CHAPTER 3

The Environment and Consumption

CHAPTER OBJECTIVES

- **A.** Understand the Interaction Between Environment and Consumption
- **B.** Human Activity and Climate Change
- **C.** Understand Sources of Energy and Their Use Across International Regions
- **D.** Human Activity and the Atmosphere
- **E.** Human Activity and Water
- **F.** Human Activity and Land
- **G.** Human Activity and Biodiversity

A. Understand the Interaction Between Environment and Consumption

ASHKELON DESALINATION PLANT

The Middle East offers a perspective on the increasing need to take water conservation more seriously. This region of the world is one of the most arid areas and is largely devoid of drinking water. In Israel and other countries in the region, water is viewed a natural resource of utmost importance. Israel has faced a chronic water shortage for years, and there is speculation that it will be difficult to supply municipal and household water requirements in the near future. The current cumulative deficit in Israel's renewable water resources amounts to about two billion cubic meters—an amount equal to the annual consumption of the country.[1] Human and nonhuman factors contribute to the country's

© DAVID BUIMOVITCH/AFP/Getty Images

FIG. 3-1a

© DAVID BUIMOVITCH/AFP/Getty Images

FIG. 3-1b

The Ashkelon Desalinization Plant and One of Its Employees Enjoying the Fruits of the Labor

water resource problem. The water deficit has developed due to drought conditions as well as to low precipitation levels. In addition, salt and other pollutants have invaded existing water sources. Increases in growth and development call for an additional need for about 60% more water by 2020.[2]

In 2000, the Israeli government launched a master plan designed to alleviate the water problem. The Ashkelon Desalinization Plant was completed in 2005 at a cost of $212 million. The facility uses a reverse osmosis technology in which seawater is pushed at high pressure through a membrane that filters out salt molecules and produces clean water. The facility also has an on-site power plant that enables it to avoid production disruptions incurred on a grid-based power system. Up to 96% of the energy associated with concentrated saltwater at the end of the purification process can be captured and used to generate power. The use of the advanced technologies enables the utility to provide water at 52.7 cents per cubic meter, making the plant one of the world's cheapest producers of desalinated water.[3]

The Ashkelon facility illustrates how governments and organizations can augment interaction with the environment. To stimulate interest in making further modifications to our interaction with the environment, we identify current trends in the environment in this chapter. If we have an understanding of our current situation, then we can monitor environmental conditions to track progress. Furthermore, if we can identify action that influences the environment, we are equipped to act to reduce our influence.

It is essential to recognize that all commerce and consumption operate within natural boundaries. Although some natural assets such as wind power are renewable, others (e.g., crude oil) are not sustainable. Sustainable resources can be regenerated, and they offer ecological advantages that limit the firm's reliance on scare resources. Consequently, effective green marketers increasingly favor adoption of sustainable technologies and assets.

Today, there is unequivocal evidence of climate change, and human action is a primary driver of this change.[4] The Earth's temperature has risen 0.74°C in the last century, and the best estimate for warming over this century is 1.8 to 4.0°C. Change of this magnitude will have an enormous influence on many aspects of life. If firms and individuals wish to quell or stop this trend in climate change, then it is essential to understand our current environmental situation and identify marketing factors that influence the environment.

Although many people now agree that climate change is occurring, few recognize how commerce, industrial activity, and consumption directly affect the environment. As a starting point, we outline the influence of marketing activity on climate change, energy, the atmosphere, water, and land. Our discussion of the atmosphere addresses ozone depletion and air pollution. Our examination of water includes reviews of freshwater, oceans and fisheries, and water purity. Our analysis of land examines urban expansion, land degradation, deforestation, desertification, and waste management.

We distinguish among climatic, atmospheric, water, land, and biodiversity facets of the environment to provide background on trends in the environment. These environmental issues are interactive rather than independent. Moreover, factors that have a primary influence on one facet of the environment likely also influence others. For example, ozone depletion is an aspect of the atmosphere, but it influences water and biodiversity.[5]

B. Human Activity and Climate Change

In 2007, the United Nations reported that 11 of the last 12 years ranked among the warmest years in global surface temperature since 1850. This report underscores the critical level of climate change faced on the planet. Indeed, climate change is shaping up to be the biggest environmental issue that business has ever faced.[6]

Climate change refers to a change in climate attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability over comparable periods of time.[7] The Earth is surrounded by a natural blanket of gases that keeps the planet warm enough to sustain life. Solar enegy in the form of visible light that hits the Earth's surface warms the planet. The Earth emits energy back out to space in the form of thermal radiation. Greenhouse gases block the radiation from escaping, resulting in the **natural greenhouse effect**. This natural effect raises the Earth's temperature by approximately 30°C and is essential for life.[8]

Since the beginning of the Industrial Revolution, increasing emissions of greenhouse gases have been making the blanket thicker. This artificial influence on the environment is known as the **enhanced greenhouse effect**. The Earth must rid itself of energy at the same rate at which it receives energy from the sun. As the blanket of greenhouse gases thickens, less energy is lost to space. The system primarily restores balance through global warming of the Earth's lower atmoshere and surface. Thus, increases in greenhouse gases lead to increases in the Earth's surface temperature.

Climate change has several critical influences on the environment that include the following:[9]

a) *Higher temperatures and increased risk*. The climate takes time to respond to emissions, and the response can take decades. Furthermore, oceans absorb and release heat more slowly than the atmosphere does. The result of these effects is higher temperatures for centuries after stabilization of greenhouse gases. A substantial portion of the strain is associated with higher and more frequent temperature spikes such as those that Europe faced in the summer of 2003. Excess mortality in France alone for the August 1 to 15 period was 11,435 deaths.[10] Evidence also suggests that human influence has more than doubled the risk of European mean summer becoming as hot as 2003, with the likelihood of such events to increase a hundredfold over the next four decades.[11]

b) *Decline in the quantity and quality of freshwater*. Rising temperatures influence the level of moisture in the air. Warmer atmospheres hold more moisture and produce more precipitation, especially in the form of heavy cloudbursts. In addition, greater heat speeds up evaporation. Together, these changes in the cycling of water reduce the quantity and quality of freshwater supplies across all major geographic regions.

c) *Increased health risk*. Although climate change likely reduces the number of deaths due to exposure, it generally has a negative effect on health. Climate change alters distribution patterns of malarial mosquitoes and other carriers of infectious diseases. It also affects the seasonal distribution of allergy-causing pollen.

d) *Rising sea levels*. Climate change associated with higher temperatures is resulting in higher sea levels. Evidence indicates that the Antarctic and Greenland ice sheets are losing mass and contributing to rising sea levels. The rise in sea levels over the last 20 years is twice as fast as the average over the 20th century, and the 20th century experienced a growth rate substantially greater than that of the previous two millennia.[12] These rising sea levels increase coastal flooding and erosion.

e) *Threats to biodiversity*. Biodiversity refers to the animal and plant life that surround us. Climate change over the last 30 years has modified the distribution and location of many species. Increases in average temperatures are associated with increasing levels of species extinction such that 20 to 30% of species face an increased risk of extinction.[13] This trend is attributed to shifts in vegetation zones, shifts in ranges of individual species, interaction between climate change and habitat fragmentation, and changes in ecosystem functioning.[14] Species extinction is likely to occur across regions on the planet.
f) *Affects the most vulnerable*. Exposure to climate change is greatest among the poor and those with limited resources to invest in mitigating and preventing effects of climate change.
g) *Displaced people and environmental refugees*. Changes in climate have potential to force departures from the Arctic climates due to lack of biodiversity and degradation of habitat. Simultaneously, climate change may force departures from tropical areas where inhabitants live just above sea level. These trends will lead to increased displacement and higher numbers of environmental refugees.[15]

Climate change also has several direct influences on business that include the following:[16]

a) *Agriculture*. Rising temperatures and volatile weather patterns adversely affect the agricultural sector and complicate efforts to speculate on future values of agricultural-based commodities (e.g., frozen orange juice, pork bellies).
b) *Tourism*. Winter- and summer-based tourism sites stand to lose considerably due to climate change. Rising temperatures eliminate ski resorts and rising sea levels *drown* beaches. In addition, severe thunderstorms are problematic for airlines and other transportation systems.
c) *Insurance*. The insurance industry is particularly susceptible to climate change. As the premiums and costs associated with underwriting policies become more difficult to assess, costs increase and the number of providers decreases.
d) *Transportation and related costs*. As climate change increases, government will likely act to control greenhouse gas emissions. Consequently, industries that have heavy transportation needs (e.g., automobile production) face higher costs of operation. Similarly, industries that use petroleum-related raw materials (e.g., plastics production) face greater costs.
e) *New product/solution development*. Although climate change has many negative consequences, it presents enormous opportunities for entrepreneurs that develop technologies, services, and products. Consumer demand for products that reduce energy costs or eliminate the need to rely on carbon-based fuels will receive greater attention.

Given its strong influence on the environment, it is essential to examine factors that accelerate the extent of climate change. We distinguish among three types of gases that influence the environment.[17] Gases with a direct influence on climate change include naturally occurring gases and synthetic gases that are the result of industrial activity. The natural gases include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Synthetic gases include hydrofluourocarbons (HFCs), perflourocarbons (PFCs), and sulfur hexafluoride (SF_6). These fluorinated gases are also referred to as **F gases**.

Some gases do not have a direct effect on global warming but influence the formation and destruction of other greenhouse gases, including carbon monoxide (CO), oxides of nitrogen (NO_x), and nonmethane volatile organic compounds. Figure 3-2 indicates increases in gases with a direct effect on climate change over

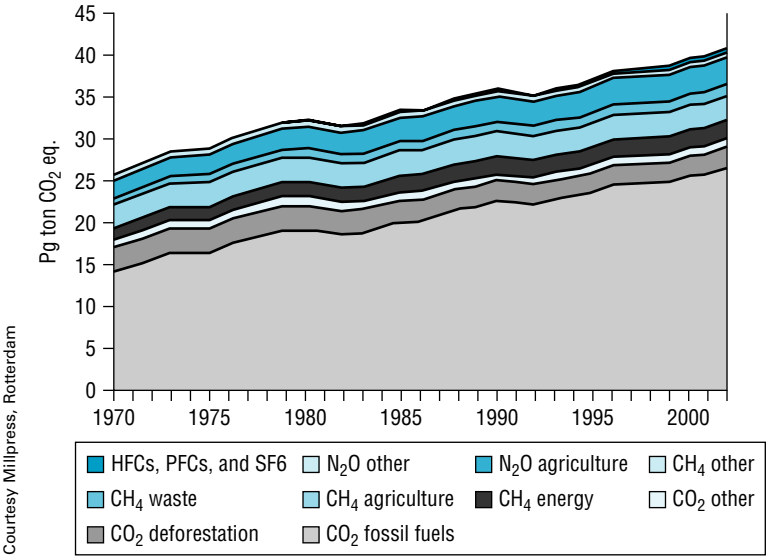


FIG. 3-2 Trend in Global Emissions of Greenhouse Gases 1970–2002

Source: *Olivier, Jospeh G.J., John A. van Aardenne, Frank Dentener, and Laurens Ganzeveld "Recent trends in global greenhouse gas emissions: regional trends and spatial distribution of key sources," http://www.mnp.nl/edgar/Images/Olivier2005-FT2000-NCGG4-Utrecht_tcm32-22124.pdf, (February 17, 2010).*

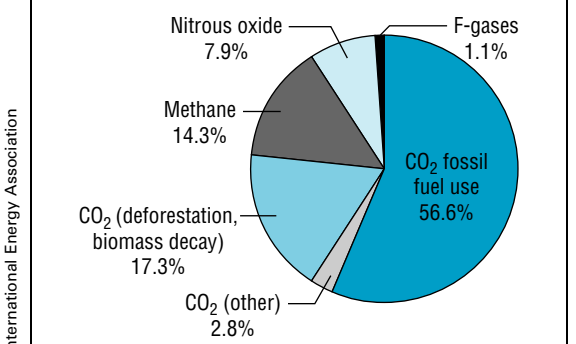


FIG. 3-3a Global Anthropogenic Greenhouse Gas Emissions in 2004

Source: *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth of the Intergovernmental Panel on Climate Change. Figures 2.1b IPCC, Geneva, Switzerland.*

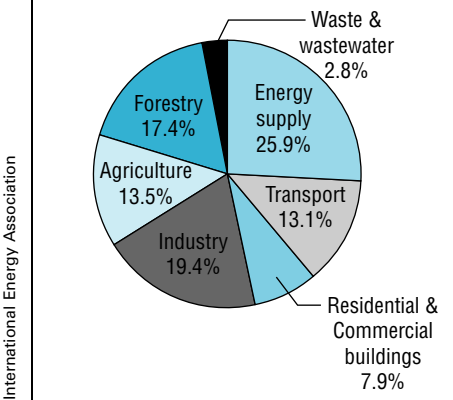


FIG. 3-3b Greenhouse Gas Emissions by Sector in 2004

Source: *Climate Change 2007: Synthesis Report Synthesis Report, An Assessment of the Intergovernmental Panel on Climate Change*

Source: *http://www.iea.org/Papers/2008/Indicators_2008.pdf (February 10, 2010).*

the 1970 to 2002 horizon. Over this 30-year period, greenhouse gas emissions increased by 60%. Figure 3-3a provides an overview of the emissions for each gas with direct influences on global warming.

Figure 3-3b indicates the global sources of these greenhouse gases by industrial sector. Energy accounts for more than 25% of greenhouse emissions, and a

TABLE 3-1 GLOBAL WARMING POTENTIALS (100-YEAR TIME HORIZON)[18]

GAS		GLOBAL WARMING POTENTIAL	GAS		GLOBAL WARMING POTENTIAL
CO_2	Carbon dioxide	1	HFC-227ea	F-gas	2,900
CH_4	Methane	21	HFC-236fa	F-gas	6,300
N_2O	Nitrous oxide	310	HFC-4310mee	F-gas	1,300
HFC-23	F-gas	11,700	CF_4	F-gas	6,500
HFC-32	F-gas	650	C_2F_6	F-gas	9,200
HFC-125	F-gas	2,800	C_4F_{10}	F-gas	7,000
HFC-134a	F-gas	1,300	C_6F_{14}	F-gas	7,400
HFC-143a	F-gas	3,800	SF_6	F-gas	23,900
HFC-152a	F-gas	140			

Source: United States Environmental Protection Agency.

substantial portion of these emissions are associated with coal. The industrial sector represents the second largest contributor at 19.4%. Forestry, including deforestation and decay from logging and deforestation, accounts for another 17.4%, whereas agriculture accounts for 13.5%. The transportation sector, by contrast, represents 13.1% of greenhouse gas emissions.

In order to compare gases, scientists have developed an index of global warming potential that compares the ability of a greenhouse gas to trap heat in the atmosphere relative to carbon dioxide emissions. Table 3-1 identifies the global warming potential of greenhouse gases with a direct effect on the climate. Thus, sulfur hexafluoride has 23,900 times the warming potential as an equivalent amount of carbon dioxide.

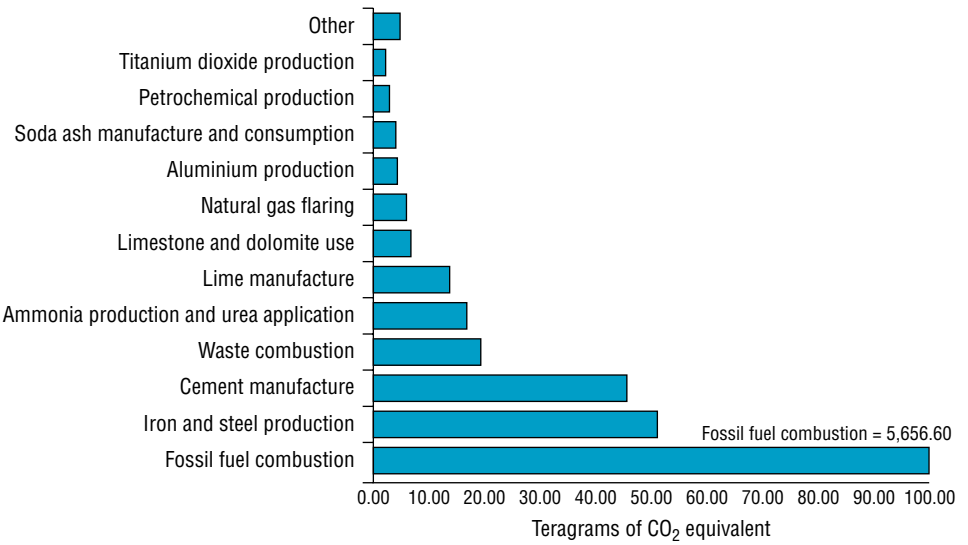
Carbon Dioxide

Carbon dioxide (CO_2) accounts for more than 80% of the greenhouse emissions worldwide. Since 1750, global atmospheric concentrations of carbon dioxide have increased by about 35%.[19] Currently, China has the largest emissions of any country, yet the United States has the largest emissions per capita. The two countries alone account for 40% of carbon dioxide emissions, with Europe providing an additional 15%.[20]

In the United States, emissions have risen by 15.8% over the 1990 to 2004 period.[21] Factors that contribute to this increase include a growing domestic economy as well as significant increases in emissions from electricity generation and transportation. As Figure 3-4 illustrates, the burning of fossil fuels represents the largest source of greenhouse emissions in the United States. Coal used to generate electricity represents the single largest contributor to carbon dioxide emissions. Petroleum used in transportation also contributes substantially to carbon dioxide emissions (see Figure 3-5). Iron and steel production and cement manufacture also contribute significantly to carbon dioxide emissions. Reductions in domestic production of pig iron, sinter, and coal coke contribute to a 40% reduction in iron- and steel-related carbon dioxide emissions since 1990. By contrast, carbon dioxide emissions associated with cement production have risen 37% since 1990.

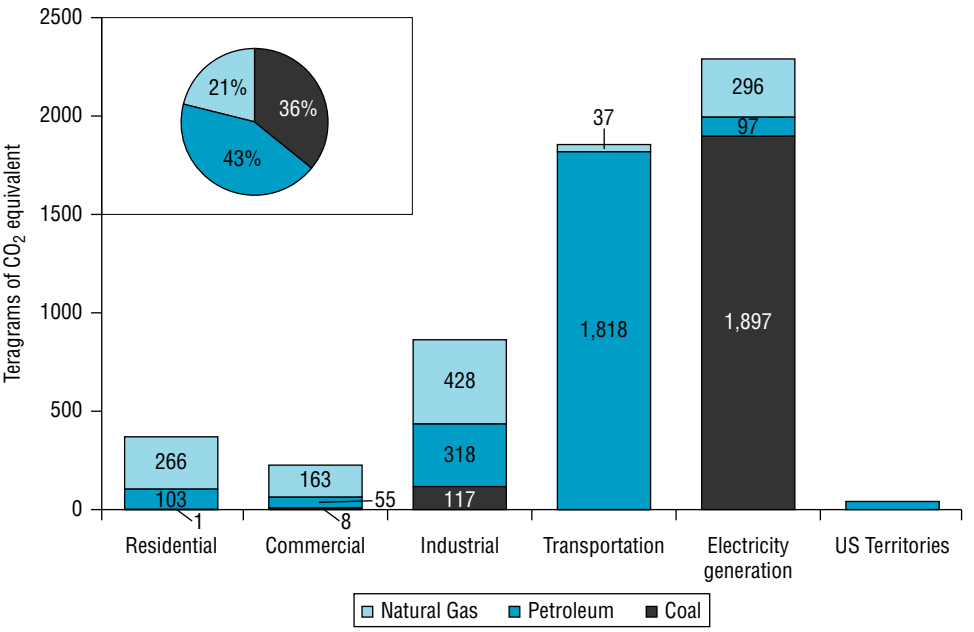
Waste combustion is also a significant contributor to carbon dioxide emissions. Due in part to the increased amounts of plastics and other fossil carbon-containing materials in municipal solid waste, the amount of waste combustion-based carbon dioxide emissions has increased by 77% since 1990.

FIG. 3-4 2004 U.S. Carbon Dioxide Emissions



Source: *U.S. State Department, "Greenhouse Gas Inventory," http://www.state.gov/documents/organization/89651.pdf (February 17, 2010).*

FIG. 3-5 2004 U.S. Fossil Fuel Usage by Industry



Source: *U.S. State Department, "Greenhouse Gas Inventory," http://www.state.gov/documents/organization/89651.pdf (February 17, 2010).*

Methane

Methane (CH_4) is the second-largest contributor to greenhouse gas emissions. As Table 3-1 illustrates, methane is more than 20 times as effective as carbon dioxide at trapping heat in the atmosphere. Since 1750, methane emissions have increased

by 143%.[22] Landfills represent the largest manmade sources of methane emissions at 25% of U.S. output. Although the amount of solid waste continues to increase, methane levels are declining due to the portion that is captured and burned at landfills. Similarly, methane emissions from natural gas systems (6% of total CH_4) are in decline due to improvements in technology and management practices. **Enteric fermentation** refers to intestinal processing of methane associated with the digestion process for cattle. This source is also in decline due to decreases in populations of beef and dairy cattle as well as improved feed quality for cattle.[23]

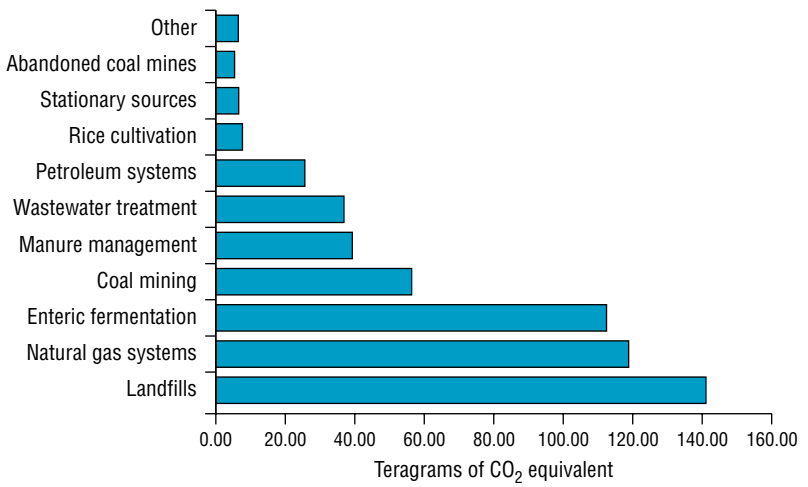
Nitrous Oxide

Nitrous oxide (N_2O) is the third-largest contributor to greenhouse gas emissions. Although emissions are substantially lower than those of carbon dioxide, nitrous oxide is 310 times more powerful than CO_2 in its ability to trap heat in the atmosphere (see Table 3-1). Since the Industrial Revolution (i.e., about 1750), nitrous oxide emissions have increased by approximately 25%. Fertilizer applications and related soil management practices account for 68% of N_2O emissions in the United States. Historical data do not indicate long-term increases or decreases in this source of emissions. The second source of nitrous emissions is in mobile combustion. Over the last decade, control technologies have been developed that yield a steady drop in N_2O emission associated with mobile sources.

Fluorinated Gases

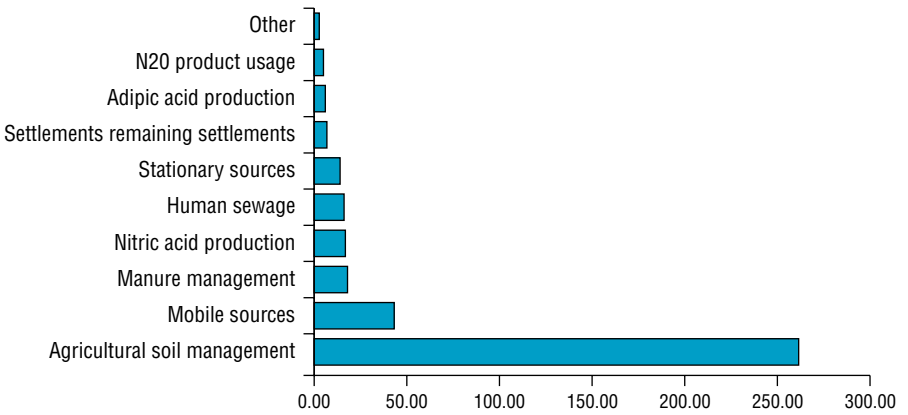
F-gases is a collective term that describes hydrofluourocarbons (HFCs), perflourocarbons (PFCs), and sulfur hexafluoride (SF_6). In contrast to the previous three gases, which occur naturally in the atmosphere, F-gases are produced almost exclusively via industrial activity. These gases represent about 2.0% of U.S. emissions, but they have global warming potentials that range from 140 (HFC-152a) to 23,900 times the potential for carbon dioxide. In addition, sulfur dioxide and

FIG. 3-6 2004 U.S. Methane Emissions



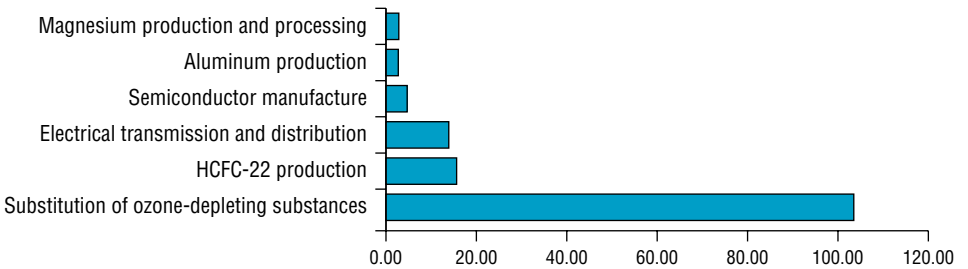
Source: *U.S. State Department, "Greenhouse Gas Inventory," http://www.state.gov/documents/organization/89651.pdf (February 17, 2010).*

FIG. 3-7 2004 U.S. Nitrous Oxide Emissions



Source: *U.S. State Department, "Greenhouse Gas Inventory," http://www.state.gov/documents/organization/89651.pdf (February 17, 2010).*

FIG. 3-8 2004 U.S. F-Gas Emissions



Source: *U.S. State Department, "Greenhouse Gas Inventory," http://www.state.gov/documents/organization/89651.pdf (February 17, 2010).*

PFCs have long atmospheric lifetimes that result in nearly irreversible atmospheric accumulation once emitted.

The largest and fastest growing source of HFCs and PFCs is via their use as alternatives to ozone-depleting substances (ODS). Emissions of these gases have increased markedly since the **Montreal Protocol** came into effect, requiring the phase-out of ODSs. Nevertheless, increases associated with substitution for ODSs are offset by decreases in F-gas emissions from other sources. For example, the aluminum industry reduced F-gas production by 85% over the 1990 to 2004 era. In addition, emissions from electrical transmission and distribution fell by 52% from 1990 to 2004. These reductions are associated with industry efforts to reduce emissions and higher purchase prices for sulfur dioxide.

C. Understand Sources of Energy and Their Use Across International Regions

The examination of energy use complements the analysis of climate change because many of the antecedents to climate change are energy related. Figure 3-9 illustrates how the mix of energy sources has evolved worldwide since 1973. Although it

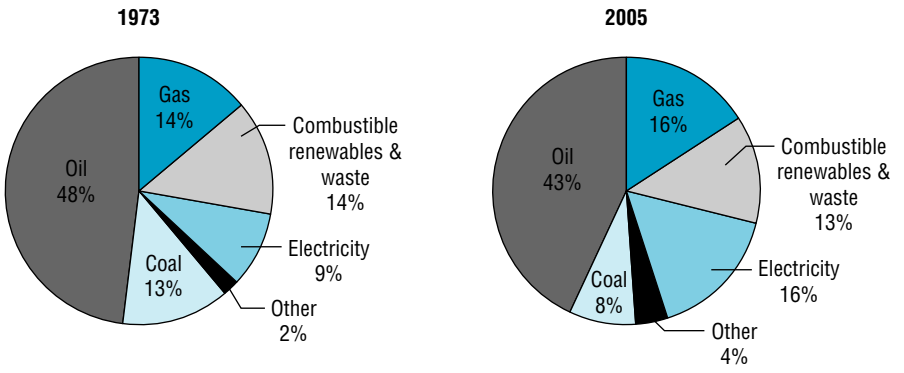


FIG. 3-9 Evolution From 1973 to 2005 of World Total Primary Energy Consumption by Fuel (MTOE = million tons of oil equivalency)

Source: *Key World Energy Statistics © OECD/IEA, 2007, page 28. http://www.iea.org/textbase/nppdf/free/2007/key_stats_2007.pdf (accessed July 31, 2008).*

represents a smaller portion of the energy supply than it once did, at 43.4%, oil remains the primary energy source used worldwide. Oil consumption remains high due to the rising transportation sector (i.e., increasers in passenger travel and freight transport) and expansion in the service economy.[24] Coal and gas together account for another 23.9% of consumption. Electricity usage is increasing and now represents 16.3% of fuel consumption. Combustible renewables and waste that are primarily employed in emerging economies account for 12.9% of consumption. The remaining 3.5% includes geothermal, solar, wind, and heat power. Although there have been substantial strides in these sources of energy, they currently represent a small fraction of consumption.

Review of the data from 1990 through 2005 reveals some intriguing trends. The data underscore the merits of contrasting energy use in OECD (Organization for Economic Co-operation and Development) countries (Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States) and the rest of the world. The final energy usage per unit of gross domestic product has fallen by 26% during this era. Most of these reductions associated with structural changes and efficiency improvements are in non-OECD countries. Although energy use increased by 23%, the associated carbon dioxide emissions rose by 25%. Most of the growth in energy usage and CO_2 emissions occurred outside of OECD countries.

The data outlined in Figure 3-10 also indicate differences between energy use and forms of energy employed in OECD countries versus the rest of the world. Final energy use grew by 19% in the OECD, whereas the growth in energy use outside the region was 27%. Transportation represents the highest percentage of energy use in the OECD at 35%, yet the sector only accounts for 17% of usage outside the OECD. The manufacturing sector in the OECD uses 27% of the energy, but outside of the

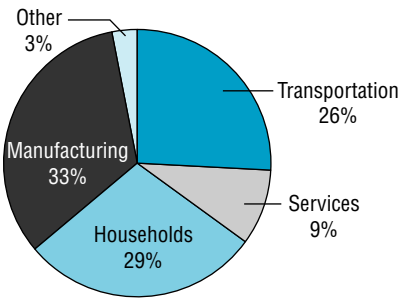


FIG. 3-10 Shares of Global Final Energy Consumption and Total Final Energy Consumption by Sector

Source: *Worldwide Trends in Energy Use and Efficiency: Key Insights from IEA Indicator Analysis © OECD/IEA, 2008, figures 2.1 and 2.2, page 17.*

OECD this percentage increases to 38%. At 36% of energy consumption, the household sector represents as substantial portion of energy use outside the OECD.

The usage rates are related to the forms of energy that are used in the OECD versus the rest of the world. Due to the importance of transportation, oil represents 47% of energy used in the OECD, yet it only represents 28% outside the bloc. Electricity represents 22% of the energy employed in the OECD, yet only 14% outside of the OECD. Biomass, including wood, agricultural residue, and animal dung, remains an important source of fuel outside the OECD, where more than 2.4 billion people still rely on these energy sources.

D. Human Activity and the Atmosphere

Ozone depletion, and air pollution are facets of the atmosphere influenced by consumption. Consider first the extent of ozone depletion.

Ozone

Ozone is a form of oxygen naturally occurring in the atmosphere. In contrast to the typical oxygen molecule that has two oxygen atoms, the ozone molecule contains three atoms and is labeled O_3. Ozone is observed in two regions of the atmosphere. Approximately 10% of ozone is in the troposphere, the region closer to Earth. This area ranges from the Earth's surface to about 6 miles in altitude.[25] Ozone appearing in this level is an air pollutant that is harmful to breathe and is harmful to crops, trees, and other vegetation. Ozone is the main ingredient in smog.

The remaining 90% of the ozone resides in the stratosphere. This second region ranges from the top of the troposphere to about 31 miles in altitude. The large amount of ozone in the stratosphere is often referred to as the **ozone layer**. Ozone in this layer absorbs some of the sun's biologically harmful ultraviolet (UV) radiation.[26] Depletion of this ozone leads to increased amounts of UV radiation reaching the Earth, which leads to more cases of skin cancer, cataracts, and impaired immune systems. Overexposure to UV radiation is believed to be contributing to the increase in melanoma, the most fatal of all skin cancers. UV radiation can also damage sensitive crops, such as soybeans, and reduce crop yields.[27]

The human activity that contributes to ozone depletion involves use of gases containing the halogens chlorine and bromine. Figure 3-11 provides an overview of

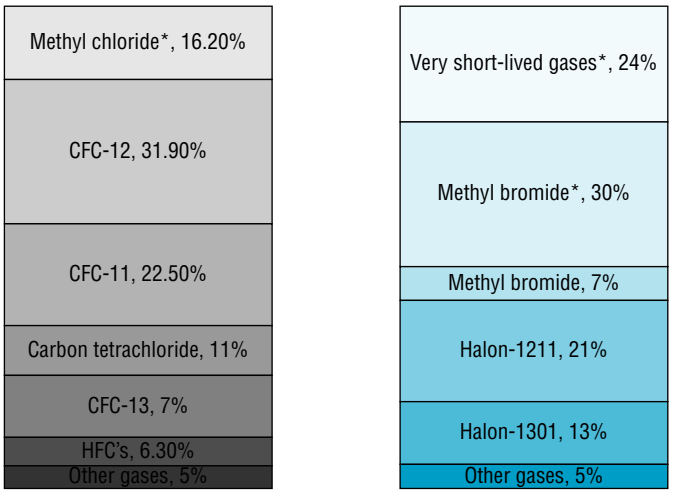


FIG. 3-11 Primary Sources of Chlorine and Bromine for the Stratosphere in 2004

*Indicates natural rather than human production.

Source: *From TWENTY QUESTIONS AND ANSWERS ABOUT THE OZONE LAYER: 2006 UPDATE. Lead author: D. W. Fahey. © 2006 United Nations. Reprinted with the permission of the United Nations. http://ozone.unep.org/Assessment_Panels/SAP/Scientific_Assessment_2006/Twenty_Questions.pdf (accessed February 19, 2010).*

chlorine- and bromine-based ozone-depleting halogens in the stratosphere. Chlorine is a component of CFCs used in refrigerators and air conditioners. Carbon tetrachloride, methyl chloride, and methyl chloroform are also chlorine-based halogens. Bromine-based halogens include halons used in fire extinguishers, large-scale computers, military hardware, and commercial aircraft engines. Methyl bromide used as an agricultural fumigant is also a bromine-based halogen.

After these halogens have been emitted into the atmosphere, they accumulate in the troposphere and are transported to the stratosphere. Once in the stratosphere, these halogen gases are converted to reactive agents by the sun's ultraviolet radiation. The average emission of these gases into the stratosphere is smaller in tropical regions. Emissions in arctic regions are more pronounced, and this effect is more acute during winter and spring. Unique weather and atmospheric conditions in Antarctica result in an ozone hole in this region.

Air Pollution

Air pollution is a global health concern with marked influence on humans and the environment. Regulatory agents use six factors known as **criteria pollutants** to establish air quality levels.[28] These factors include sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone oxygen, lead, and particulate matter (PM). Particulate matter includes chemical compounds (sulphate, nitrate, ammonium, organic carbon, elemental carbon, and soil dust), heavy metals (arsenic, cadmium, mercury), volatile organic compounds (e.g., benzene), polycyclic aromatic hydrocarbons, and persistent organic pollutants (dioxins and furans). Most forms of particulate matter become pollutants through the burning of fossil fuels, biomass,

and solid waste, whereas ammonium as a pollutant primarily derives from agriculture.

It is important to distinguish between outdoor and indoor pollution. Outdoor air pollution accounts for 1.4% of total global mortality and amounts to 800,000 deaths annually. Eighty-one percent of the mortality occurs in people 60 years of age or older. The incidence of death is strongly related to geography: 49% of the deaths occur in the region that includes Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Maldives, Myanmar, Nepal, or Timor Leste. Another 19% of deaths occur in Southeast Asia. In addition to the mortality data, outdoor pollution increases hospitalization and emergency room visits, asthma attacks, bronchitis, respiratory symptoms, and lost work days.[29]

Indoor air pollution is the more egregious form of airborne contamination because it is implicated in more than 1.6 million deaths per year.[30] In addition, indoor pollution is associated with higher incidences of acute lower respiratory infections, chronic obstructive pulmonary disease, and lung cancer.[31] The incidence of death related to indoor air pollution is related to geography. Indoor air pollution is responsible for 1.2 million deaths per year in Afghanistan, Angola, Bangladesh, Burkina Faso, China, the Democratic Republic of the Congo, Ethiopia, India, Nigeria, Pakistan, and the United Republic of Tanzania. Moreover, in the 21 most affected countries (Afghanistan, Angola, Benin, Burkina Faso, Burundi, Cameroon, Chad, the Democratic Republic of the Congo, Eritrea, Ethiopia, Madagascar, Malawi, Mali, Mauritania, Niger, Pakistan, Rwanda, Senegal, Sierra Leone, Togo, and Uganda), indoor air pollution is implicated as the cause of 5% or more of the total burden of disease.[32]

The likelihood of experiencing health problems due to indoor air pollution is associated with income, gender, and age. Figure 3-12 outlines the relationship between prosperity and fuel usage. Electricity is used in the most affluent societies and is relatively clean and efficient. By contrast, the crop waste and wood used in emerging economies is relatively unclean and inefficient. These fuels produce indoor smoke with several health-damaging pollutants including particulate matter, carbon monoxide, nitrous oxides, sulfur oxides, formaldehyde, and carcinogens (chemical substances that increase the risk of cancer).[33]

In many countries, women bear the primary responsibility for food preparation. In emerging economies, women typically cook with crop waste or wood.

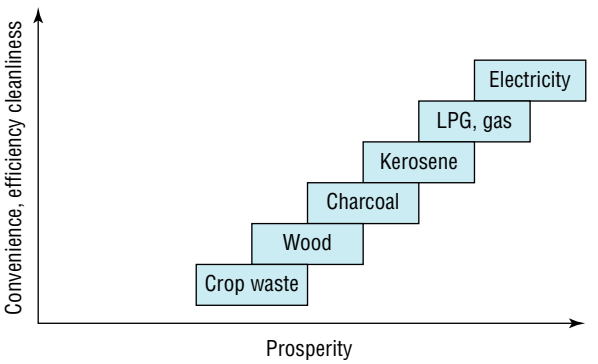


FIG. 3-12 Relationship of Prosperity With Fuel Cleanliness, Efficiency, Cost, and Convenience.

Source: *World Health Organization, http://www.who.int/mediacentre/events/HSD_Plaq_10.pdf (accessed July 30, 2008).*

Wood provides around 15% of energy needs in developing countries, rising to 75% in tropical Africa. In more than 30 countries, wood still provides more than 70% of energy, and in 13 countries it is more than 90%. Because women do the majority of the cooking, they are more susceptible to indoor air pollution than men are. In addition, young children present during cooking are exposed to indoor smoke. This air pollution increases the risk of chronic obstructive pulmonary disease, the leading cause of death among children under 5 years of age in developing countries.[34]

Air pollution has a number of ancillary environmental effects. First, the level of ozone in the troposphere results in crop losses in Europe alone that exceed $5 billion annually. Second, acid rain associated with sulfur and nitrogen historically leads to lake acidification and forest decline in North America and Europe. Although this trend has been markedly reduced, there is growing concern about acidification in other regions, notably Asia. Finally, nitrogen deposits continue to drive losses in the number of species present in sensitive ecosystems. These settings include heaths, bogs, and mires in North America and Europe.

E. Human Activity and Water

Access to Clean Drinking Water

Water is essential for life, yet the influence of consumption on water use is not well understood. Ninety-seven percent of the world's water supply is saline, leaving 3% freshwater.[35] Almost 70% of the freshwater is frozen in the icecaps of Antarctica and Greenland. The remainder is primarily present as soil moisture or lies in deep underground aquifers as groundwater not accessible to human use. Less than 1% of the world's water is available for human use. This water is found in lakes, rivers, reservoirs, and underground sources shallow enough to be tapped at an affordable cost. The three primary uses of freshwater include irrigation (70%), industry (20%), and residential purposes (10%).[36]

The availability of freshwater is related to geographic location. The World Health Organization estimates that one sixth of the world's population does not have access to clean drinking water, whereas two fifths of the world population lacks access to adequate sanitation services.[37] Figures 3-13a and 3-13b illustrate the distribution of this population across the globe. The data underscore the magnitude of the problem in Asia and Africa. These water issues are particularly problematic for people living in rural areas. Sanitation coverage in rural areas is less than half that of urban settings such that 1.3 billion rural inhabitants face poor sanitation in India and China alone.

Although there are deep underground aquifers that can be drilled for human use, only lakes, rivers, reservoirs, and shallow underground sources are renewed by rain and snowfall. Consequently, only this freshwater is available on a sustainable basis.[38]

Several critical consequences of inadequate and unsanitary water include the following:

a) *Falling water tables*. While freshwater derived from lakes, rivers, and shallow underground resources is replenishable, water from connate or fossil aquifers cannot be recharged.[39] The Ogallala aquifer in the United States, the deep aquifer in the North China Plain, and the Saudi aquifer are prime examples of such water repositories. Because these aquifers cannot be replenished, their depletion means

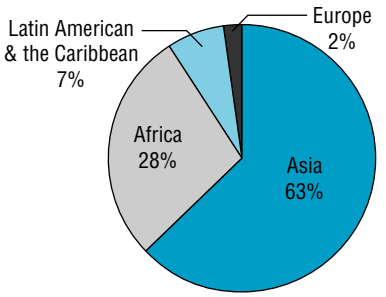


FIG. 3-13a Distribution of Global Population Not Served With Improved Water Supply by Region

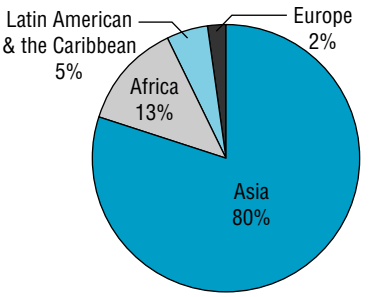


FIG. 3-13b Distribution of Global Population Not Served With Improved Sanitation Supply by Region

Source: *World Health Organization (2000), Global Water Supply and Sanitation Assessment 2000 Report, Geneva, Switzerland: World Health Organization, 7. http://www.who.int/water_sanitation_health/monitoring/jmp2000.pdf (February 10, 2010).*

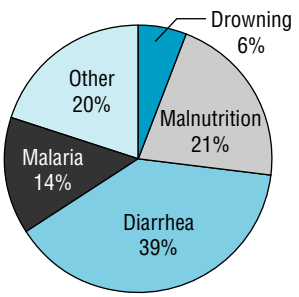
the end of irrigation and, consequently, a marked change in or end of agriculture in the dependent areas.[40]

b) *Floods and droughts*. Too much water and too little water are the result of variability in the hydrologic cycle influenced by climate change and alterations in land use patterns.[41] Australia, Bangladesh, India, China, Somalia, the United States, and many European countries experienced severe flooding during the last decade of the 20th century, and there is evidence that the number of flood and drought disasters is increasing.[42]

c) *Disease*. Figure 3-14 outlines the global burden of disease associated with lack of adequate water. The World Health Organization estimates that 1.4 million children die every year due to diarrhea acquired due to unsafe water, inadequate sanitation, or insufficient hygiene.[43] Inadequate water supplies raise the number of fatalities associated with malnutrition, malaria, drowning, and other diseases.

d) *Farmers losing to cities*. The economics of production do not favor agriculture over other industries when water is considered. For example, it takes 14 tons of water to make a ton of steel worth $560, yet it takes 1,000 tons of water to

FIG. 3-14 Diseases Contributing to the Water-, Sanitation-, and Hygiene-related Disease Burdens



Source: *A. Prüss-Üstün, R. Bos, F. Gore, and J. Bartram,* Safer Water, Better Health: Costs, Benefits and Sustainability of Interventions to Protect and Promote Health, *(Geneva, Switzerland: World Health Organization, 2008):* p. 7.

grow a ton of wheat worth $200.[44] Countries focused on expanding their economies and creating jobs are increasingly favoring industry over agriculture.

e) *Political tension*. The water resources of the 232 international rivers that exist today are ordinarily shared by several countries.[45] The Jordan, Ganges, Colorado, Nile, Zambezi, Amazon, Danube, and Rhine are all examples of international rivers. Conflicts occur between nations due to water scarcity, inadequate distribution, or due to a lack of agreements for distribution.

Factors that contribute to inadequate and unsanitary water include the following:

a) *Population growth and urbanization*. Increases in population are highly related to water resources. As the population increases, land, clean water, and other natural resources become scarce. Moreover, urbanization exacerbates this problem because growing cities demand increases in the water supply.[46] Estimates suggest that the population will increase by 3 billion people by 2050, with the great majority of this increase in urban areas.[47]

b) *Poverty and low human development*. Not surprisingly, the level of poverty and the extent of human development are associated with the water supply. The impoverished are exposed to malnutrition, unclean water, and inadequate sanitation services.[48] Improved education constrains the influences of the environment, yet individuals in many emerging economies do not have access to higher education.

c) *Food security*. Food security refers to access by all people at all times to enough food for an active, healthy life. It includes the ready availability of nutritionally adequate and safe foods as well as the assured ability to acquire personally acceptable foods in a socially acceptable way.[49] Food insecurity affects one out of every six people on the planet.[50] Although food production has increased in many parts of the world over the past few decades, malnutrition remains a problem due to rapid population growth and urbanization.

Oceans and Fisheries

Oceans. Consumption has a marked influence on oceans and fisheries. Mounting evidence indicates that the arctic is warming twice as fast as the rest of the planet is, with the summer sea ice shrinking at 9.1% a decade from 1979 to 2006.[51] At this rate, the sea could be ice free as early as 2030.[52] Nevertheless, substantially more heat is absorbed through water rather than through ice, leading to the melting of the Greenland ice sheet. As the ice melts, some water filters through cracks in glaciers and increases the break-off of icebergs into the ocean. A similar process is occurring in Antarctica, and together these trends indicate potential for rising sea levels. If the sea were to rise 10 meters, one eighth of the world's population would be vulnerable.[53] China, India, Bangladesh, Viet Nam, Indonesia, Japan, Egypt, and the United States would have millions of potential climate change refugees. Some of the world's largest cities—New York, London, Shanghai, and Calcutta—would be partially or totally inundated, and considerable amounts of productive farmland would be lost.

Rivers. Over the past half century, the demand for water has tripled, and the demand for hydroelectric power has grown even faster.[54] Consequently, the worldwide number of dams more than 15 meters high has increased to 45,000 from 5,000. These dams deprive rivers of some of their flow, and the associated evaporation is 10% of their capacities.[55] For example, Colorado River water usage by

Colorado, Utah, California, Arizona, and Nevada results in very little water reaching the Gulf of California. Similar conditions on multiple continents markedly inhibit river ecosystems and their fisheries.

Lakes. On every continent, lakes are shrinking and in some cases disappearing as a result of consumption. The dissolution of lakes is due to excessive diversion of water from rivers and the overpumping of aquifers.[56] For example, the Aral Sea in Central Asia has lost four fifths of its volume since 1960. Expansion of the Soviet cotton industry led to the diversion of two rivers from the sea. As the sea shrank and the water became more saline, the fish died, along with a maritime industry that produced 50,000 tons of seafood annually.

Water Impurities

Unless it has been distilled, water is not pure. Water impurities emerge from naturally occurring substances, agriculture, urbanization, industry, and water treatment.[57] Consider first naturally occurring substances.

Naturally occurring substances. Substances that occur in nature that influence water purity include inorganic and organic materials. Inorganic materials are those that do not contain carbon. These chemicals accrue due to the flowing of water over rocks and soil. Four substances known to be associated with adverse health effects are fluoride, arsenic, selenium, and nitrate. Given their adverse health consequences, it is essential to monitor their levels prior to examining human influence. The pH level of the water should also be monitored because influence of these chemicals is exacerbated by the level of acidity in the water. Organic compounds (i.e., chemicals that contain carbon) emerge from the breakdown of plants or algae and other microorganisms.

Agriculture. The farming sector plays a significant role in the quality of water because agricultural runoff is the leading source of impurities in lakes and rivers.[58] *Fertilizer* in the form of manure or human excrement increases levels of nitrates, ammonium salts, and organic nitrogen compounds, whereas chemical fertilizers increase nitrogen levels when these nutrients are used in excess. Biosolids used as fertilizer are treated residues from industrial or municipal waste or septic soil. These biosolids similarly lead to increased nitrate levels in water. *Animal practices* such as feedlots produce large amounts of waste that also lead to higher levels of nitrates. *Pesticides* refers to a broad mix of chemicals that have chemical and physical properties that contribute to runoff. *Irrigation and drainage* transport pollutants and alter salt balances in soil. Consequently, they raise the level of nitrates and selenium in soil.

Urbanization. The increasing population in urban areas is traced to three categories of contaminant sources. **Point sources** refers to pollution discharged from a specific location and includes on-site sanitation waste disposal locations. These point sources increase levels of nitrate and ammonium in water. **Nonpoint sources** are widely spread and difficult to identify as origins of pollutants. Three primary forms of nonpoint polluters are fuel storage locations, chlorinated solvents, and pesticides. **Diffuse point sources** refers to conditions under which there are many small point sources. For example, urban runoff from small point sources raises levels of nitrates, ammonium, and heavy metals in water.

Industry. Industrial practices include mining and manufacturing. Mining increases multiple types of metals in water, including arsenic, antimony, barium, cadmium, fluoride, and nickel. Manufacturing and processing of materials contribute a variety of chemicals with diverse properties that influence water purity.

Water treatment. Ironically, the efforts to treat water can also contribute impurities. **Chlorine** is used as a disinfectant in the purification process, but in excess it reacts naturally with organic matter to produce unwanted by-products such as chloroform. **Coagulants** such as aluminum and iron salts are important barriers to microbiological contaminants. Although these chemicals are not significant health risks, they may lead to discoloration or sediment. **Conveyors** are the pipes and fittings used to transport water. The most common conveyor is iron, a substance prone to corrosion. Corrosion due to low alkalinity, sediment, and microbes yields to water discoloration. Lead, copper, and zinc are also conveyors that may be present in water. Although lead is more likely to be present at unacceptable levels, copper and zinc are more prevalent in newer buildings. Finally, polyvinyl chloride (PVC) is a form of plastic often used as a conveyor of water. Because lead is often used as a stabilizer for PVC, use of this material may lead to elevated levels of lead.

F. Human Activity and Land

Urban Expansion

Urban expansion refers to the increasing use of land associated with increases in urban populations. In 2007, the urban population on the planet exceeded the rural population for the first time.[59] Current estimates project that the population in developing countries' cities will double in the next 30 years from 2 to 4 billion people. These cities will likely triple their land area. By contrast, the urban population in industrialized countries is expected to grow by 11% from 0.9 to 1 billion people over the same period. Urban land use in these areas is expected to grow by 2.5 times over the next 30-year period.

Research examining of the role of urbanization indicates that many factors are associated with the rise in urban population. Urbanization may be both the cause and the consequence of these factors. Forces that seem to shape expansion include aspects of the local natural environment (e.g., existence of drillable water aquifers), demographic factors (e.g., level of urbanization in a country), economics (e.g., property taxes), prevailing transport systems, consumer preferences (e.g., preference for urbanism), and metropolitan governance. **Greenfield development** refers to construction on a previously unused piece of property. This type of development has been implicated as a factor that yields air pollution, excessive energy use, greenhouse gas production, and traffic congestion. Furthermore, cities draw upon rural areas for water and waste disposal. As cities increase their land masses, the interaction with the environment must remain a central concern.

Land Degradation

Land degradation is a collective term that refers to the long-term loss of ecosystem function and services due to disturbances from which the systems cannot recover unaided.[60] Current estimates indicate significant land degradation of 12% of the global land area over the past quarter century. This land area is home to about 1 billion people. The primary areas of concern for degradation are subequatorial Africa, southeast Asia, south China, north central Australia, Central America, the Caribbean, and southeast Brazil, as well as the boreal forests of Alaska, Canada, and Siberia.

The degradation of land has direct and indirect consequences.[61] The direct effects include losses of organic soil carbon, soil water storage, nutrients, and

below-ground biodiversity. The decline in water resources brings about indirect effects that include loss of wildlife habitat and loss of productive capacity.

Two factors that give rise to land degradation are soil erosion and chemical contamination. Soil erosion is a naturally occurring phenomenon that is accelerated by improper land management. Erosion is catalyzed by clearing of forests or grasslands, mining, and urban development. When these activities are improperly managed, topsoil is lost. Consequently, the area experiences losses of soil organic matter, nutrients, water holding capacity, and biodiversity. Chemical pollutants are problematic in industrialized economies and developing markets. Industrial centers of the 20th century in the United States, Europe, and former Soviet Union contain more than 2 million contaminated sites containing cyanide, heavy metals, mineral oil, and chlorinated hydrocarbons. Chemical contaminants also include persistent organic pollutants (POPs) such as the insecticide DDT that persist in the environment for long periods. POPs have been linked to cancer, damage to the nervous system, reproductive disorders, and disruption of the immune system.[62]

Deforestation and Desertification

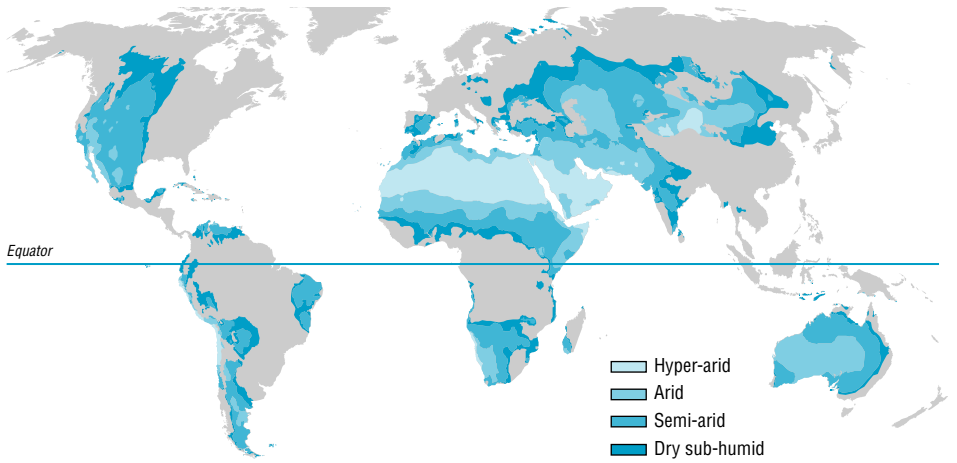
Forests are important parts of ecosystems that sustain life. Forests prevent soil erosion, maintain soil fertility, support biodiversity, and provide homeopathic and traditional medicines. Furthermore, forests support local economies and provide important sources of fuel. Over the past 15 years, the global forest area has shrunk at an annual rate of 0.2%. Although the forest area has expanded in Europe and North America, deforestation has been observed in Africa, Latin America, and the Caribbean. The 10 countries with the largest net forest loss per year between 2000 and 2005 are Brazil, Indonesia, Sudan, Myanmar, Zambia, United Republic of Tanzania, Nigeria, Democratic Republic of the Congo, Zimbabwe, and Venezuela. These countries had a combined net forest loss of 8.2 million hectares per year. By contrast, Bulgaria, Chile, China, Cuba, France, Italy, Portugal, Spain, the United States, and Vietnam, had a combined net forest gain of 5.1 million hectares per year.

Deforestation is associated with several factors.[63] In many cases, trees are removed from forests for use as fuel or as raw materials in production. Deforestation also occurs due to climate change, disease, invasive species, pests, and air pollution. Economic factors—notably agriculture and mining—increase the level of deforestation. Demographic trends such as changes in population density and urbanization raise demands for timber and firewood, and they increase the demand for water resources. The demographic trends increase the amount of deforestation.

Increased deforestation has several notable consequences for the environment.[64] Reductions in forest acreage result in loss of habitat and consequently lead to limited biodiversity. Deforestation reduces the amount of stored carbon and disturbs biological cycles. In addition, fewer forests mean diminished water resources, lower water quality, and less soil water retention.

Desertification refers to land degradation in arid, semiarid, or dry subhumid areas due to climatic variations and human activities.[65] When individual land degradation processes combine to affect large areas of drylands, desertification occurs.[66] Populations living in poor countries suffer the most due to desertification. Across the globe, drylands cover 40% of the Earth's land surface and support more than 2 billion people. Although 90% of this population lives in developing countries, Western countries are also vulnerable to deforestation. Figure 3-15 provides an overview of global drylands. One third of the Mediterranean and 85% of the rangeland in the United States are susceptible to deforestation.

FIG. 3-15 Global Drylands



Source: *United Nations Environmental Programme (2007), Global Environmental Outlook: GEO4 Environment for Development, Nairobi, Kenya: United Nations Environmental Programme, (LAND). http://www.unep.org/geo/geo4/report/GEO-4_Report_Full_en.pdf (accessed February 10, 2010).*

Because desertification occurs over a prolonged period of time in large areas, there is not a consistent measure to chart transition to deserts. The direct cause of deforestation is usually the expansion of cropping, grazing, or wood harvesting. As the level of deforestation increases, ecosystems become less resilient to other environmental conditions.

Global concerns about deforestation have important repercussions for every company that uses wood, paper, or cardboard packaging.[67] Although activists initially targeted prominent retailers about their packaging, today these organizations are focused on a broader mix of companies that use wood-related products in production, marketing, and distribution.

G. Human Activity and Biodiversity

Biodiversity refers to the variety of life on Earth.[68] It includes genetic diversity among individual beings in a population, diversity of species, and diversity of ecosystems and habitats. Biodiversity is the basis of agriculture in that it enables the production of wild and cultivated foods while also contributing to the health and nutrition of humans, animals, and plants.

Biodiversity provides provisional, regulatory, supportive, and cultural services to an ecosystem. **Provisional services** are the supply of food, fuel, or fiber made available for consumption in an ecosystem. For example, the annual world fish catch provides $58 billion in service to the world's ecosystems.[69] The **regulatory services** control interaction between factors in an ecosystem. For example, honeybee pollination of agricultural products is a regulatory service whose global value is estimated at $2 to $8 billion.[70] **Supporting services** maintain the conditions for life on Earth and include soil formation, soil protection, nutrient cycling, and water cycling. **Cultural services** refer to the spiritual, recreational, and aesthetic benefits afforded to an ecosystem through biodiversity. For instance, coral reefs for fisheries and tourism provide worldwide cultural services of $30 billion.[71]

When biodiversity is threatened, the provisional, regulatory, supportive, and cultural benefits enjoyed in the ecosystem are also affected. Unfortunately, 60% of ecosystems that have been assessed are degraded or used unsustainably.[72] Rates of species extinction are 100 times higher than baseline rates based on fossil records. Among the major vertebrate groups that have been examined, 22% of mammals, 12% of birds, 30% of reptiles, 31% of amphibians, and 39% of fishes are threatened with extinction.[73] The percentage among plants is greater—70% of species are threatened (see Table 3-2).

TABLE 3-2[75] THREATENED SPECIES BY MAJOR GROUPS

	NUMBER OF DESCRIBED SPECIES	NUMBER OF SPECIES EVALUATED BY 2007	NUMBER THREATENED IN 2007, AS % OF SPECIES EVALUATED
Vertebrates			
Mammals	5,490	5,490	21%
Birds	9,998	9,998	12%
Reptiles	9,084	1,677	28%
Amphibians	6,433	6,285	30%
Fishes	31,000	4,443	32%
Subtotal	**62,305**	**27,893**	**22%**
Invertebrates			
Insects	1,000,000	2,619	27%
Mollusks	85,000	2,306	45%
Crustaceans	47,000	1,735	35%
Corals	2,175	856	27%
Others	171,075	99	52%
Subtotal	**1,305,250**	**7,615**	**35%**
Plants			
Mosses	16,236	95	86%
Ferns and allies	12,000	211	66%
Gymnosperms	1,021	909	35%
Dicotyledons	281,821	10,876	73%
Monocotyledons	4,053	2	0%
Green algae	6,081	58	16%
Red algae	321,212	12,151	70%
Subtotal	**16,236**	**95**	**86%**
Others			
Lichens	17,000	2	100%
Mushrooms	31,496	1	100%
Brown algae	3,067	15	40%
Subtotal	**28,849**	**18**	**50%**
TOTAL	**1,740,330**	**47,677**	**36%**

Source: *IUCN 2009. IUCN Red List of Threatened Species. Version 2009.2. International Union for Conservation of Nature and Natural Resources.*

Five factors that account for reduced biodiversity include habitat conversion, invasive alien species, overexploitation, climate change, and pollution.[74] Habit conversion such as deforestation reduces the amount of available natural habitat, homogenizes species composition, fragments landscapes, and degrades soil. *Invasive alien species* refers to the introduction of new species into an ecosystem. The new species may be competitors or predators of existing species and lead to genetic contamination. Overexploitation, or the harvesting of species above sustainable rates, leads to decreased populations and extinctions. Climate change robs species of their habitats, resulting in contraction of species ranges, changes in species compositions, and extinction. Pollution yields higher mortality rates, influences nutrient availability, and raises levels of acidification in soil and water. Importantly, all these effects on biodiversity constrain the level of provisional, regulatory, supportive, and cultural services in an ecosystem and have significant consequences for the well-being of humans.

Summary

A. Understand the Interaction Between Environment and Consumption

It is essential to recognize that commerce and consumption operate within natural boundaries. Some natural assets such as wind power are renewable, yet many others are not sustainable. Sustainable resources can be regenerated, and they offer ecological advantages that limit a company's exposure to scare resources. Consequently, effective green marketers increasingly favor adoption of sustainable technologies and assets.

B. Human Influences on Climate Change

Climate change concerns changes in climate attributed to human activity that alters the composition of the global atmosphere. Climate change is associated with higher atmospheric temperatures and increased risk, decline in the quantity and quality of freshwater, rising sea levels, and threats to biodiversity. The human-related influences on the environment have direct implications for agriculture, tourism, insurance, transportation, and new product development.

Gases with a direct influence on climate change include naturally occurring gases and synthetic gases that are the result of industrial activity. Carbon dioxide accounts for more than 80% of the greenhouse emissions worldwide. The other natural gases are methane and nitrous oxide. Synthetic gases include hydrofluourocarbons, perflourocarbons, and sulfur hexafluoride.

C. Understand Sources of Energy and Their Use Across International Regions

Fossil fuels in the form of oil and coal dominate energy use across the globe. Oil is the primary energy source used worldwide, and much of this energy usage is associated with increases in the transportation sector. Coal and gas together also account for sizeable percentages of consumption. Consumption in OECD countries is substantially different from emerging economies.

D. Human Influences on the Atmosphere

Ozone depletion, air pollution, and energy are facets of the atmosphere influenced by consumption. Depletion of stratospheric ozone leads to increased amounts of UV radiation, which is associated with more cases of skin cancer, cataracts, and impaired immune systems. Air pollution is a global health concern, and regulatory agents use six factors known as *criteria pollutants* to establish air quality levels.

E. Human Influences on Water

The availability of freshwater is declining in many parts of the world. Current estimates suggest that one sixth of the world's population does not have access to clean drinking water and two fifths of the world population lacks access to adequate sanitation services. The lack of acceptable levels of potable and sanitary water is most serious in Asia and Africa. Lack of water facilities is associated with falling water tables, floods and droughts, disease, and political tension.

F. Human Influences on Land

Human influences on land are attributed to urban expansion, land degradation, and deforestation. Forces related to urban expansion include aspects of the local natural environment, demographics, economics, prevailing transport systems, consumer preferences, and metropolitan governance. The direct effects of land degradation include losses of organic soil carbon, soil water storage, nutrients, and below-ground biodiversity. Reductions in forest acreage result in loss of habitat and limited biodiversity. Deforestation also reduces the amount of stored carbon and disturbs biological cycles.

G. Human Influences on Biodiversity

Human activity is believed to be related to reduced biodiversity: Current rates of species extinction are markedly higher than baseline rates based on fossil records. All vertebrate groups and plant life have substantial percentages of species that are threatened.

Keywords

chlorine, 52
climate change, 37
coagulants, 52
conveyors, 52
criteria pollutants, 46
cultural services, 54
diffuse point sources, 51
enhanced greenhouse effect, 37
enteric fermentation, 42
F gases, 38
greenfield development, 52
Montreal Protocol, 43
natural greenhouse effect, 37
nonpoint sources, 51
ozone layer, 45
point sources, 51
provisional services, 54
regulatory services, 54
supporting services, 54

Questions

1. How did the recognition of the interrelationship between the environment and humankind influence the need to develop the Ashkelon Desalinization Plant?
2. What is the natural greenhouse effect and how does human action influence this effect?
3. What are four industries that are affected by climate change, and how are people in these industries trying to reduce the influence of climate change on their operations?
4. If carbon dioxide represents 80% of the world's greenhouse gases, why is it necessary to consider other greenhouse gases?
5. What is the role of fossil fuels in climate change?
6. How do indoor and outdoor air pollution influence the incidence of disease? How is this incidence of disease related to geography?
7. Is the lack of access to inadequate and unsanitary water a global issue? Why or why not?
8. More people now live in cities than in rural areas. What factors are related to urban expansion?
9. Describe two factors that increase land degradation.
10. What are the consequences of a decline in biodiversity?

Endnotes

[1] Jewish Virtual Library, "Israel's Chronic Water Problem," February 17, 2010, http://www.jewishvirtuallibrary.org/jsource/History/scarcity.html.

[2] Bruno Sauvet-Goichon, "Ashkelon Desalination Plant—A Successful Challenge," *Desalination* 203, no. 1–3 (2007): 75–81.

[3] Jeffrey Marlow, "The Pursuit of Cost-Effective Desalination," *New York Times*, September 21, 2009, http://greeninc.blogs.nytimes.com/2009/09/21/on-the-pursuit-of-cost-effectivedesalination/ NOTE: This blog story does not appear to have been printed by NYTimes.

[4] United Nations Environment Programme, *Global Environmental Outlook 4* (Valetta, Malta: Progress Press, 2007), 572.

[5] M. D. Lemonick and D. Cray, "The Ozone Vanishes," *Time* 139, no. 7 (February 17, 1992): 60–63.

[6] Daniel C. Esty and Andrew S. Winston, *Green to Gold* (New Haven, CT: Yale University Press, 2006), 366.

[7] United Nations, "United Nations Framework Convention on Climate Change," 1992, http://unfccc.int/resource/docs/convkp/conveng.pdf (accessed April 28, 2010).

[8] United Nations Framework Convention on Climate Change, "The Greenhouse Effect and the Carbon Cycle," http://unfccc.int/essential_background/feeling_the_heat/items/2903.php (accessed April 28, 2010).

[9] See Note 8 above.

[10] WHO, "The Health Impacts of 2003 Summer Heatwaves," *Briefing Note for the 53 Session of the World Health Organization Regional Committee for Europe*, September 8, 2003, 73.

[11] Peter A. Stott, D. A. Stone, and M. R. Allen, "Human Contribution to the European Heatwave of 2003," *Nature* 432, no. 7017 (2004): 610–614.

[12] John Church, "Global Sea Levels: Past, Present and Future," *United Nations Educational, Scientific and Cultural Organization*, 2008, 12.

[13] Chris D. Thomas, Alison Cameron, Rhys E. Green, Michel Bakkenes, Linda J. Beaumont, Yvonne C. Collingham, Barend F. N. Erasmus and others, "Extinction Risk from Climate Change," *Nature* 427, no. 6970 (2004): 145–148.

[14] Maarten Kappelle, Margret M. I. Van Vuuren, and Pieter Baas, "Effects of Climate Change on Biodiversity: a Review and Identification of Key Research Issues," *Biodiversity and Conservation* 8, no. 10 (1998): 1383–1397.

[15] See Note 6 above.

[16] See Note 8 above.

[17] U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2008," April 15, 2010, http://www.epa.gov/climatechange/emissions/usinventoryreport.html (accessed April 28, 2010).

[18] International Energy Agency, *Worldwide Trends in Energy Use and Efficiency* (Paris, France: International Energy Agency, 2008), 17, http://www.iea.org/Papers/2008/Indicators_2008.pdf (accessed April 28, 2010).

[19] David Hofmann, *Long-lived Greenhouse Gas Annual Averages for 1979–2004* (Boulder, CO: National Oceanic and Atmospheric Administration, Earth Systems Research Laboratory, Global Monitoring Division, 2004).

[20] *Business & the Environment with ISO 14000 Updates*, "Momentum for Greenhouse Gas Cuts Grows," 18, no. 7 (2007): 1–4.

[21] US State Department, "Greenhouse Gas Inventory," http://www.state.gov/documents/organization/89651.pdf (accessed April 28, 2010).

[22] See Note 21 above.

[23] See Note 21 above.

[24] International Energy Agency, *Worldwide Trends in Energy Use and Efficiency* (Paris: International Energy Agency), 94, http://www.iea.org/Textbase/Papers/2008/Indicators_2008.pdf (accessed April 28, 2010).

[25] D. W. Fahey, *Twenty Questions and Answers About the Ozone Layer: 2006 Update*, 2006, http://ozone.unep.org/Assessment_Panels/SAP/Scientific_Assessment_2006/Twenty_Questions.pdf (accessed April 28, 2010).

[26] See Note 25 above.

[27] See Note 25 above.

[28] See Note 7 above.

[29] B. Osro, *Outdoor Air Pollution: Assessing the Environmental Burden of Disease at National and Local Levels* (Geneva, Switzerland: World Health Organization, 2004), 62.

[30] World Health Organization, *Indoor Air Pollution and Household Energy Monitoring: Workshop Resources* (Geneva: World Health Organization, 2005), 20.

[31] World Health Organization, "Indoor Air Pollution and Health," http://www.who.int/mediacentre/factsheets/fs292/en/index.html (accessed April 28, 2010).

[32] World Health Organization, "National burden of disease due to indoor air pollution," http://www.who.int/indoorair/health_impacts/burden_national/en/index.html (accessed April 28, 2010).

[33] World Health Organization, "Pollution and exposure levels," http://www.who.int/indoorair/health_impacts/exposure/en/index.html (accessed April 28, 2010).

[34] Nigel Bruce, Rogelio Perez-Padilla, and Rachel Albalak, "The Health Effects of Indoor Air Pollution Exposure in Developing Countries," 78, no. 9 (2000): 1078–1092.

[35] U.S. Geologiocal Survey, "Earth's Water Distribution," http://ga.water.usgs.gov/edu/waterdistribution.html (accessed April 28, 2010).

[36] Lester R. Brown, "Draining Our Future," *Futurist* (May–June, 2008): 16–22.

[37] G. H. Brundtland and C. Bellamy, "Global Water Supply and Sanitation Assessment 2000 Report," 2001, http://www.who.int/docstore/water_sanitation_health/Globassessment/GlobalT C.htm (accessed April 28, 2010).

[38] Sandra L. Postel, Gretchen C. Daily, and Paul R. Ehrlich, "Human Appropriation of Renewable Fresh Water," *Science* 271, no. 5250 (1996): 785–788.

[39] C. W. Fetter, *Applied Hydrogeology* (New York: Macmillan, 1994).

[40] Lester R. Brown, *Plan B 3.0: Mobilizing to Save Civilization* (New York, NY: W.W. Norton, 2008), 691.

[41] Laszlo Somlyody and Olli Varis, "Freshwater Under Pressure," *International Review for Environmental Strategies* 6, no. 2 (2003): 181–204.

[42] International Federation of Red Cross and Red Crescent Societies, *World Disaster Report* (Geneva, Switzerland: IFRC, 2007), 244.

[43] A. Prüss-Üstün, R. Bos, F. Gore, and J. Bartram, *Safer Water, Better Health: Costs, Benefits and Sustainability of Interventions to Protect and Promote Health* (Geneva, Switzerland: World Health Organization, 2008), 60.

[44] See Note 43 above.

[45] Ryutaro Hashimoto, "Current Status and Future Trends in Freshwater Management," *International Review of Environmental Strategies* 3, no. 2 (2002): 222–239.

[46] See Note 41 above.

[47] See Note 40 above.

[48] See Note 41 above.

[49] Cathy C. Campbell, "Food Insecurity: A Nutritional Outcome or a Predictor Variable," *Journal of Nutrition* 121, no. 3 (1991): 408–415.

[50] See Note 41 above.

[51] Julienne Holland Stroeve and others, "Arctic Sea Ice Decline: Faster than Forecast," *Geophysical Research Letters* 34, no. 9 (2007): L09501.

[52] David Adam, "Meltdown of Winter Ice Linked to Greenhouse Gases," *Guardian* (May 15, 2006): 12.

[53] Gordon McGranahan, Deborah Balk, and Bridget Anderson, "The Rising Tide: Assessing the Risks of Climate Change and Human Settlements in Low Elevation Coastal Zones," *Environment and Urbanization* 19, no. 1 (2007): 17–37.

[54] John Krist, "Water Issues Will Dominate California's Agenda This Year," *Environmental News Network* (February 21, 2003): 33.

[55] See Note 40 above.

[56] See Note 40 above.

[57] Terrence Thompson and others, *Chemical Safety of Drinking Water: Assessing Priorities for Risk Management* (Geneva, Switzerland: World Health Organization, 2007), 160.

[58] United States Environemntal Protection Agency, "Protecting Water Quality from Agricultural Runoff," http://www.epa.gov/owow/nps/Ag_Runoff_Fact_Sheet.pdf (accessed April 28, 2010).

[59] Shlomo Angel, Stephen C. Sheppard, and Daniel L. Civco With Robert Buckley, Anna Chabaeva, Lucy Gitlin, Alison Kraley, Jason Parent, and Micah Perlin, *The Dynamics of Global Urban Expansion* (Washington, DC: The World Bank, 2005), 12.

[60] See Note 4 above.

[61] See Note 60 above.

[62] Alexander V. Sergeev and David O. Carpenter, "Hospitalization Rates for Coronary Heart Disease in Relation to Residence Near Areas Contaminated with Persistent Organic Pollutants and Other Pollutants," *Environmental Health Perspectives* 113, no. 6 (2005): 756–761.

[63] Food and Agriculture Organization, *Global Forest Resources Assessment 2005—Progress Towards Sustainable Forest Management*. Forestry Paper 147 (United Nations: Rome, 2006a): 320.

[64] See Note 60 above.

[65] United Nations General Assembly, "United Nations General Assembly Document A/AC.241/27," September 12, 1994, 4.

[66] See Note 60 above.

[67] See Note 6 above.

[68] See Note 60 above.

[69] FAO, *The State of the World's Fisheries and Aquaculture 2004* (Rome, Italy: Food and Agriculture Organization of the United Nations, 2004), 154.

[70] G. P. Nabhan and S. L. Buchman, "Services Provided by Pollinators," in *Nature's Services—Societal Dependence on Natural Ecosystems*, ed. G. E. Daily (Washington, DC: Island Press, 1997), 392.

[71] UNEP, *Marine and Coastal Ecosystems and Human Well-Being: A Synthesis Report Based on the Findings of the Millennium Ecosystem Assessment*. DEW/0785/NA. (Nairobi, Kenya: United Nations Environment Programme, 2006a), 80.

[72] See Note 4 above.

[73] IUCN, "IUCN Red List of Threatened Species. Version 2009.2." 2009, *International Union for Conservation of Nature and Natural Resources*. http://www.iucnredlist.org/documents/summarystatistics/2009RL_Stats_Table_1.pdf (accessed April 28, 2010).

[74] See Note 70 above.

[75] See Note 73 above.