UNIT VII: GLOBAL CHANGE (10–15%)

Areas on Which You Will Be Tested

A. **Stratospheric Ozone**—formation of stratospheric ozone, ultraviolet radiation, causes of ozone depletion, effects of ozone depletion, strategies for reducing ozone depletion, and relevant laws and treaties.

B. **Global Warming**—greenhouse gases and the greenhouse effect, impacts and consequences of global warming, reducing climate change, and relevant laws and treaties.

C. **Loss of Biodiversity**
   1. Habitat loss—overuse, pollution, introduced species, and endangered and extinct species.
   2. Maintenance through conservation.
   3. Relevant laws and treaties.

Stratospheric Ozone and Global Warming

CHAPTER 11

I believe that global warming is a myth. And so, therefore, I have no conscience problems at all and I'm going to buy a Suburban next time.
—Rev. Jerry Falwell

STRATOSPHERIC OZONE

The stratosphere contains approximately 97% of the ozone in the atmosphere and most of it lies between 9 and 25 miles (15 to 40 km) above Earth's surface. Most ozone is formed over the tropics. However, slow circulation currents carry the majority of it to the poles, resulting in the thickest layers over the poles and the thinnest layer above the tropics. It also varies somewhat due to season, being somewhat thicker in the spring and thinner during the autumn. The increase in temperature with height in the stratosphere occurs because of absorption of ultraviolet radiation by ozone.

Ozone is formed in the stratosphere by the reaction of ultraviolet radiation striking an oxygen molecule. This results in the oxygen molecule splitting apart and forming atomic oxygen: $O_2 + hv \rightarrow O + O$. Atomic oxygen can now react with molecular oxygen to form ozone: $O + O_2 \rightarrow O_3$. The reverse reaction also occurs when ultraviolet radiation strikes an ozone molecule, causing it to form atomic oxygen and molecular oxygen: $O_3 + hv \rightarrow O + O_2$. Atomic oxygen can also react with ozone to produce oxygen gas: $O + O_3 \rightarrow O_2 + O_2$. Generally, these reactions balance each other so that the concentration of ozone in the stratosphere remains fairly constant, which keeps the amount of UV radiation reaching Earth also constant. Various forms of life on Earth have evolved over millions of years with fairly constant amounts of UV radiation.

Ultraviolet Radiation

The sun emits a wide variety of electromagnetic radiation, including infrared, visible, and ultraviolet. Ultraviolet radiation can be subdivided into three forms: UVA, UVB, and UVC.

UVA

320 to 400 nm wavelength. Closest to blue light in the visible spectrum. The form that usually causes skin tanning. UVA radiation is 1,000 times less effective than UVB in producing skin redness, but more of it reaches Earth's surface than UVB. Birds, reptiles, and bees can see UVA. Many fruits, flowers, and seeds also stand out more strongly from the background in ultraviolet wavelengths. Many birds have patterns in their plumage that are not visible in the normal spectrum (white light) but become visible in ultraviolet. Urine of some animals is also visible only in the UVA spectrum.

UVB

290 to 320 nm wavelength. Causes blistering sunburns and is associated with skin cancer.

UVC

10 to 290 nm. Found only in the stratosphere and largely responsible for the formation of ozone.

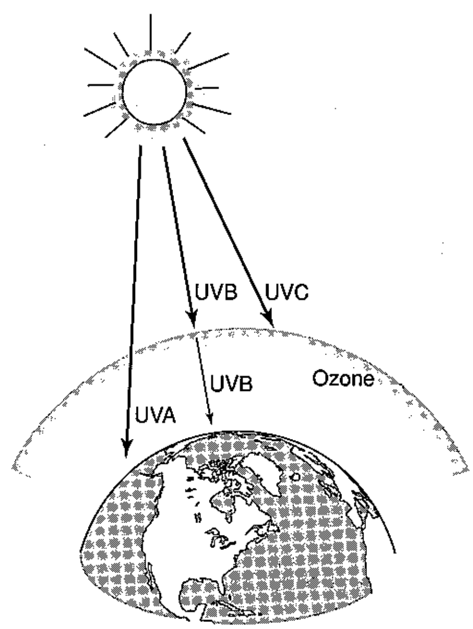


Figure 11.1 Ultraviolet radiation reaching Earth

Causes of Ozone Depletion

Thinning of the ozone layer was first discovered in 1985. It occurs seasonally and is due to the presence of human-made compounds containing halogens (chlorine, bromine, fluorine, or iodine). Measurements indicate that the ozone over the Antarctic has decreased as much as 60% since the late 1970s with an average net loss of about 3% per year worldwide.

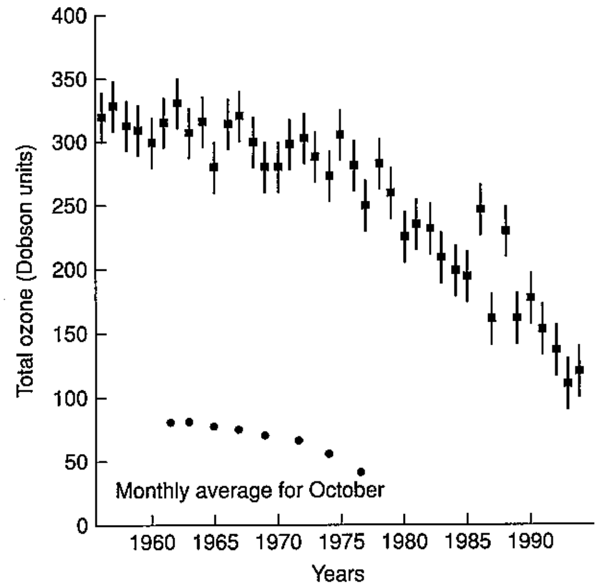
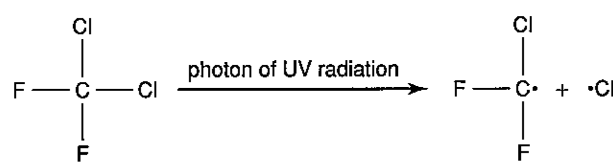


Figure 11.2 Ozone concentration over Antarctica (1955–1995)

The main culprits in the depletion of the ozone layer are compounds known as CFCs (chlorofluorocarbons). First manufactured during the 1920s, they are used as refrigerants (for example, Freon), aerosol propellants, electrical part cleaning solvents, and in the manufacture of foam products and insulation. By 1974, nearly 1 million tons of CFC gases were produced each year, and the chemicals were generating $8 billion worth of business. The largest single source of CFCs to the atmosphere is leakage from air conditioners. The average residence time of CFCs in the environment is 200 years.

When a CFC molecule enters the stratosphere, ultraviolet radiation causes it to decompose and produce atomic chlorine:



This atomic chlorine then reacts with the ozone in the stratosphere to produce chlorine monoxide (ClO):

$$Cl + O_3 \rightarrow ClO + O_2$$

The chlorine monoxide then reacts with more ozone to produce even more atomic chlorine in what becomes essentially a chain reaction:

$$ClO + O_3 \rightarrow Cl + 2O_2$$

Thus, one chlorine atom released from a CFC can ultimately destroy over 100,000 ozone molecules. Much of the destruction of the ozone layer that is occurring now is the result of CFCs that were produced many years ago since a CFC molecule takes 8 years to reach the stratosphere and the residence time in the stratosphere for a CFC molecule is over 100 years.

Bromine, found in much smaller quantities than chlorine, is about 50 times more effective than chlorine in its effect on stratospheric ozone depletion and is responsible for about 20% of the problem. Bromine is found in halons, which are used in fire extinguishers. Methyl bromide is used in fumigation and agriculture. It is naturally released from phytoplankton and biomass burning.

Effects of Ozone Depletion

During the onset of the 1998 Antarctic spring, a hole three times the size of Australia (over 3,500 miles [5,600 km] in diameter) developed in the ozone layer over the South Pole. Stratospheric ozone protects life from harmful ultraviolet radiation. Harmful effects of increased UV radiation include:

- Increases in skin cancer
- Increases in sunburns and damage to the skin
- Increases in cataracts of the eye
- Reduction in crop production
- Deleterious effects to animals (they don't wear sunglasses or sunscreen)
- Reduction in the growth of phytoplankton and the cumulative effect on food webs
- Increases in mutations since UV radiation causes changes in DNA structure
- Cooling of the stratosphere
- Reduction in the body's immune system
- Climatic change

Strategies for Reducing Ozone Depletion

Although most developed countries have phased out ozone-destroying chemicals, they are still legal in developing nations. There are several alternatives to CFC use. First, HCFC replaces chlorine with hydrogen. Unfortunately, it is still capable of destroying ozone albeit less effectively because it breaks down more readily in the troposphere. Second, alternatives to halons can be used in fire extinguishers. Third, helium, ammonia, propane, or butane can be used as a coolant. Helium-cooled refrigerators use 50% less electricity than those using CFCs or HCFCs. Individuals can use pump sprays instead of aerosol spray cans when possible, comply with disposal requirements of the Clean Air Act for old refrigerators and air conditioners, read labels and, when choices are available, use ozone friendly products, and support legislation that reduces ozone-destroying products.

RELEVANT LAWS AND TREATIES

Montreal Protocol (1987): Designed to protect the stratospheric ozone layer. The treaty was originally signed in 1987 and substantially amended in 1990 and 1992. The Montreal Protocol stipulated that the production and consumption of compounds that deplete ozone in the stratosphere—chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform—were to be phased out by 2000 (2005 for methyl chloroform).

London (1990): The countries that signed the Montreal Protocol met again in London and decided that a total phaseout of CFCs was necessary. They agreed that this could be achieved by the year 2000. Control measures were also adopted for carbon tetrachloride and methyl chloroform.

Copenhagen (1992): The phaseout schedule for CFCs was again accelerated, with the industrialized countries agreeing to stop production by 1996. This goal had already been prescribed in the United States in the 1990 amendments to the Clean Air Act. In 1994, the European Community decided that a phaseout could be achieved in Europe by 1995.

GLOBAL WARMING

When sunlight strikes Earth's surface, some of it is reflected back toward space as infrared radiation (heat). Greenhouse gases absorb this infrared radiation and trap the heat in the atmosphere.

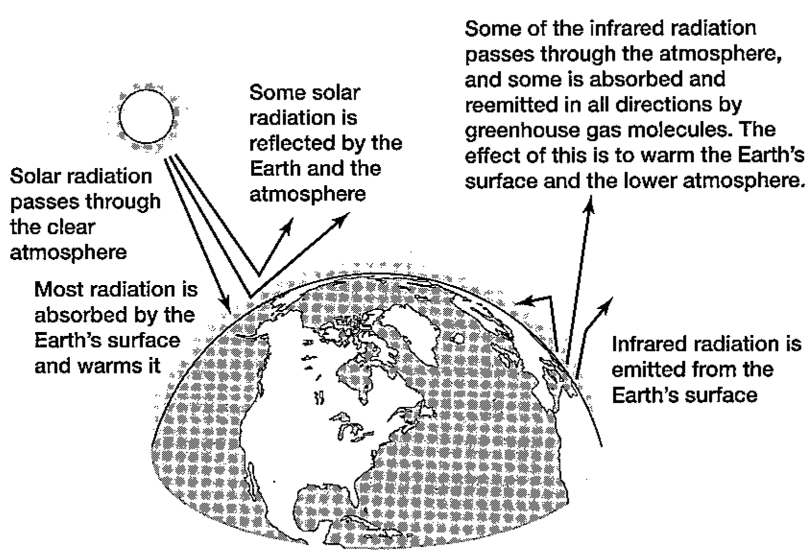


Figure 11.3 The greenhouse effect

Greenhouse Gases

Greenhouse Gas	Average Time in Troposphere (Years)	Relative Warming Potential (CO_2 = 1)	Source
Carbon dioxide (CO_2)	100	1	Burning oil, coal, plants, deforestation, cellular respiration
Carbon tetrachloride (CCl_4)	45	1,500	Cleaning solvent
Chlorofluorocarbons (CFCs)	15 (100 in stratosphere)	1,000–8,000	Air conditioners, refrigerators, foam products, insulation
Halons	65	6,000	Fire extinguishers
Hydrochlorofluorocarbons (HCFCs)	10–400	500–2,000	Air conditioners, refrigerators, foam products, insulation
Hydrofluorocarbons (HFCs)	15–400	150–13,000	Air conditioners, refrigerators, foam products, insulation
Methane (CH_4)	15	25	Rice cultivation, enteric fermentation, production of coal, natural gas leaks
Nitrous oxide (N_2O)	115	300	Burning fossil fuels, fertilizers, livestock wastes, plastic manufacturing
Sulfur hexafluoride (SF_6)	3,200	24,000	Electrical industry as a replacement for PCBs
Tropospheric Ozone (O_3)	Variable	3,000	Combustion of fossil fuels

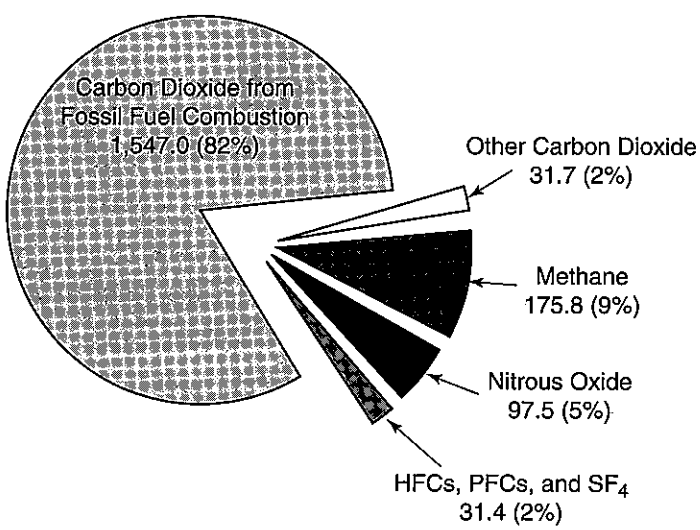


Figure 11.4 U.S. anthropogenic greenhouse gas emissions 2001
(Million Metric Tons of Carbon Equivalent)

Levels of several important greenhouse gases have increased by about 25% since large-scale industrialization began around 150 years ago. During the past 20 years, about three-quarters of human-made carbon dioxide emissions were from burning fossil fuels. In the United States, greenhouse gas emissions come mostly from energy use. These are driven largely by economic growth, fuel used for electricity generation, and weather patterns affecting heating and cooling needs. Energy-related carbon dioxide emissions, resulting from petroleum and natural gas, represent 82% of total U.S. anthropogenic (caused by humans) greenhouse gas emissions.

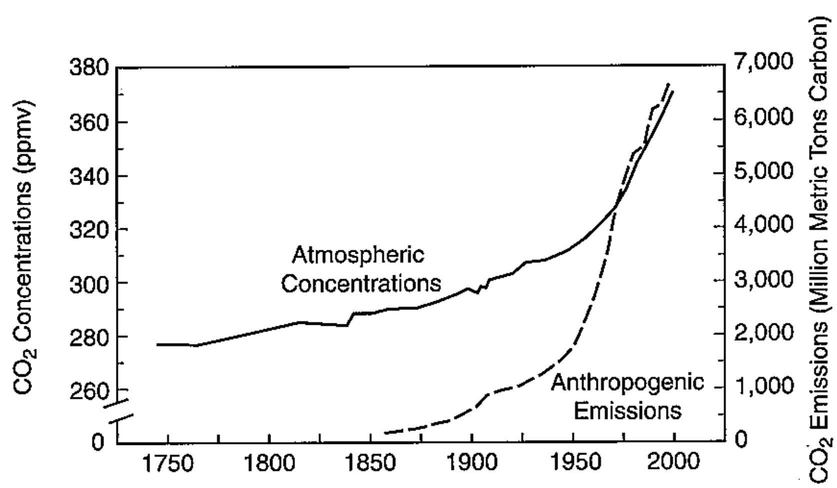


Figure 11.5 Trends in atmospheric concentrations
Source: Oak Ridge National Laboratory

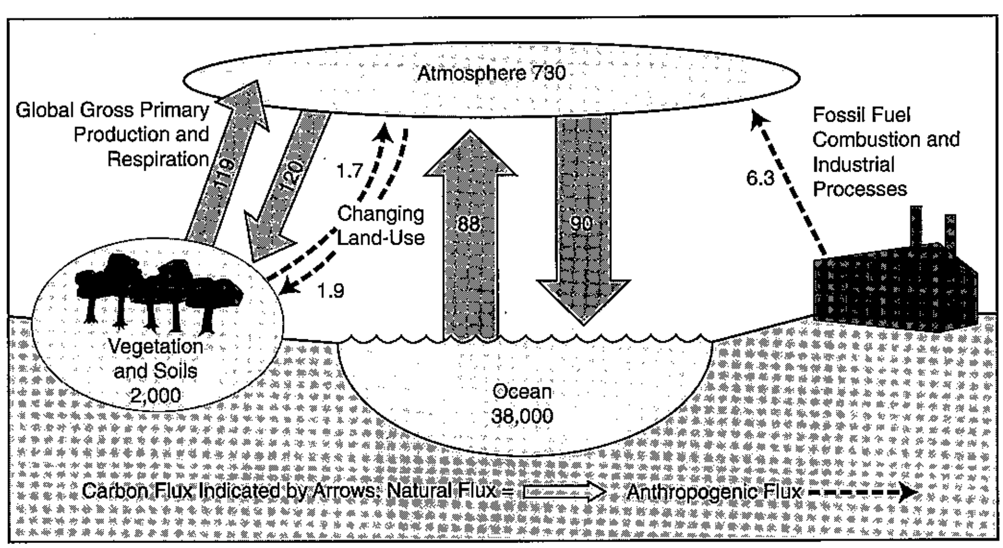


Figure 11.6 Global carbon cycle (billion metric tons carbon)
Source: Intergovernmental Panel on Climate Change

Concentrations of carbon dioxide in the atmosphere are naturally regulated by numerous processes collectively known as the carbon cycle. The movement (flux) of carbon between the atmosphere and the land and oceans is dominated by natural processes, such as plant photosynthesis. Although these natural processes can absorb some of the net 6.1 billion metric tons of anthropogenic carbon dioxide emissions produced each year (measured in carbon equivalent terms), an estimated 3.2 billion metric tons is added to the atmosphere annually. Earth's positive imbalance between emissions and absorption results in the continuing growth in greenhouse gases in the atmosphere.

Impacts and Consequences of Global Warming

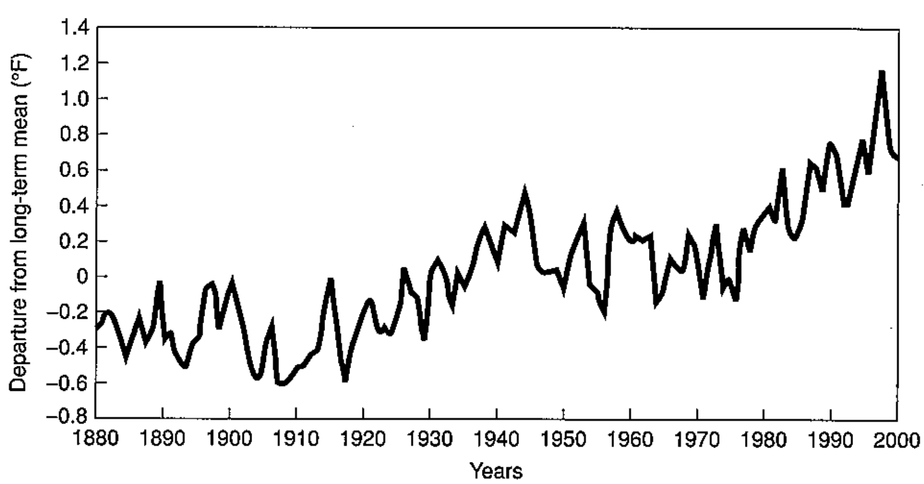
Global warming affects the weather, the economy, and numerous other aspects of life.

ACIDIFICATION

The oceans currently absorb 1 metric ton of carbon dioxide per person per year. Increased carbon dioxide absorption of oceans will lower the pH of seawater. This adversely affects corals, plankton, organisms with shells, and reproduction rates as eggs and sperm are exposed to higher levels of acid.

CHANGES IN TROPOSPHERIC WEATHER PATTERNS

Air temperatures today average 5°F to 9°F (3°C to 5°C) warmer than they were before the Industrial Revolution. Historic increases in air temperature averaged less than 2°F (1°C) per 1,000 years. Higher temperatures result in higher amounts of rainfall due to higher rates of evaporation. Worldwide, hurricanes of category 4 or 5 have risen from 20% of all hurricanes in the 1970s to 35% in the 1990s. Precipitation due to hurricanes in the United States has increased 7% during the 20th century. More rainfall increases erosion, which then leads to higher rates of desertification due to deforestation. This then leads to losses in biodiversity as some species are forced out of their habitat. El Niño and La Niña patterns and their frequencies have also changed.



Source: U.S. National Climatic Data Center, 2001

Figure 11.7 Global temperature changes (1880–2000)

DISPLACEMENT OF PEOPLE

The United Nations estimates that by the year 2050, 150 million people will need to be relocated worldwide. This will occur due to the effects of coastal flooding, shoreline erosion, and agricultural disruption.

ECOLOGICAL PRODUCTIVITY

Satellite photos have shown that productivity in the Northern Hemisphere has increased since 1982. However, biomass increases due to warmer temperatures reaches a certain point—the point where limiting factors of water and nutrients curb future productivity increases. In the tropics, plants increase productivity more so than trees (which are carbon sinks). With higher percentages of plants due to increased temperatures and carbon dioxide concentrations, the rates of decomposition increase because plants are shorter lived. As a result, more carbon enters the carbon cycle.

FOREST FIRES

Boreal forest fires in North America used to average 2.5 million acres (10,000 sq km). They now average 7 million acres (28,000 sq km). Forest management practices may also be contributing to the increase.

GLACIER MELTING

Total surface area of glaciers worldwide has decreased by 50% since the end of the 19th century. Temperatures of the Antarctic Southern Ocean rose 0.31°F (0.17°C) between the 1950s and the 1980s. Glacier melting causes landslides, flash floods, glacial lake overflow, and increased variation in water flows into rivers. Hindu Kush and Himalayan glacier melts are reliable water sources for many people in China, India, and much of Asia. Global warming initially increases water flow, causing flooding and disease. Flow will then decrease as the glacier volume dwindles, resulting in drought. Eventual decreases in glacial melt will also affect hydroelectric production.

INCREASED HEALTH AND BEHAVIORAL EFFECTS

Higher temperatures result in higher incidences of heat-related deaths. Estimates indicate that a temperature increase of just 2°F (1°C) will result in approximately 25,000 additional homicides in the United States due to stress and resulting rage.

INCREASE IN DISEASE

Rates of malaria (due to increase in mosquitoes), cholera, and other waterborne diseases will increase. Remediation and mitigation efforts will end up costing more.

INCREASED PROPERTY LOSS

Weather-related disasters have increased 3-fold since the 1960s. Insurance payouts have increased 15-fold (adjusted for inflation) during this same time period. Much of this can be attributed to people moving to vulnerable coastal areas.

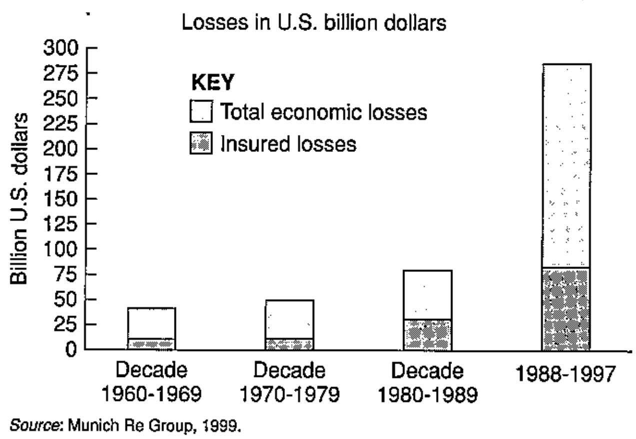


Figure 11.8 Weather and flood catastrophes since 1960

LOSS IN ECONOMIC DEVELOPMENT

Money that was designed to increase education, improve health care, reduce hunger, and improve sanitation and fresh water supplies, will instead be spent on mitigating the effects of global warming.

LOSS OF BIODIVERSITY

Arctic fauna will be most affected. The food webs of polar bears that depend on ice flows, birds, and marine mammals will be negatively impacted. Many refugee species currently have shifted their ranges toward the poles, averaging 4 miles (6 km) per decade. Bird migrations are averaging over two days earlier per decade. Grasses have become established in Antarctica for the first time. Many species of fish and krill that require cooler waters will be negatively impacted. Decreased glacier melt will impact migratory fish, such as salmon, that need sufficient river flow.

RELEASES OF METHANE FROM HYDRATES IN COASTAL SEDIMENTS

Methane hydrate (methane clathrate) is a form of water ice that contains methane within its crystal structure. Extremely large deposits of this resource have been discovered in ocean sediments.

RELEASES OF METHANE FROM THAWING PERMAFROST REGIONS

Thawing of permafrost would increase bacterial levels in the soil and eventually lead to higher releases of methane. Estimates of melting of permafrost peat bogs in Siberia could release as much as 70,000 million metric tons of methane (a greenhouse gas) within the next few decades.

RISE IN SEA LEVEL

Sea levels have risen 400 feet (120 m) since the peak of the last ice age (18,000 years ago). From 3,000 years ago to the start of the Industrial Revolution, the rate of sea level rise averaged 0.1 to 0.2 mm per year. Since 1900, sea level has risen about 3 mm per year (over a 10-fold increase). An increase in global temperatures of 3°F to 8°F (1.5°C to 4.5°C) is estimated to lead to an increase of 6 to 37 inches (15 cm to 95 cm) in sea level. If all glaciers, ice caps, and ice sheets melted on Earth, the sea level would rise about 225 feet (69 m). Rises in sea level would:

- Increase coastal erosion
- Create higher storm surge flooding with coastal inundation
- Increase loss of property and coastal habitats
- Cause losses in fish and shellfish catches
- Cause loss of cultural resources and values such as tourism and recreation
- Cause losses in agriculture and aquaculture due to diminishing soil and water quality
- Result in the intrusion of salt water in aquifers.

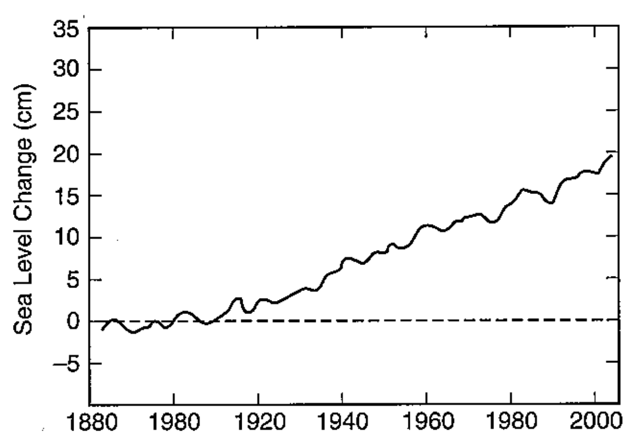


Figure 11.9 Sea level rise (1880–2000)

SLOWING OR SHUTDOWN OF THERMOHALINE CIRCULATION

Melting of the glaciers in Greenland would shift the salt water–freshwater balance in the North Atlantic. This would result in a decrease of heavier saline waters sinking than in traditional ocean circulation patterns. This would have significant effects on the fishing industry. Localized cooling in the North Atlantic brought about through the reduction of thermohaline circulation currents (North Atlantic drift) could result in much colder temperatures in Great Britain and Scandinavia.

Reducing Climate Change

World carbon dioxide emissions are expected to increase by 2% annually between 2001 and 2025. Much of the increase in these emissions is expected to occur in the developing world, such as China and India, where emerging economies fuel economic development with fossil energy. Developing countries' emissions are expected to grow by 3% annually between 2001 and 2025 and surpass emissions of industrialized countries by 2018.

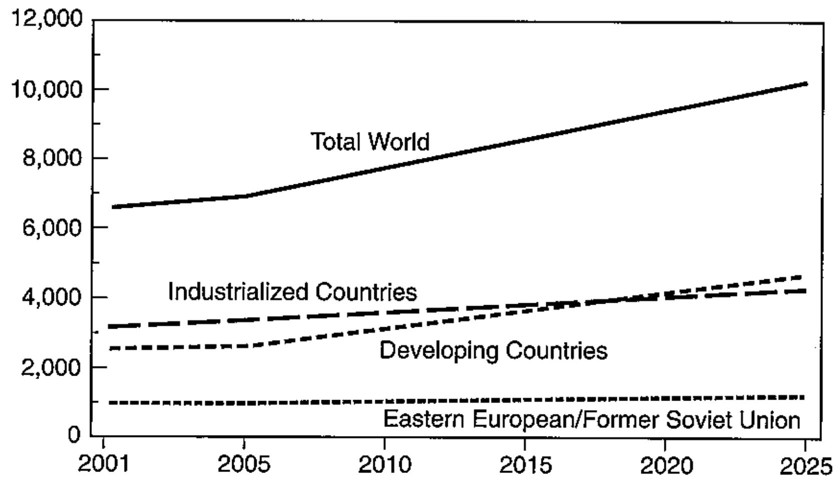


Figure 11.10 World carbon dioxide emissions by region, 2001–2025 (million metric tons of carbon equivalent)
Source: Energy Information Administration

The United States produces about 25% of global carbon dioxide emissions from burning fossil fuels. This is due primarily to a robust economy and 85% of the U.S. energy needs being met through burning fossil fuels.

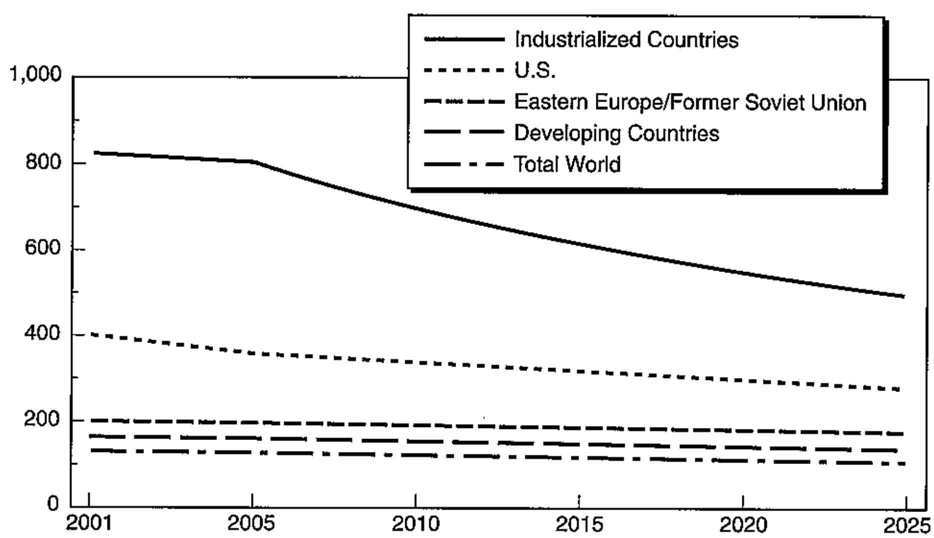


Figure 11.11 Carbon intensity by region, 2001–2025 (metric tons of carbon equivalent per million)
Source: Energy Information Administration

To stabilize the current global warming crisis would require:

1. A decrease in methane emissions by 8%
2. A decrease in nitrous oxide emissions by 50%
3. A decrease in carbon dioxide emissions by up to 80%

Six methods can be used to reduce dramatic climatic changes brought on by global warming. The first is increasing the efficiency of cars, which would then reduce the dependence on oil and other fossil fuels. Cars currently represent 25% of the carbon dioxide emissions in the United States. The second method is to use energy more efficiently and move to renewable energy sources (wind, solar, geothermal, bioenergy, and so on). The third is finding chemical substitutes that do not impact global warming and banning chemicals that do. The fourth method is to slow down the rate of deforestation and encourage reforestation. The fifth is reducing dependence on inorganic, nitrogen-based fertilizers and substituting conservation tillage techniques. The sixth is to support treaties, protocols, and legislation that require a reduction in greenhouse gases.

LOSS OF BIODIVERSITY

Information on habitat destruction needs to be compared with past habitat conditions. Long-term history of habitat conditions can be obtained from fossil records, ice core samples, tree ring analysis, and the analysis of pollen. Organisms can cope with habitat destruction by migration, adaptation, and acclimatization. Migration depends on the magnitude of degradation, rate of degradation, organism's ability to migrate, access routes or corridors, and proximity and availability of suitable new habitats. Adaptation is the ability to survive due to changing environmental conditions. Adaptation depends on the magnitude of degradation, rate of degradation, birth rate, length of generation, population size, genetic variability, and gene flow between populations as a function of variation. Acclimatization is the ability to adjust to environmental changes on an individual or population level. Acclimatization depends on the magnitude and rate of degradation and the physiological and/or behavioral limitations of the species.

Plants are initially more susceptible to habitat loss than animals. This occurs for several reasons: plants cannot migrate; dispersal rates of seeds are slow events (for example, spruce trees can increase their range about 1 mile, or 1.6 km, every 100 years); plants cannot seek nutrients or water; seedlings must survive and grow in degraded conditions; and stressed plants become prone to disease and infestation.

Overuse

Worldwide, more than 3 million fishing boats remove 70 million to 90 million tons of fish and shellfish from the oceans each year. Of the world's marine fish stocks, 70% are fully exploited, overfished, or depleted. Twenty-million metric tons of bycatch (fish and shellfish not sought after) are destroyed each year and represents one-fourth of all catch taken from the sea. Around 80,000 whales, dolphins, seals, and other marine mammals perish as bycatch each year. Shrimp trawlers throw back 5.2 pounds (2.4 kg) of marine life that will eventually die for every pound (0.5 kg) of shrimp they catch. Overall, this amounts to almost 3 billion pounds (1.4 billion kg) of fish destroyed annually by the shrimp industry.

Pollution

Pollution results from human activities such as urban sprawl, transportation, and industry. More significantly in terms of wildlife and biodiversity, human activity expands the effects of pollution into areas where environmental quality may not yet have been severely compromised. Industrial and transportation sources release pollutants into the air, water, and soil that are toxic to most species and degrade their habitats. In addition, light and noise associated with human activity often have negative effects on wildlife behavior and natural cycles.

Pollutants have devastating effects on wildlife when they are released into the soil and water. They affect an animal's endocrine, reproductive, and immune systems. Wildlife can be exposed to pollutants through skin absorption, the animals or plants they eat, and the water they drink. Amphibians and other aquatic species are especially vulnerable to pollutants in streams, rivers, and lakes.

Plants or wildlife (especially species with thin, moist skin such as amphibians) can inhale or absorb air pollutants, causing health problems. Air pollution also contaminates water and soil through acid rain. Sulfur dioxide, a main component of acid rain, can damage plant communities by impairing photosynthesis processes. Plants weakened by acid rain may become vulnerable to root rot, insect damage, and disease, causing serious damage to plant communities and forest ecosystems.

Noise can affect wildlife behavior and physiology. Noise can also cause chronic stress, increased heart rates, metabolism and hormone imbalance, and nervous system stimulation. These responses may cause energy loss, food intake reduction, an avoidance and abandonment of habitat, and even injury or death. Noise will often flush birds from their nests, causing broken eggs, injured young, or exposure to predators. Finally, birdsongs and calls that are used to mate and establish territories may be disrupted by excessive human noise pollution.

Developed areas produce artificial light that causes problems for wildlife that depend on the light from the moon and stars to navigate. Streetlights, neon signs, parking lots, and late-night golf driving ranges may potentially keep wildlife from moving, nesting, or foraging near urban areas.

Introduced Species

Invasive or exotic species are animals and plants that are transported to any area where they do not naturally live. The spread of nonnative species has emerged in recent years as one of the most serious threats to biodiversity. It has undermined the ecological integrity of many native habitats and pushed some rare species to the edge of extinction. Some introduced species simply outcompete native plants and animals for space, food, or water. Others may also fundamentally alter natural disturbance regimes and other ecological processes, making it difficult or impossible for native species to survive. About 15% of the estimated 6,000 nonnative plant and animal species in the United States cause severe economic or ecological impacts. Exotic species have been implicated in the decline of approximately 40% of the species listed for protection under the federal Endangered Species Act.

A major marine source is marine ballast. Every 60 seconds, ships discharge 40,000 gallons (150,000 L) of ballast water that contains foreign plant and animal species into U.S. harbors. Often these plants and animals grow at uncontrolled rates because they have no natural predators in these new locations. These introduced species often become pests and crowd out native plants and animals. Over 250 invasive species of plants and animals are found in San Francisco Bay alone. Common examples of invasive species include zebra mussels, tumbleweed, kudzu, the mongoose, and gypsy moths.

Endangered and Extinct Species

Since 1500 C.E., 816 species have become extinct, 103 of them since 1800—a rate 50 times greater than the natural background rate. In the next 25 years, extinction rates are expected to rise as high as 25%. According to the Nature Conservancy, about one-third of all U.S. plant and animal species are at risk of becoming extinct. Mammals listed as "endangered" rose from 484 in 1996 to 520 in 2000, with primates increasing from 13 to 19. Endangered birds increased from 403 species to 503 species. Endangered freshwater fish more than doubled—from 10 species to 24 species in four years. One-fourth of all mammals and reptiles, one-fifth of all amphibians, one-eighth of all birds, and one-sixth of all conifers are in some manner endangered or are threatened to the point of extinction.

Maintenance Through Conservation

Maintaining and protecting wildlife consists of three major approaches:

- **Species approach**—Protecting *endangered species* through legislation.
- **Ecosystem approach**—Preserving balanced *ecosystems*.
- **Wildlife management approach**—Managing *game species* for sustained yield through international treaties to protect migrating species, improving wildlife habitats, regulating hunting and fishing, creating harvest quotas, and developing population management plans.

Biodiversity can be protected by:

1. Properly designing and updating laws that legally protect endangered and threatened species (such as the Endangered Species Act)
2. Protecting the habitats of endangered species through private or governmental land trusts
3. Reintroducing species into suitable habitats
4. Managing habitats and monitoring land use
5. Establishing breeding programs for endangered or threatened species
6. Creating and expanding wildlife sanctuaries
7. Restoring compromised ecosystems
8. Reducing nonnative and invasive species

RELEVANT LAWS AND TREATIES

Lacey Act (1900): Aided in restoring birds in parts of the United States where they had become scarce.

Migratory Bird Treaty Act (1918): Implemented the protection of migratory birds.

Multiple-Use Act (1960): Directed that the national forests be managed for timber, watershed, range, outdoor recreation, wildlife, and fish purposes.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (1963): An international agreement between governments to ensure that international trade in wild animals and plants did not threaten their survival.

Fur Seal Act (1966): Prohibited the taking of fur seals.

National Wildlife Refuge System Act (1966): Provided for the administration and management of the National Wildlife Refuge System.

Marine Mammal Protection Act (1972): Established federal responsibility to conserve marine mammals.

Marine Protection and Sanctuaries Act (1972): Established national marine sanctuaries.

Endangered Species Act (1973): Provided a program for the conservation of threatened and endangered plants and animals and the habitats in which they are found.

Fishery Conservation and Management Act—Magnuson-Stevens Fisher Act (1976): Established a 200-mile (320-km) zone off the coast of the United States that is off-limits for foreign fishing.

Alaska National Interest Lands Conservation Act (1980): Designated large areas of Alaska as national parks, wildlife refuges, and national forests.

Convention for the Conservation of Antarctic Marine Living Resources (1980): A treaty that required management of all southern ocean fisheries that have potential negative effects on the Antarctic ecosystem.

Nonindigenous Aquatic Nuisance Prevention and Control Act (1990): Federal program to prevent introduction of and to control the spread of aquatic invasive species.

QUICK REVIEW CHECKLIST

- ☐ **Stratospheric Ozone**
  - ☐ ultraviolet radiation
    - ☐ UVA
    - ☐ UVB
    - ☐ UVC
  - ☐ causes of ozone depletion
  - ☐ effects of ozone depletion
  - ☐ strategies for reducing ozone depletion
  - ☐ relevant laws and treaties
    - ☐ Montreal Protocol (1987)
    - ☐ London (1990)
    - ☐ Copenhagen (1992)
- ☐ **Global Warming**
  - ☐ greenhouse gases
    - ☐ carbon dioxide
    - ☐ methane
    - ☐ nitrous oxide
    - ☐ HFC, CFC, HCFC, SF_6
  - ☐ impacts and consequences of global warming
    - ☐ acidification
    - ☐ changes in tropospheric weather patterns
    - ☐ displacement of people
    - ☐ ecological productivity
    - ☐ forest fires
    - ☐ glacier melting
    - ☐ health and behavioral effects
    - ☐ disease
    - ☐ property loss
    - ☐ economic development
    - ☐ biodiversity
    - ☐ methane hydrates in coastal sediments
    - ☐ thawing of permafrost and release of methane
    - ☐ rise in sea level
    - ☐ effect on thermohaline circulation
- ☐ **Reducing Climate Change**
- ☐ **Loss of Biodiversity**
- ☐ **Overuse**