclear reactors. Whereas some peripheral countries, such as India, are enthusiastic about increasing their nuclear energy production, core countries such as Sweden are phasing out dependence on nuclear power. Australia, where there is a very strong antinuclear movement, is one of the few core countries to have rejected nuclear power altogether. (After International Nuclear Safety Center Web site, http://www.insc.anl.gov/pwrmaps/map/world_map.html, "Maps of Nuclear Power Reactors: World Map" 2002, p.1, retrieved June 15, 2005).

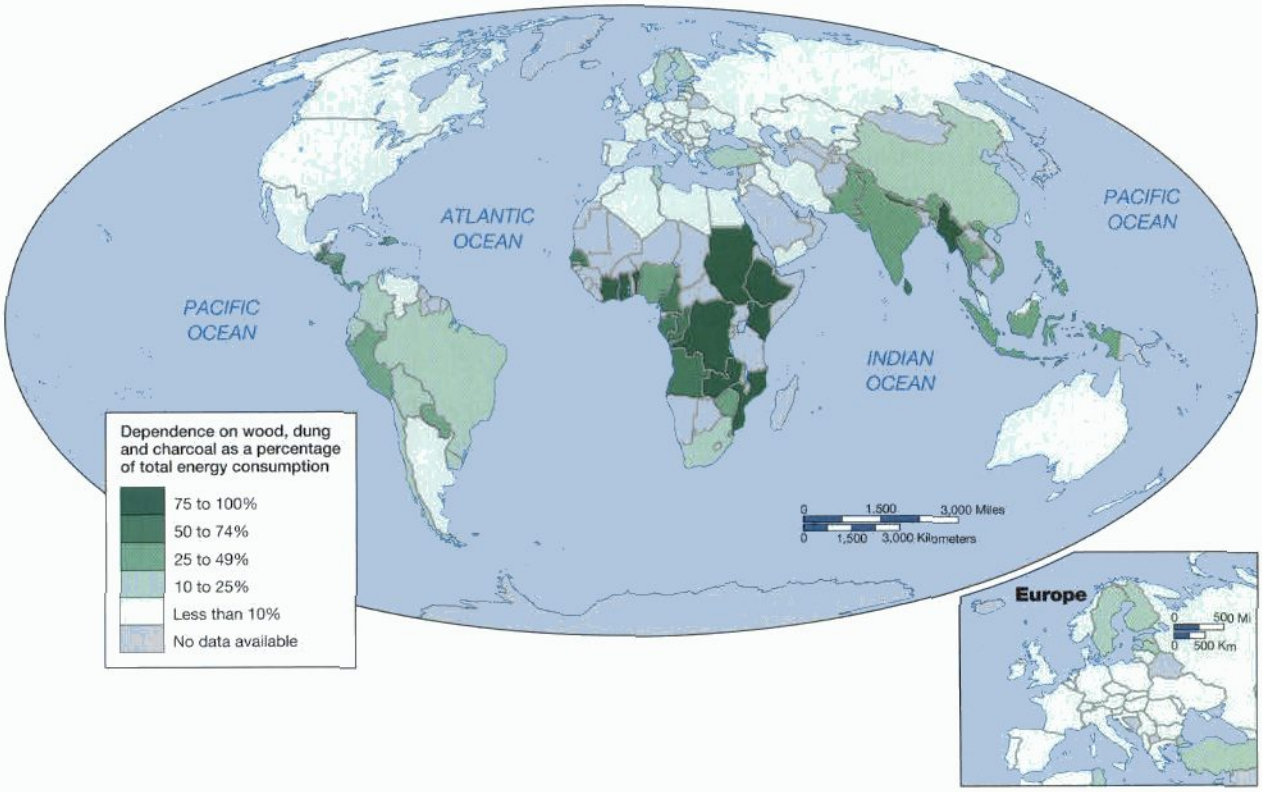


Figure 4.25 Global use of woodfuels, 2001 Firewood, charcoal, and dung are considered traditional fuels, and although their availability is decreasing, dependence upon them is increasing. Dependence on traditional sources of fuel is especially high in the periphery where, in Africa, for example, they are the most important energy source for cooking and heating. Wood and charcoal, although renewable sources, are replenished very slowly. Acute scarcity will be a certainty for most African households in the twenty-first century. (After United Nations Development Programme, 2001. *World Resources 2000–2001, People and Ecosystems: The Fraying Web of Life,* Washington, DC: World Resources Institute, p. 98.)

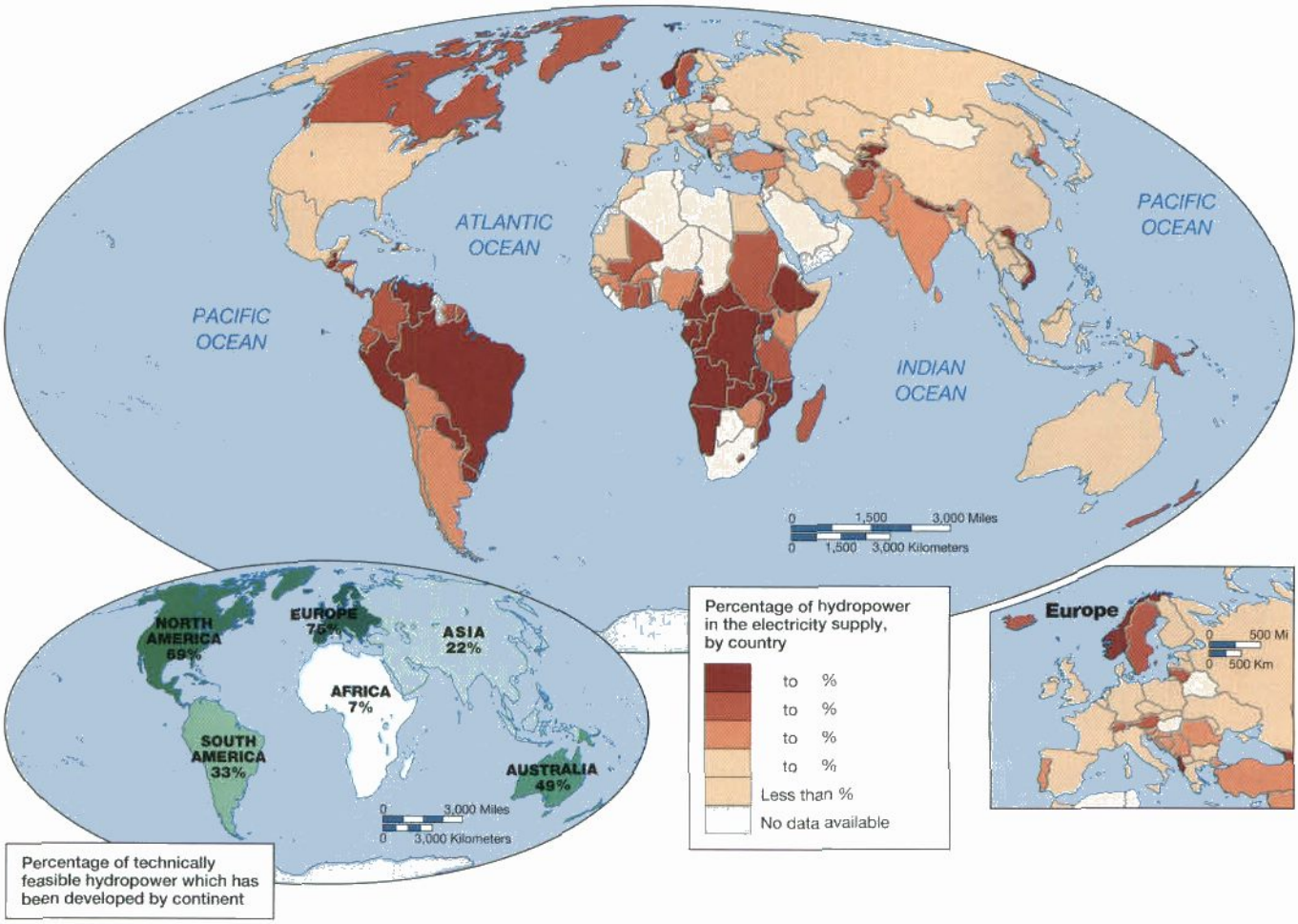


Figure 4.26 Percent of hydropower in the electricity supply by country, 2002 Although the great dam-building era for core countries is now largely completed, many peripheral countries, in a bid to participate more actively in the world economy, are building dams. Only a few countries are almost exclusively dependent on the hydropower produced from dams. These include Norway, Nepal, Zambia, Ghana, Paraguay, and Costa Rica. While the power produced by dams is environmentally benign, the construction of large dams can be extremely destructive of the environment and can dislocate large numbers of people. Still, given the increasing need for electricity by rapidly eveloping peripheral countries, hydropower is becoming a more attractive energy option for many of these countries because of the uncertain supply of oil in the future. The larger map shows the amount of hydropower that is currently available; the smaller one shows the potential for hydropower development, especially for peripheral regions.

transport and deposition, mineral quality and soil moisture, channeling and bank scouring, and aquatic biota and flora, as well as conditions threatening to human health. Furthermore, the construction of dams dramatically alters the surrounding terrain, often with serious consequences. For example, clearance of the forest for dam construction often leads to large-scale flooding. The felled trees are usually left to decay in the impounded waters, which become increasingly acidic. The impounded waters can also incubate mosquitoes, which carry diseases such as malaria. The remedies for such problems are difficult to determine, and many argue that new dam projects should not be undertaken without a clear sense of the complex of indirect social and environmental costs (**Figure 4.27**).

One reason hydroelectric power continues to be appealing, however, is that it produces few atmospheric pollutants as compared to fossil fuels. Indeed, coal and gas power stations as well as factories, automobiles, and other forms of transportation are largely responsible for the increasingly acidic quality of Earth's atmosphere. While people as well as other organisms naturally produce many gases, including oxygen and carbon dioxide, increasing levels of industrialization and motor vehicle use have destabilized the natural balance of such gases, leading to serious atmospheric pollution (see Box 4.3: "Global Climate Change and the Kyoto Protocol"). Increasing the level of acids in the atmosphere are sulfur dioxide, nitrogen oxides, and hydrocarbons, among other gases, which are released into the atmosphere from motor vehicle exhaust, industrial processes, and power generation (based on fossil fuels). If these gases reach sufficient concentrations and are not effectively dispersed in the atmosphere, acid rain can result.

Acid rain is the wet deposition of acids upon Earth through the natural cleansing properties of the atmosphere. Acid rain occurs as the water droplets in clouds absorb cer-

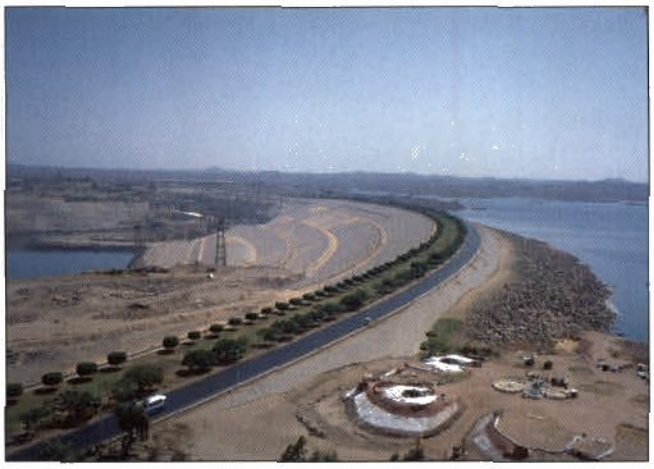


Figure 4.27 Aswan High Dam, Egypt Completed in 1970 at a cost of $1 million, the Aswan High Dam was a significant engineering feat, as well as an important symbol of Egypt's bid for economic independence. The dam is of rock-filled construction and is 111 meters (364 feet) high. The impoundment of water caused by the dam flooded out numerous settlements along the Nile River, requiring the resettlement of tens of thousands of people in both Egypt and Sudan. In addition to its human impacts, the dam affected the natural fertilizing processes of the Nile and flooded out the site of one important ancient temple while restoring another to the open air.

tain gases that later fall back to Earth as acid precipitation. Also included under the term *acid rain* are acid mists, acid fogs, and smog. The effects of acid rain are widespread. Throughout much of the Northern Hemisphere, for example, forests are being poisoned and killed, and soils are becoming too acidic to support plant life. Lakes are becoming acidic in North America and Scandinavia. In urban areas, acid rain is corroding marble and limestone buildings, such as the Parthenon in Athens and St. Paul's Cathedral in London, as well as other historic structures in Europe. **Figure 4.28** illustrates the global problem of acid emissions that come back to Earth as acid rain.

Before giving up all hope that the use of energy can ever be anything but detrimental to the environment, it is important to realize that alternatives exist to fossil fuels, hydroelectric power, and nuclear energy. Energy derived from the sun, the wind, Earth's interior (geothermal sources), and the tides has been found to be clean, profitable, and dependable. Japan, the United States, and Germany all have solar energy production facilities that have proved to be cheap and nonpolluting. Although contributing only small amounts to the overall energy supply, the production of energy from geothermal and wind sources has also been successful in a few locations around the globe. Italy, Germany, the United States, Mexico, and the Philippines all derive some of their energy production from geothermal or wind sources.

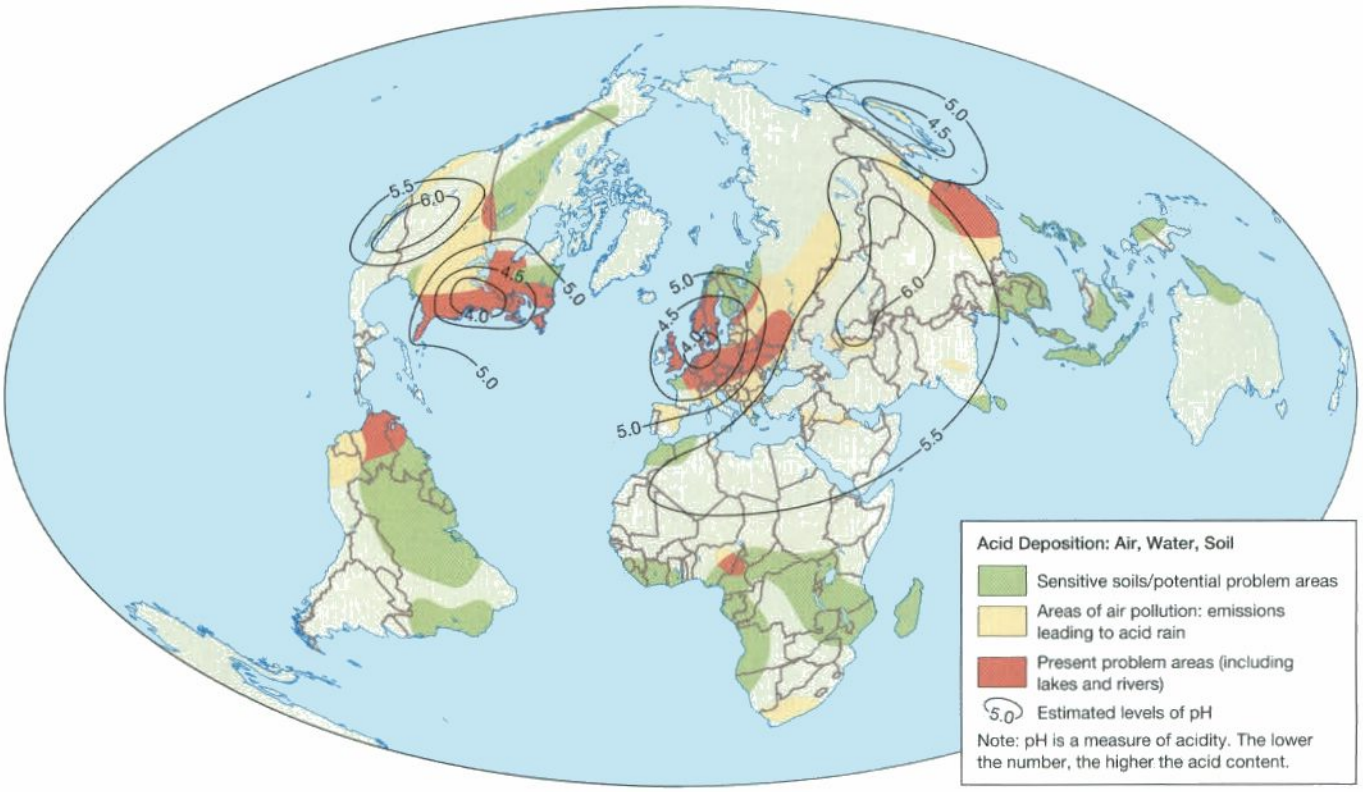
Nonrenewable alternative sources of energy, such as fuel cells and cogeneration, are also beginning to appear and become more widely adopted. A fuel cell converts chemical energy directly into electricity by combining hydrogen and oxygen in a controlled reaction. Fuel cells emit no pollution, as the waste exhaust is water vapor and heat. One of the most promising uses of fuel cells is for road transportation. Cogeneration, also known as Combined Heat and Power or CHP, is the production of energy and heat in one single process for dual output streams. In conventional electricity generation, only about 35 percent of the fuel is actually converted to electricity, while the rest is lost as waste heat. Since cogeneration produces both heat and electricity, it is able to achieve efficiency of upwards of 90 percent. It is the most efficient way to use fuel.

Monies to support the development of geothermal, wind, and tidal energy, as well as fuel cells and cogeneration, have been scarce, however, due to the opposition of oil and gas companies, as well as other political factors, such as powerful oil and gas lobbies. While viable alternatives exist to traditional energy sources, the further development of these alternatives is likely to hinge on future political and economic factors.

Impacts of Land-Use Change on the Environment

In addition to industrial pollution and steadily increasing demands for energy, the environment is also being dramatically affected by pressures on the land. The clearing of land for fuel, farming, grazing, resource extraction, highway building, energy generation, and war all have significant impacts. Land may be classified into five categories: forest, cultivated land, grassland, wetland, and areas of settlement. Geographers understand land-use change as occurring in either of two ways: conversion or modification. *Conversion* is the wholesale transformation of land from one use to another (for example, the conversion of forest to settlement). *Modification* is an alteration of existing cover (for example, when a grassland is overlaid with railroad line or when a forest is thinned and not clear-cut). As human populations have increased and the need for land for settlement and cultivation has also increased, changes to the land have followed.

One of the most dramatic impacts of humans upon the environment is loss or alteration of forest cover as it has been cleared for millennia to make way for cultivation and settlement. Forests are cleared not only to obtain land to accommodate increases in human numbers but also to extract the vast timber resources they contain. The approximate chronology and estimated extent of the clearing of the world's forests since preagricultural times are shown in **Table 4.2**. The table shows that the forested area of the world has been reduced by about 8 million square kilometers (about 3 million square miles) since preagricultural times. Rapid clearance of the world's forests has occurred either through logging, settlement, and agricultural clearing or through fuelwood cutting around urban areas. **Figure 4.29** shows the global extent of deforestation in recent years.



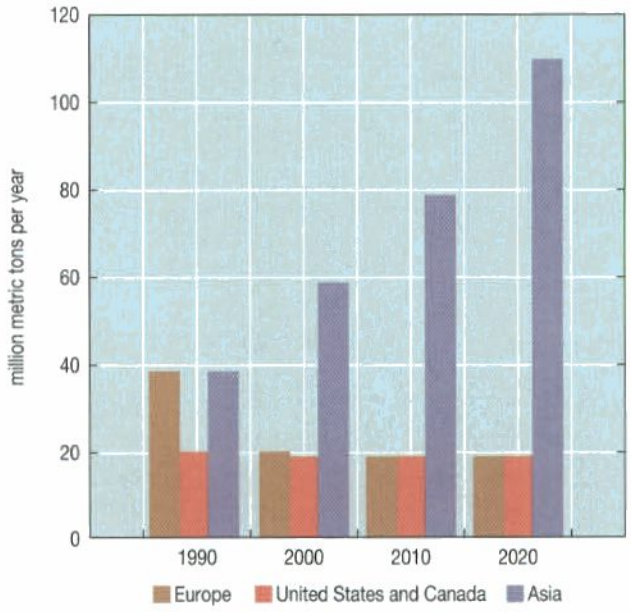


Figure 4.28 Global acid emissions, 1990s Acid emissions affect various elements of the natural and the built environment. In some parts of the world, the damage to soils is especially severe. In others, acid emissions cause serious air pollution. Lakes and rivers are also affected by acid emissions, resulting in fish and other wildlife kills. Large amounts of acid-producing chemicals may be generated in one place but exported to another by prevailing winds. More than three-quarters of the acid deposition in Norway, Switzerland, Austria, Sweden, the Netherlands, and Finland is blown in from Western and Eastern Europe. Most industrialized countries have cut sulfur dioxide emissions to help mitigate the damage of acid rain on ecosystems. But the acid rain problem is not yet solved: Emissions of oxides of nitrogen have remained constant or are rising in North America and Europe. At the same time, acid rain is emerging as a major problem in the developing world, especially in parts of the Asia and the Pacific region where energy use has surged. It is likely that the acid emissions experienced in the core countries in the twentieth century will be repeated in the periphery in the twenty-first century. (After J. L. Allen, *Student Atlas of Environmental Issues,* Duskin/McGraw Hill, 1997, p. 45; World Resources Institute, *World Resouces 1998–1999,* Acid Rain: Downpour in Asia, 1998.)

TABLE 4.2 Estimated Area Cleared ($\times$ 1000 km^2)

Region or Country		Pre-1650	1650–1749	1750–1849	1850–1978	Total High Estimate	Total Low Estimate
North America		6	80	380	641	1,107	1,107
	H	18				288	
Central America	L	12	30	40	200	—	282
	H	18					
Latin America	L	12	100	170	637	925	919
Australia, New Zealand, and the South Pacific	H	6	6	6	362	380	
	L	2	4	6	362	—	374
	H	70	180	270	575	1,095	
Former USSR	L	42	130	250	575	—	997
	H	204	66	146	81	497	
Europe	L	176	54	186	81	—	497
	H	974	216	596	1,220	3,006	
Asia	L	640	176	606	1,220	—	2,642
	H	226	80	216	469	759	
Africa	L	96	24	42	469	—	631
Total highest		**1,5**	**758**	**1,592**	**4,185**	**8,057**	
		22					
Total lowest		***986***	***598***	***1,680***	***4,185***		***7,449***

Source: B. L. Turner II, W. C. Clark, R. W. Kates, J. F. Richards, J. T. Mathews, and William B. Meyer, *The Earth as Transformed by Human Action: Global and Regional Changes in the Biosphere over the Past 300 Years.* Cambridge: Cambridge University Press, 1990, p. 180.

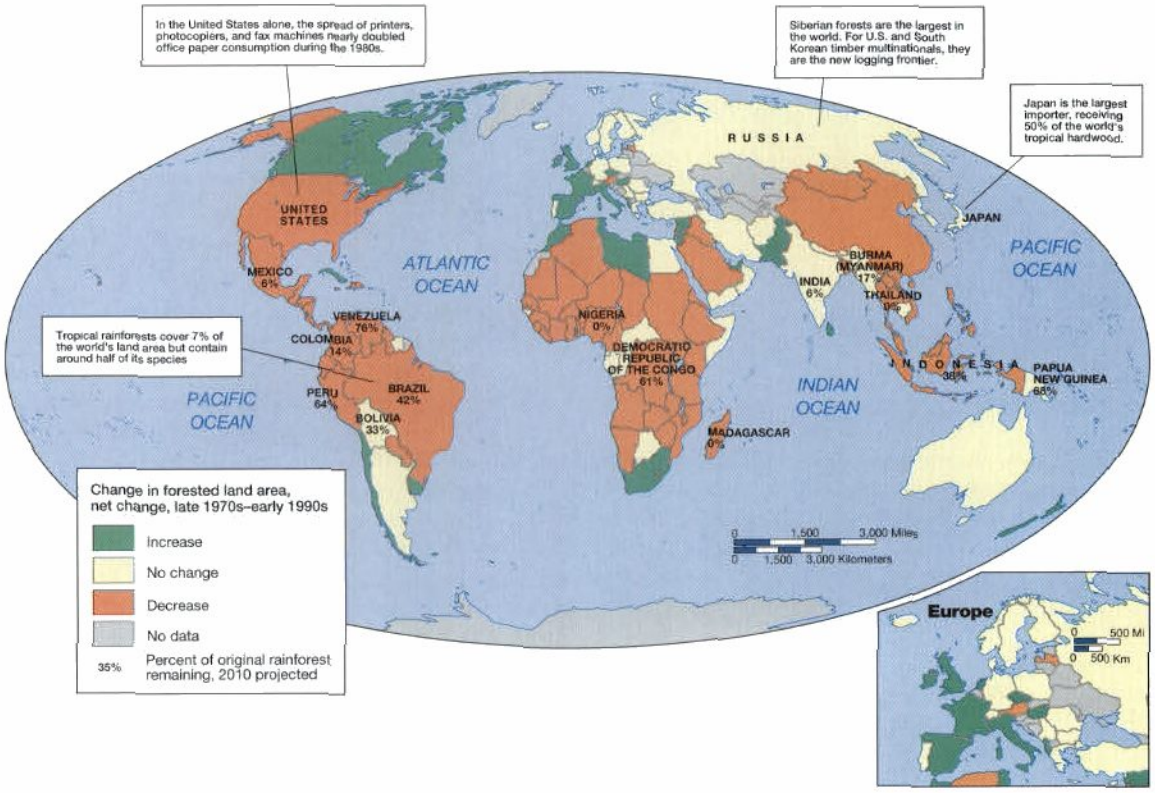


Figure 4.29 Global deforestation The world's forests are disappearing or being reduced or degraded everywhere, but especially in tropical countries. Since agriculture emerged about 10,000 years ago, human activities have diminished the world's forest resources by about twenty-five percent. Whereas forests once occupied about one-third of Earth's surface, they now take up about one-quarter. Playing an important role in the global ecosystem, they filter air and noise pollution, provide a habitat for wildlife, and slow down water runoff, helping to recharge streams and groundwater. They also influence climate at local, regional, and global levels. (After J. Seager, *The New State of the Earth Atlas,* 2nd ed. New York: Simon & Schuster, 1995, pp. 72–73.)

Global Climate Change and the Kyoto Protocol

Since the 1992 Earth Summit in Rio de Janiero, the international community has been seeking a way to strike a balance between increasing the pace of economic development without further threatening the global environment. The biggest potential threat to the global environment is the impact that increased energy use will have on global climate. At the Rio Earth Summit, 167 nations ratified the Framework Convention on Climate Change with the aim of solving the problem of how to reduce the amount of greenhouse gases—gases that are leading to the warming of the Earth's atmosphere—that are generated by energy use (**Figure 4.E**). An equally critical aim is to ensure that the burden of protecting the environment is shared equitably across all nations.

In December 1997 these nations began to address the problem of balancing global economic development and environmental protection more substantively by forging the Kyoto Protocol. The protocol marks the first time that an attempt was made to limit the amount of greenhouse gas emissions generated by core countries. The aim of the protocol is to cut the combined emissions of greenhouse gases from core countries by roughly 5 percent from their 1990 levels by 2012. (Core countries account for a disproportionate amount of CO_2 emissions, as **Figure 4.F** makes clear.) It also specifies the amount each core nation must contribute toward meeting that reduction goal. Nations with the highest CO_2 emissions—the United States, Japan, and most European nations—are expected to reduce emissions by a range of 6 to 8 percent.

Although the Kyoto Protocol represents a real advance on the 1992 agreement reached in Rio, there are still important issues that have yet to be completely worked out among the 167 nations involved in the protocol. One of the most controversial is whether core countries will be allowed to participate in "emis-

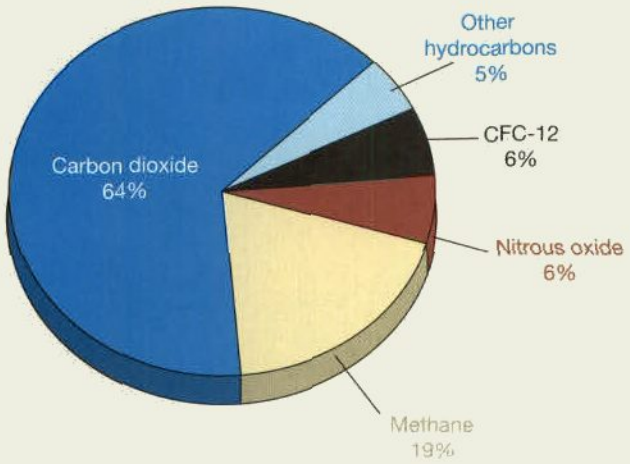


Figure 4.E Greenhouse gases The most central pollutant involved in global climate change is CO_2, carbon dioxide. In addition to CO_2, the Kyoto Protocol focuses on five other greenhouse gases: methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), and a number of hydrofluorocarbons (HFCs).

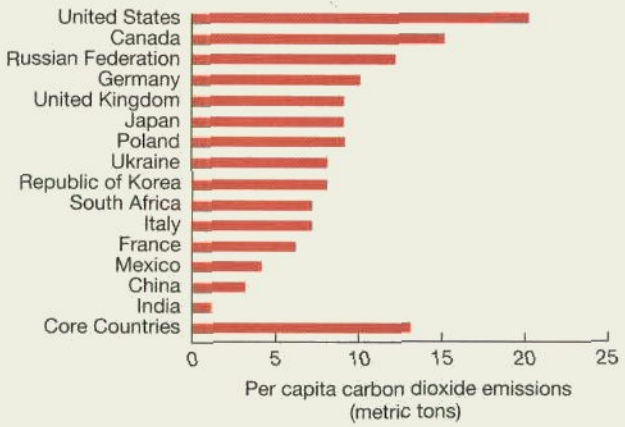


Figure 4.F Per capita CO_2 emissions CO_2 emissions are a good proxy for all greenhouse gases. The graph shows core countries as a whole, plus several core countries with especially high per capita levels of CO_2 emissions as well as a few rapidly developing semiperipheral countries. India and China, with very high populations, have relatively low per capita CO_2 emissions, while the United States and Canada, with populations far lower than India or China, have a massive contribution to CO_2 emissions. This difference is not surprising, given that energy use is highly correlated with level of wealth.

sions trading." In this scenario, a nation whose emissions fall below its treaty limit will be allowed to sell credit for its remaining emissions allotment to another nation, which in turn can use the credit to meet its own treaty obligations. Those who advocate the emissions trading approach to pollution control believe such a program will help curb the cost of controlling greenhouse gases by allowing emissions cuts to occur where they are least expensive.

A second important, and as yet unresolved, issue is the extent to which peripheral nations will be involved in limiting global emissions. While the original 1992 climate treaty placed the burden of reducing global climate change on core countries, which are unquestionably most responsible for the current buildup of greenhouse gases, peripheral countries are also expected to play a role. The Kyoto Protocol, however, does not set any binding limits on peripheral country emissions, nor does it establish a mechanism or timetable for these countries to take on such limits voluntarily. One interesting way of encouraging environmentally sensitive development in peripheral countries is the so-called Clean Development Mechanism. This would allow core countries to invest in projects in peripheral countries that reduce greenhouse gas emissions and in return receive credit for the reductions. The aim is to help peripheral countries develop their economies without increasing the overall contribution to greenhouse gas emissions.

Although it is unlikely that the Kyoto accord will bring about deep emissions cuts, climate negotiators would like to see a new treaty developed that will enable progress to continue well into the twenty-first century. The hope is to stimulate energy policy reform at the same time as new research and development investments bring low-emission technologies to market. It is also possible that the Kyoto Protocol itself could be expanded to include more comprehensive emission cuts designed eventually to stabilize greenhouse gas concentrations at a safe level. **Figure 4.G** shows the projected levels of CO_2 emissions, which are considered a reliable proxy for all greenhouse gases, under various scenarios. Unfortunately, after nine years of international negotiations, in mid-2001 President George Bush announced that the United States would no longer honor its commitment

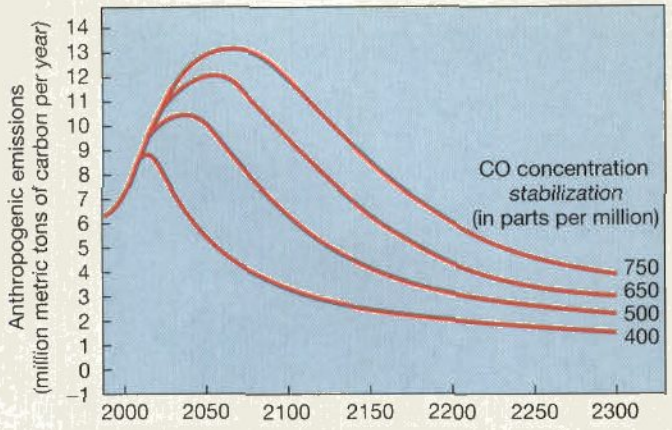


Figure 4.G Impact of proposed reductions in future emissions To stabilize CO_2 emissions, very deep cuts will be necessary for core countries at the same time that peripheral countries must be allowed to pursue economic development. One important way to make this possible is through the development of low-emission technologies.

to the 1997 Kyoto agreement because he feared the ramifications of the Protocol would negatively affect U.S. energy companies and diminish economic growth in the United States and the rest of the globalizing world. The implications of this decision are that the United States will continue to be the world's largest single generator (over 25 percent) of greenhouse gases—emissions that are leading to worldwide rises in temperature. Such temperature increases—known as global warming—have more potential to damage Earth's web of life than any other factor outside of nuclear war or a collision with an asteroid. In addition to causing rising sea levels throughout the world (which could result in widespread loss of property and livelihoods), global warming is also likely to contribute to increases in heat-related deaths (especially respiratory illnesses) and a widening of the range of disease-carrying rodents and bugs (which would cause increases in malaria, dengue fever, and Lyme disease, among other afflictions).

Adapted from World Resources Institute, "Negotiating Climate: Kyoto Protocol Marks a Step Forward," 1999. Web site: http://www.igc.org/trends/kyoto.html

The permanent clearing and destruction of forests, *deforestation*, is currently occurring most alarmingly in the world's rain forests. The U.N. Food and Agricultural Organization has estimated that rain forests globally are being destroyed at the rate of 0.40 hectare (1 acre) per second. Today rain forests cover less than 7 percent of the land surface, half of what they covered only a few thousand years ago. Destruction of the rain forests, however, is not just about the loss of trees, a renewable resource that is being eliminated more quickly than it can be regenerated. It is also about the loss of the biological diversity of an ecosystem, which translates into the potential loss of biological compounds that may have great medical value. The destruction of rain forests is also about destabilizing the oxygen and carbon dioxide cycles of the forests, which may have long-term effects on global climate. Much of the destruction of the South American rain forests is the result of peripheral countries' attempts at economic development. Figure 4.30 illustrates this point with reference to the Bolivian Amazon rain forest. The introduction of coca production has become an important source of revenue for farmers in the region and has led to the removal of small tracts of forest. Still, removal of the rain forest for agricultural production in Bolivia is minimal when compared to other South American countries, such as Brazil and Colombia.

Figure 4.30 Coca growing in Bolivia The Bolivian portion of the Amazon remains relatively intact as compared with nearby Brazil. Two factors, however, may diminish its relatively pristine state. The first is the increased logging of hardwoods. The second is the production of coca for export as cocaine. Shown in this photograph are coca leaves drying on white cloths in a cleared-out area of the rain forest. Coca is Bolivia's chief export and accounts for over half a million jobs in a largely subsistence economy. In the Chapare region, over 100,000 hectares (247,100 acres) of coca are under production.

Great geographical variability exists with respect to human impacts on the world's forests. For most of the core regions, net clearance of the forests has been replaced by regeneration. Yet for most of the periphery, clearance has accelerated to such an extent that one estimate shows a 50 percent reduction in the amount of forest cover since the early 1900s.

Cultivation is another important component of global land use, which we deal with extensively in Chapter 8. However, one or two points about the environmental impacts of cultivation are pertinent here. During the past 300 years the land devoted to cultivation has expanded globally by 450 percent. In 1700 the global stock of land in cultivation took up an area about the size of Argentina. Today it occupies an area roughly the size of the entire continent of South America. While the most rapid expansion of cropland since the mid-twentieth century has occurred in the peripheral regions, the amount of cropland has either held steady or been reduced in core regions. The expansion of cropland in peripheral regions is partly a response to growing populations and rising levels of consumption worldwide. It is also due to the globalization of agriculture (see Chapter 8), with some core-region production having been moved to peripheral regions. The reduction of cropland in some core regions is a result both of this globalization and of a more intensive use of cropland—utilizing more fertilizers, pesticides, and farm machinery—and new crop strains.

Grasslands are also used productively the world over, either as rangeland or pasture for livestock grazing. Most grasslands are found in arid and semiarid regions that are unsuitable for farming because of lack of water or poor soils (Figure 4.31). Some grasslands, however, occur in more rainy regions where tropical rain forests have been removed and replaced by grasslands. Other grasslands occur at the mid-latitudes, such as the tall- and short-grass prairies of the central United States and Canada. Approximately 68 million square kilometers (26 million square miles) of the land surface is currently taken up by grasslands.

Human impacts on grasslands are largely of two sorts. The first is the clearing of grasslands for other uses, most frequently settlement. As the global demands on beef production have increased, so has the intensity of use of the world's grasslands. Widespread overgrazing of grasslands has led to their acute degradation. In its most severe form, overgrazing has led to desertification. Desertification is the spread of desert conditions resulting from deforestation, overgrazing, and poor agricultural practices, as well as reduced rainfall associated with climatic change. One of the most severe examples of desertification has been occurring in the Sahel region of Africa since the 1970s. The degradation of the grasslands bordering the Sahara Desert, however, has not been a simple case of careless overgrazing by thoughtless herders. Severe drought, land decline, recurrent famine, and the breakdown of traditional systems for coping with disaster have all combined to create increased pressure on fragile resources, result-

Figure 4.31 African grasslands
Also known as savannas, grasslands include scattered shrubs and isolated small trees and are normally found in areas with high-average temperatures and low-to-moderate precipitation. They occur in an extensive belt on both sides of the equator. African tropical savannas, such as the one pictured here in Kenya, contain extensive herds of hoofed animals, including gazelles, giraffes, zebras, wildebeests, antelope and the elephants. Wild species are essential to the safari tourism industry in Africa and would die off without the nourishment that savannas provide.

ing in a loss of grass cover and extreme soil degradation. While the factors behind the human impacts on the Sahelian grasslands are complex, the fact remains that the grasslands have been severely degraded, and the potential for their recovery is still unknown (**Figure 4.32**).

Land included in the wetland category covers swamps, marshes, bogs, peatlands, and the shore areas of lakes, rivers, oceans, and other water bodies. Wetlands can be associated either with salt water or fresh water (**Figure 4.33**). Most of Earth's wetlands are associated with the latter.

Human impacts on wetland environments are numerous. The most widespread has been the draining or filling of wetlands and their conversion to other land uses, such as settlement or cultivation. One reliable estimate places the total area of the world's wetlands at about 8.5 million square kilometers (3.3 million square miles), with about 1.5 million square kilometers (0.6 million square miles) lost to drainage or filling. For example, Australia has lost all of the original 20,000 square kilometers (7,740 square miles) of wetlands to conversion. For the last 400 years or so, people have regarded wetlands as nuisances, if not sources of disease. In core countries, technological innovation made modification and conversion of wetlands possible and profitable. In San Francisco, California, for example, the conversion of wetlands in the mid-nineteenth century allowed speculators and real estate developers to extend significantly the central downtown area into the once marshy edges of San Francisco Bay. The Gold Rush in the Sierra Nevada sent millions of tons of sediment down the rivers into the bay, filling in marshes and reducing its nearshore depth. It is estimated that in 1850 the San Francisco Bay system, which includes San Pablo Bay as well as Suisun Bay, covered approximately 315 square kilometers (about 120 square miles). One hundred years later only about 125 square kilometers (about 50 square miles) remained. By the 1960s the conversion and modification of the wetlands (as well as the effects of

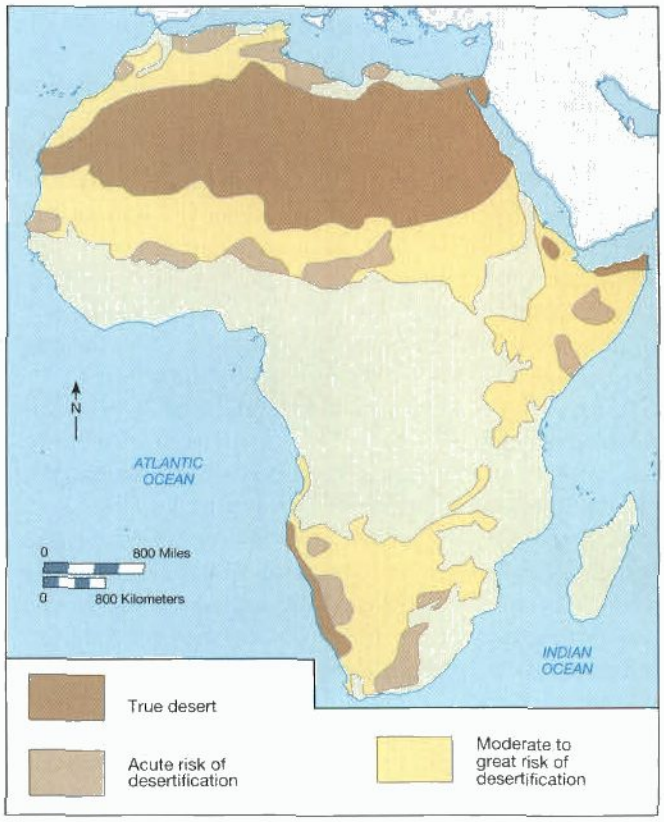


Figure 4.32 Desertification in sub-Saharan Africa
Desertification is a mounting problem in many parts of the world, but especially in sub-Saharan Africa (the portion of Africa between North Africa's Sahara Desert and the five countries that make up southern Africa). Overgrazing on fragile arid and semiarid rangelands and deforestation without reforestation are thought to be the chief causes of desertification in this part of Africa.

Figure 4.33 Wetlands Throughout the world, freshwater and saltwater wetlands help to control floods, preserve the water supply, and provide a natural environment for a wide variety of wildlife and a source of recreation for residents of nearby population centers. Shown here is the Yolo Basin Wildlife Area, with the skyline of Sacramento, California, in the background.

pollution pouring directly into the bay) had so dramatically transformed water quality and the habitats of fish, fowl, and marine life that the viability of the ecosystem was seriously threatened.

The combustion of fossil fuels, the destruction of forest resources, the damming of watercourses, and the massive change in land-use patterns brought about by the pressures of globalization—industrialization being the most extreme phase—contribute to environmental problems of enormous proportions. It is now customary to speak of the accumulation of environmental problems we, as a human race, experience as global in dimension. Geographers and others use the term **global change** to describe the combination of political, economic, social, historical, and environmental problems with which human beings across Earth must currently contend. Very little, if anything, has escaped the embrace of globalization, least of all the environment.

In fact, no other period in human history has transformed the natural world as profoundly as the last 500 years. While we reap the benefits of a modern way of life, it is critical to recognize that these benefits have not been without cost. Fortunately, the costs have not been accepted uncritically. Over the last two to three decades, responses to global environmental problems have been on the increase as local groups have mobilized internationally. In the next section we examine popular and institutional responses to global environmental problems.

THE GLOBALIZATION OF THE ENVIRONMENT

Global Environmental Politics

The increasing importance of flows and connections—economic, political, social, and cultural—means that contemporary globalization has resulted in an increasingly shrinking world. In addition to allowing people and goods to travel farther faster and to receive and send information more quickly—the smaller world that globalization has made possible—means that political action has also become global. It can now move beyond the confines of the state into the global political arena, where rapid communications enable complex supporting networks to be developed and deployed, facilitating interaction and decision making. A good example can be seen in the protests that occurred in Seattle, Washington, in 1999 over the World Trade Organization (WTO) meeting, in Genoa, Italy, in July 2001 over the Group of 8 (G8) summit, and in Bangkok in 2003 to protest the meeting of the Asian Pacific Economic Cooperation summit meeting. Telecommunications, and especially the Internet, enabled protest leaders to organize and deploy demonstrators from interested groups all over the world. Such protests reflect a truly global politics that matches the global politics of institutions like the WTO, the International Monetary Fund (IMF), the World Bank, and the G8.

One indication of the increasingly global nature of politics outside of formal political institutions is the increase in environmental organizations whose purview and membership are global (**Figure 4.34**). These organizations have emerged in response to the global impact of contemporary environmental problems, such as fisheries depletion, global warming, the increasing use of genetically modified seeds, and the widespread decline in global biodiversity. Since the 1990s these groups, ranging from lobbying organizations to nongovernmental organizations (NGOs) to direct-action organizations to political parties like the Green Party in Europe and drawing on distinctive traditions and varying levels of resources, have become an important international force. Although states tend to exclude global environmental organizations from formal political decision making, these groups have had important impacts on the creation of international environmental institutions and laws, such as the regulation of international waters and the control of marine pollution (the London Dumping Convention in 1972 and the United Nations Law of the Sea in 1982), as well as specific agreements on protection of such wildlife as polar bears and seals, trade in internationally determined rare species, and on the Antarctic ecosystem.

Most dramatic have been the major conventions signed on the international transport of hazardous waste materials (the Basel convention in 1989), air pollution controls on chloroflurocarbon (CFC) emissions (the Vienna and Montreal Protocols in 1985 and 1987), as well as a range of treaties regulating transboundary acid rain in North America and Europe. Increasingly, agreements and conventions protecting biodiversity are being created, and not a moment too soon. The decline in the diversity of simple foodstuffs, like lettuce, potatoes, tomatoes, and squash, occurred most dramatically over the course of the twentieth century. For instance, in 1903 there were 13 known varieties of asparagus; by 1983 there was just one, or a decline of 97.8 percent. There were 287 known varieties of carrots in 1903, but this has fallen to just 21, a fall of 92.7 percent. A decline in the diversity of foodstuffs means that different resistances to pests inherent in these different varieties have also declined, as have their different nutritional values and tastes.

Moreover, new sources of medicine may be lost not only because of deforestation in tropical forests but also because of the decline in indigenous languages, cultures, and traditions. The Convention on Biological Diversity that emerged from the Rio Summit in 1992 is attempting to protect global biodiversity by preserving and protecting indigenous cultures and traditions, recognizing that many indigenous people have extensive knowledge of local plants and animals and their medicinal uses. As globalization homogenizes languages and draws more and more people into a capitalist market system, traditional knowledge and practices are being lost. The U.N. Environment Program devotes a great deal of its energies to biological and cultural diversity. Even the WTO has begun to recognize the value of indigenous knowledge and the promise of biodiversity through its advocacy of intellectual property rights of both corporations and indigenous peoples. For the latter, this means protection against "bioprospecting," the practice in which companies attempt to exploit indigenous knowledge of plants for commercial purposes without compensating those individuals who have developed detailed knowledge of their medicinal value.

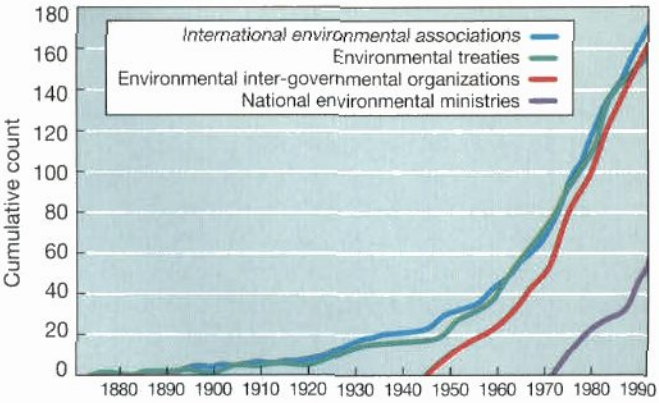


Figure 4.34 Growth of international environmental organizations Since the Second World War, there has been a dramatic increase in global environmental problems, as well as national, international, and voluntary organizations to assess and address those problems. (After data from D. Held, A. McGrew, D. Goldblatt, and J. Perraton, Global Transformations. Cambridge: Polity, 1999, p. 388.)

Clearly, global environmental awareness is on the rise from both the conservative (such as the WTO) and progressive (such as programs devoted to preserving genetic diversity in seed strains) ends of the political spectrum. This increasing awareness is directly responsible for the staging of global environmental conferences like Rio in 1992, Kyoto in 1997, and Johannesburg in 2002, which have not only affected international laws but continue to shape the debates about and responses to environmental problems. Most recently, the terms of these debates have centered on the concept of sustainability.

Environmental Sustainability

The interdependence of economic, environmental, and social problems, often located within widely different political contexts, means that some parts of the world are ecological time bombs. The world currently faces a daunting list of environmental threats, including the destruction of tropical rain forests and consequent loss of biodiversity; widespread health-threatening pollution; the degradation of soil, water, and marine resources essential to food production; stratospheric ozone depletion; and acid rain. Most of these threats are greatest in the world's periphery, where daily environmental pollution and degradation amount to a catastrophe that will continue to unfold in slow motion in the coming years.

In the peripheral regions there is simply less money to cope with environmental threats. The poverty endemic to

peripheral regions also adds to environmental stress. In order to survive, the rural poor are constantly impelled to degrade and destroy their immediate environment, cutting down forests for fuelwood and exhausting soils with overuse. In order to meet their debt repayments, governments feel compelled to generate export earnings by encouraging the harvesting of natural resources. In the cities of the periphery, poverty encompasses so many people in such concentrations as to generate its own vicious cycle of pollution, environmental degradation, and disease. Even climate change, an inherently global problem, seems to pose its greatest threats to poorer, peripheral regions.

A more benign relationship between nature and society has been proposed under the principle of *sustainable development*, a term that incorporates the ethic of intergenerational equity, with its obligation to preserve resources and landscapes for future generations (see Box 7.1; "Sustainable Development"). Geographers such as William Adams and Timothy O'Riordan conceive of sustainable development as including ecological, economic, and social measures to prevent environmental degradation while promoting economic growth and social equality. Sustainable development means that economic growth and change should occur only when the impacts on the environment are benign or manageable and the impacts (both costs and benefits) on society are fairly distributed across classes and regions. This means finding less polluting technologies that use resources more efficiently, and managing renewable resources (those that replenish themselves, such as water, fish, and forests) to ensure replacement and continued yield. In practice, sustainable development policies of major international institutions, such as the World Bank, have promoted reforestation, energy efficiency and conservation, and birth control and poverty programs to reduce the environmental impact of rural populations. At the same time, however, the expansion and globalization of the world economy has resulted in increases in resource use and inequality that contradict many of the goals of sustainable development.

CONCLUSION

The relationship between society and nature is very much mediated by institutions and practices, from technology to religious beliefs. In this chapter we have seen how the nature-society relationship has changed over time and how the globalization of the capitalist world economy has had a more widespread impact on attitudes and practices than any cultural or economic system that preceded it.

Ancient humans apparently displayed a reverential attitude toward the natural world, an attitude still evident among native populations in many parts of the New World, as well as Africa and Asia. With the emergence of Judaism and, later, Christianity, humans adopted a more dominant attitude about nature. The expansion of European trade, followed by colonization and eventually industrialization, broadcast worldwide the belief that humans should take their place at the apex of the natural world. It is the Judeo-Christian attitude toward nature as it was taken up by the emergence of the capitalist economic system that is the most pervasive shaper of nature-society interactions today.

Besides exploring the history of ideas about nature and contemporary environmental philosophies and organizations in the United States, this chapter has also shown that society and nature are interdependent and that events in one part of the global environmental system affect conditions in the system elsewhere. Finally, this chapter has shown that events that have occurred in the past shape the contemporary state of society and nature.

In short, as economies have globalized so has the environment. We can now speak of a global environment in which not only the people but also the physical environments where they live and work are linked in complex and essential ways. Along with the recognition of a globalized environment have come new ways of thinking about global economic development. Sustainable development, one of these new ways of thinking, has come to dominate the agenda of international institutions as well as environmental organizations as the new century begins.

MAIN POINTS REVISITED

- **Nature and society constitute a complex relationship. In our view, nature is both a physical realm and a social creation.**

  Recognizing that nature and society are interactive requires us also to acknowledge that humans are not separate from nature but an integral part of it.

- **Because in this text we regard nature as a social creation, it is important to understand views of nature in society today as well as the history of those views. The most prominent view of nature in Western culture is derived from the Judeo-Christian tradition, one core belief of which is that nature exists to be dominated by humans.**

  Environmental philosophies have emerged and spread in an attempt to counter this view of nature. There is a wide range of philosophies and approaches circulating, most prominently in the United States.

- **Humankind's relationships with nature have developed over the course of human history, beginning with the early Stone Age. The early history of humankind included people who**

revered nature as well as those who abused it. Urbanization and industrialization have had extremely degrading impacts on the environment.

Although other societies have had substantial impacts on nature, the extent of the contemporary core society's impact on the environment is unprecedented. As peripheral countries aim to achieve the level of prosperity enjoyed in the core, their economic practices have similar environmental impacts. The result is that while core countries have begun to limit their negative environmental impacts, peripheral countries in many ways are just beginning to produce their own significant environmental problems.

- **The globalization of the political economy has meant that environmental problems are also global in scope. Deforestation, acid rain, and nuclear fallout affect us all. Many new ways of understanding nature have emerged in the last several decades in response to global environmental crises.**

Some of the most disturbing problems have to do with extensive land-use changes, such as deforestation, as well as with widespread air pollution from the burning of fossil fuels, which many scientists believe is leading to global climate change. In response to these global crises, many new ways of understanding nature have emerged in the last several decades, offering insight into our world as a complexly integrated natural system.

- **Sustainability is fast becoming the most significant approach to addressing global economic and environmental challenges. In addition, new institutional frameworks, including conventions, protocols, and organizations, are rapidly emerging to promote global sustainability.**

New institutions and organizations continue to emerge to demand accountability for a changing global economy that is creating new, more widespread, and oftentimes more disastrous environmental problems.

KEY TERMS

acid rain (p. 158)
Clovis point (p. 143)
Columbian Exchange (p. 147)
conservation (p. 139)
cultural ecology (p. 133)
deep ecology (p. 140)
deforestation (p. 145)
demographic collapse (p. 148)
desertification (p. 164)
ecofeminism (p. 140)
ecological imperialism (p. 148)
ecosystem (p. 144)
environmental ethics (p. 140)
environmental justice (p. 140)
global change (p. 166)
nature (p. 131)
Paleolithic period (p. 142)
political ecology (p. 135)
preservation (p. 139)
romanticism (p. 138)
siltation (p. 145)
society (p. 132)
technology (p. 132)
transcendentalism (p. 138)
virgin soil epidemics (p. 147)

ADDITIONAL READING

Attfield, R., *The Ethics of Environmental Concern*. Athens, GA: University of Georgia Press, 1991.

Bartsch, U., B. Muller, and A. Aaheim, *Fossil Fuels in a Changing Climate: Impacts of the Kyoto Protocol and Developing Country Participation*. New York: Oxford, 2000.

Bebbington, A. "Movements, Modernizations, and Markets: Indigenous Organizations and Agrarian Struggle in Ecuador." In R. Peet and M. Watts (eds.), *Liberation Ecologies: Environment, Development, Social Movements*. London: Routledge, 1996.

Chasek, P. S. *The Global Environment in the 21st Century: Prospects for International Cooperation*. New York: United Nations, 1999.

Cantrill, J.G., and C. L. Oravec (eds.), *The Symbolic Earth: Discourse and Our Creation of the Environment*. Lexington, KY: University Press of Kentucky, 1996.

Centers for Disease Control and Prevention, 2005. West Nile Virus, Division of Vector Borne Infectious Diseases. http://www.cdc.gov/ncidod/dvbid/westnile/background.htm; retrieved June 15, 2005.

Collingwood, R., *The Idea of Nature*. London: Oxford University Press, 1960.

Crosby, A. W., *The Columbian Exchange: Biological and Cultural Consequences of 1492*. Westport, CT: Greenwood Press, 1972.

Committee to Review the U.S. Climate Change Science Program Strategic Plan, *Implementing Climate and Global Change Research: A Review of the Draft U.S. Climate Change Science*. Washington, DC: National Research Council, 2004.

Crosby, A. W., *Germs, Seeds, and Animals: Studies in Ecological History*. Armonk, NY: M. E. Sharpe, 1994.

Diamond, I., and G. F. Orenstein, *Reweaving the World: the Emergence of Ecofeminism*. San Francisco: Sierra Club Books, 1990.

Fagen, B., *The Long Summer: How Climate Changed Civilization*. New York: Basic Books, 2004.

Glacken, C., *Traces on the Rhodian Shore*. Berkeley: University of California Press, 1967.

Goudie, A. and D. J. Cuff. *Encyclopedia of Global Change, Environmental Change and Human Society*. New York: Oxford University Press, 2002.

Litfin, K., *The Greening of Sovereignty in World Politics*. Cambridge, MA: MIT Press, 1998.

Lovell, W. G. "Heavy Shadow and Black Night: Disease and Depopulation in Colonial Spanish America," *Annals of the Association of American Geographers 82*(3): 426–443, 1992.

Maathai, W., *The Green Belt Movement: Sharing the Approach and the Experience*. New York: Lantern Books, 2004.

Marsh, G. P., *Man and Nature*. New York: Scribner, 1864.

MacNaughten, P. and J. Urry, *Contested Natures*. Thousand Oaks, CA: Sage, 1998.
Meade, M. S. and R. J. *Erickson, Medical Geography*, 2nd ed. New York: Guildford, 2005.
Merchant, C., *The Death of Nature: Women*. San Francisco: Harper & Row, 1979.
Oelschlager, M., *The Idea of Wilderness: From Prehistory to the Age of Ecology*. New Haven: Yale University Press, 1991.
Peet, R. and M. Watts, *Liberation Ecologies: Environment, Development, Social Movements*. New York: Routledge, 2004.
Peters, R. L., and T. E. Lovejoy, *Global Warming and Biological Diversity*. New Haven: Yale University Press, 1992.
Sayer, J. and B. Campbell, *The Science of Sustainable Development: Local Livelihoods and Global Environment*. Cambridge, England: Cambridge University Press, 2003.
Raven, P. H., *Nature and Human Society: The Quest for a Sustainable World: Proceedings of the '97 Forum on Biodiversity*. Washington, DC: National Academy Press, 2000.
Robbins, P., *Political Ecology: A Critical Introduction*. Oxford: Blackwell, 2004.
Simmons, I. G., *Environmental History: A Concise Introduction*. Oxford: Blackwell, 1993.
Smith, M., and L. Marx, *Does Technology Drive History? The Dilemma of Technological Determinism*. Cambridge, MA: MIT Press, 1995.
Thomas, W. L. (ed.), *Man's Role in Changing the Face of the Earth*. Chicago: University of Chicago Press, 1956.
Turner, B.L. II, et al., *The Earth Transformed by Human Action: Global and Regional Changes in the Biosphere over the Past 300 Years*. New York: Cambridge University Press, 1990.
Wood, D., *Five Billion Years of Global Change: A History of the Land*. New York: Guildford, 2004.
Worster, D., *Nature's Economy: A History of Ecological Ideas*. Cambridge, England: Cambridge University Press, 1977.
Worldwatch Institute, *State of the World 2002: A Worldwatch Institute Report on Progress Toward a Sustainable Society*. New York: W.W. Norton & Co., 2002.
Zimmerer, K., "Human Geography and 'New Ecology': The Prospect and Promise of Integration," *Annals of the Association of American Geography*, *84*(1): 108–125, 1994.

EXERCISES

On the Internet

The theme of nature, society, and technology featured in this chapter is explored online by our critical-thinking essay. It directs you to a Web site that explores the *nature*, *society*, and *technology* of the Incas, a pre-Columbian civilization. You will investigate the Incas' burial customs, deities, economy, transportation system, religion, and origin myth. In a thinking-spatially exercise, you will view and comment on maps demonstrating European expansion, environmental change, and introduction of new diseases, plants, and animals in the New World. A series of multiple-choice questions, with electronic feedback, will test your understanding of chapter concepts.

Unplugged

1. Many communities have begun to produce an index of stress, which is a map of the toxic sites of a city or region. One way to plot a rudimentary map is to use the local phone book as a data source. Use the Yellow Pages to identify the addresses of environmentally harmful and potentially harmful businesses, such as dry-cleaning businesses, gas stations, automotive repair and car-care businesses, aerospace and electronic manufacturing companies, agricultural supply stores, and other such commercial enterprises where noxious chemicals may be produced, sold, or applied. Compile a map of these activities to begin to get a picture of your locale's geography of environmental stress.
2. Locate and read a natural history of the place where your college or university is located. What sorts of plants and animals dominated the landscape there during the Paleolithic period? Do any plants or animals continue to survive in altered or unaltered form from that period?
3. Colleges and universities are large generators of waste, from plain-paper waste to biomedical and other sorts of wastes that can have significant environmental impacts. Identify how your college or university handles this waste stream and how you, as a member of the academic community, contribute to it. Where does the waste go when it leaves the university? Is it locally deposited? Does it go out of state? Remember to trace the stream of all the types of waste, not just the paper.