Desertification

Desertification is the conversion of marginal rangeland or cropland to a more desert-like land type. It is often caused by overgrazing, soil erosion, prolonged drought, or climate changes as well as the overuse of available resources such as nutrients and water. Desertification proceeds with the following steps: First, overgrazing results in animals eating all available plant life. Next, rain washes away the trampled soil, since nothing holds water anymore. Wells, springs, and other sources of water dry up. What vegetation is left dies from drought or is taken for firewood. Then weeds that are unsuitable for grazing may begin to take over. The ground becomes unsuitable for seed germination. Finally, wind and dry heat blow away the topsoil.

Federal Rangeland Management

Rangelands comprise about 40% of the landmass of the United States and are the dominant type of land in arid and semiarid regions. Nearly 80% of the lands of the western United States are classified as rangelands, whereas only 7% of some areas near the East Coast are classified as rangelands. Rangelands provide valuable grazing lands for livestock and wildlife. Rangelands serve as a source of high-quality water, clean air, and open spaces. They benefit people as a setting for recreation and as an economic means for agriculture, mining, and living communities. Rangelands serve multiple purposes:

- A habitat for a wide array of game and nongame animal species
- A habitat for a diverse and wide array of native plant species
- A source of high-quality water, clean air, and open spaces
- A setting for recreational hiking, camping, fishing, hunting, and nature experiences
- The foundation for low-input, fully renewable food production systems for the cattle industry

Jurisdiction of public grazing rangelands is coordinated through the Forest Service and the Bureau of Land Management (BLM). Before 1995, grazing policies were determined by rancher advisory boards composed of permit holders. After 1995, resource advisory councils were formed made up of diverse groups representing different viewpoints and interests. Forty percent of all federal grazing permits are owned by 3% (or approximately 2000) of all livestock operators. Federal grazing permits average about 5 cents per day per animal through federal subsidies. The true cost of doing business would make this fee closer to $10 to $20 per animal per day.

Methods of rangeland management include:

1. Controlling the number and distribution of livestock so that the carrying capacity is not exceeded
2. Restoring degraded rangeland
3. Moving livestock from one area to another to allow the rangeland to recover
4. Fencing off riparian (stream) areas to reduce damage to these sensitive areas
5. Suppressing the growth of invasive plant species
6. Replanting barren rangeland with native grass seed to reduce soil erosion

7. Providing supplemental feed at selected sites
8. Locating water holes, water tanks and salt blocks at strategic points that do not degrade the environment

Land administered by the BLM is inhabited by 219 endangered species of wildlife. Livestock grazing is the fifth-rated threat to endangered plant species, the fourth leading threat for all endangered wildlife, and the number one threat to all endangered species in arid regions of the United States.

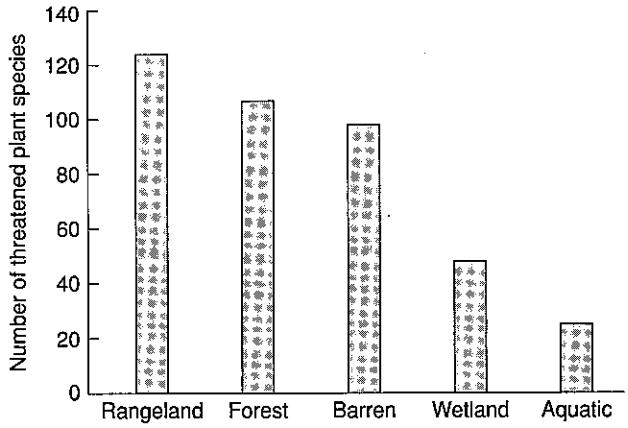


Figure 7.5 Endangered plant species as a function of biome

RELEVANT LAWS

Taylor Grazing Act (1934): Requires grazing permits on federal land.

Renewable Resources Planning Act (RPA) (1974): Mandates periodic assessments of forests and rangelands in the United States. Directs that the assessment be conducted by the U.S. Forest Service and consider a broad range of renewable resources, including outdoor recreation, fish, wildlife, water, range, timber, and minerals.

Public Rangelands Improvement Act (1978): Established and reaffirmed a commitment to manage, maintain, and improve rangelands so that they become as productive as feasible.

URBAN LAND DEVELOPMENT

The following sections discuss another form of land use—urban land development.

Planned Development

There are more than 76 million residential buildings and approximately 5 million commercial buildings in the United States alone. Together, these buildings use one-third of all the energy and two-thirds of all the electricity consumed in the United States. Energy needs of buildings account for almost half of the sulfur dioxide emissions, one-fourth of the nitrous oxide emissions, and one-third of the carbon dioxide emissions.

Green building and city characteristics focus on whole-system approaches. They include:

- Energy conservation through government and private industry rebates and tax incentives for solar and other less-polluting forms of energy
- Resource-efficient building techniques and materials
- Indoor air quality
- Water conservation through the use of xeriscaping
- Designs that minimize waste while utilizing recycled materials
- Placing buildings whenever possible near public transportation hubs that use a multitude of venues such as light rail, subways, and park and rides
- Creating environments that are pedestrian friendly by incorporating parks, greenbelts, and shopping areas in accessible areas
- Preserving historical and cultural aspects of the community while at the same time blending into the natural feeling and aesthetics of a community

Suburban Sprawl and Urbanization

Urbanization refers to the movement of people from rural areas to cities and the changes that accompany it. Areas that are experiencing the greatest growth in urbanization are countries in Asia and Africa. Asia alone has close to half of the world's urban inhabitants even though 60% of its population still lives in rural areas. Africa, which is generally considered overwhelmingly rural, now has a larger urban population than North America. Reasons for this include access to jobs, higher standards of living, easier access to health care, mechanization of agriculture, and access to education. Nations with the most rapid increases in their urbanization rates are generally those with the most rapid economic growth. From 1950 to 1990, the world's economy increased fivefold.

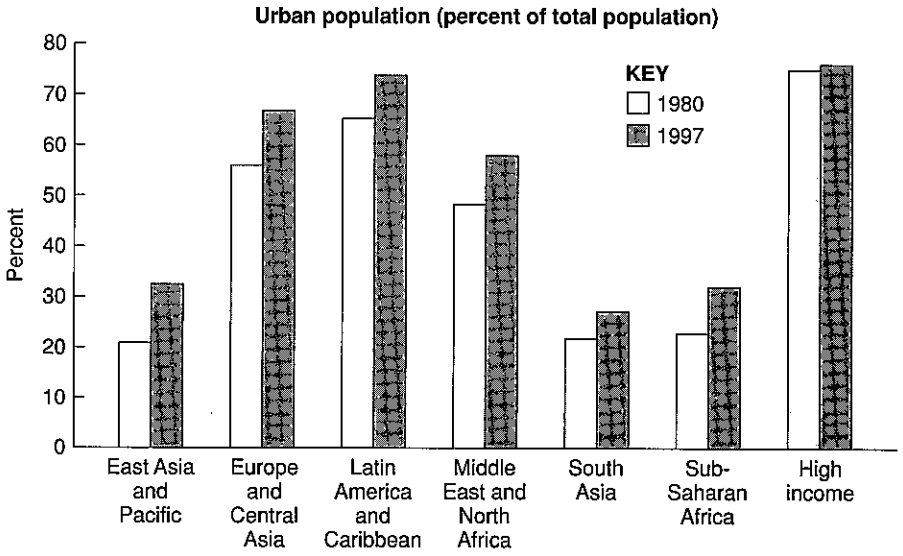


Figure 7.6 Urban population as a function of geography and income

Urbanization

Pros	Cons
Uses less land—less impact on the environment.	Impact on land is more concentrated and more pronounced. Examples include water runoff and flooding.
Better educational delivery system.	Overcrowded schools.
Mass transit systems decrease reliance on fossil fuels—commuting distances are shorter.	Commuting times are longer because the infrastructure cannot keep up with growth.
Better sanitation systems.	Sanitation systems have greater volumes of wastes to deal with.
Recycling systems are more efficient.	Solid-waste buildup is more pronounced. Landfill space becomes scarce and costly.
Large numbers of people generate high tax revenues.	Large numbers of poor people place strains on social services. This results in wealthier people moving away from urban areas into suburbs and decreasing the tax base.
Urban areas attract industry due to availability of raw materials, distribution networks, customers, and labor pool.	Higher population densities increase crime rates. Population increase may be higher than job growth.
Much of the pollution comes from point sources, enabling focused remediation techniques.	Since population densities are high, pollution levels are also high (urban heat islands, ozone levels, and water and soil pollution).

TRANSPORTATION INFRASTRUCTURE

Transportation can be via roadways or water channels. Areas without transportation infrastructure suffer an ecosystem impact.

Federal Highway System

The federal highway system contains approximately 160,000 miles (256,000 km) of roadway important to the nation's economy, defense, and mobility. Although interstate highways usually receive substantial federal funding and comply with federal standards, they are owned, built, and operated by the states in which they are located. Current federal highway taxes include an 18-cents per gallon tax on gasoline, a 25-cent per gallon tax on diesel, and a tax on heavy vehicles.

The system serves all major U.S. cities. Unlike counterparts in most industrialized countries, interstates go through downtown areas and facilitate urban sprawl. The distribution of virtually all goods and services involve interstate highways at some point. Residents of American cities commonly use urban interstates to travel to their employment.

An efficient and well-maintained federal highway system can have the following impacts on the environment:

LESS POLLUTANTS

Vehicles caught in stop-and-go traffic emit far more pollutants, particularly carbon monoxide, nitrogen oxides, and smog-forming volatile organic compounds, than they do without frequent braking and acceleration.

REDUCE GREENHOUSE GASES

Improving traffic flow and reducing congestion will decrease atmospheric carbon dioxide.

IMPROVE FUEL ECONOMY AND REDUCE FOREIGN OIL DEPENDENCE

For vehicles stuck in traffic, not only do tailpipe emissions go up but fuel economy goes down. Modest improvements to the nation's worst traffic bottlenecks would save 1 billion gallons of fuel each year.

IMPROVE THE ECONOMY

Interstates return $6 in economic productivity for every $1 invested.

IMPROVE THE QUALITY OF LIFE

An interstate highway system allows products (both perishable and nonperishable) to be distributed throughout the country in a short period of time.

RELEVANT LAW

Federal Aid Highway Act (1956): Authorized construction of the Interstate Highway System. Under the new law, the federal government agreed to fund 90% of the construction costs for the interstates. States, in turn, would provide the remaining funds, administer the construction projects, and own and operate the completed interstate highways.

Canals and Channels

The term channel is another word for strait, which is defined as a relatively narrow body of water that connects two larger bodies of water. Channels can occur naturally or be constructed. Repeated dredging of canals and channels is often necessary because of silting.

In the United States, channels frequented by ships are generally maintained by the United States Department of the Interior and monitored and policed by the United States Coast Guard. Smaller channels are maintained by the various states or local governments.

The two largest canals in the world of major economic value are the Panama Canal and the Suez Canal. The 48-mile (77 km) Panama Canal connects the Pacific Ocean with the Atlantic. It allows water transport without having to circumnavigate South America. The 163-mile (190 km) Suez Canal connects the Red Sea with the Mediterranean. It allows water transport between Europe and Asia without traveling around Africa, and 8% of the world's shipping runs through the Suez Canal.

CASE STUDY

Gatún Lake is an artificial lake created for the operation of the locks in the Panama Canal. A significant environmental problem that occurs with Gatún Lake is the drainage of water (up to 52 million gallons [197 million L] of freshwater leaves the lake every time a ship passes through the canal). Although there is sufficient annual rainfall to replenish the water used by the canal, the seasonal nature of the rainfall requires storage of water from one season to the next. The rainforest surrounding the lake traditionally played a major role by absorbing rainwater and releasing it slowly. However, due to recent deforestation of the land around the lake, rain flows rapidly down through the deforested slopes, carrying silt into the lake. The excess water is spilled out into the ocean. This results in a shortfall during the dry season and silt buildup in the lake, which must be periodically dredged.

Roadless Areas and Ecosystem Impacts

Roadless areas are places where no roads have been built and where, as a result, no logging or other development can occur. Roadless areas are havens for fish and wildlife whose habitats in many other forest areas has been fragmented or entirely destroyed. They provide habitats for more than 1,600 threatened, endangered, or sensitive plant and animal species and include watersheds that supply clean drinking water. The roadless rule protects 60 million acres, or 31%, of National Forest System lands—about 2% of the total land base of the United States. National wilderness areas are roadless, such as the Bob Marshall Wilderness Area in the western United States.

RELEVANT LAW

Roadless Area Conservation Rule (2001): This rule places about one-third of the national forest system's total acreage off-limits to virtually all road building and logging. More than half of the national forest land is already open to such activity. The plan protects 59 million acres (23 million ha) of unspoiled national forest land in 39 states. It preserves all current opportunities for public access and recreation, including hiking, fishing, hunting, camping, and mountain biking, as well as the revenue and jobs that these activities generate in local areas.

PUBLIC AND FEDERAL LANDS

The federal government manages public lands. It sets aside areas as national parks, wildlife refuges, and wetlands.

Management

The Bureau of Land Management (BLM) is responsible for managing 262 million acres (105 million ha) of land, about one-eighth of the land in the United States. The BLM also manages about 300 million additional acres (120 million ha) of subsurface mineral resources. The bureau is also responsible for wildfire management and preservation on 400 million acres (162 million ha). Most of the lands the BLM manages are located in the western United States, including Alaska. They are dominated by extensive grasslands, forests, high mountains, arctic tundra, and deserts. The BLM manages a wide variety of resources and uses including energy and minerals, timber, forage, wild horse and burro populations, fish and wildlife habitats, wilderness areas, and archaeological, paleontological, and historical sites.

RELEVANT LAW

Federal Land Policy and Management Act (1976): Outlined policy concerning the use and preservation of public lands. Granted federal jurisdiction on consequences of mining on public lands.

National Parks

There are over 1,100 national parks in the world today. However, many of them do not receive proper protection from poachers, loggers, miners, or farmers due to the costs involved.

The United States National Park System encompasses approximately 84 million acres (34 million ha), of which more than 4 million acres (1.6 million ha) remain in private ownership. The largest area is in Alaska and is more than 16% of the entire system. U.S. National parks are threatened by high demand by large numbers of visitors, which leads to congestion, eroded trails, noise that disrupts wildlife, and pollution from autos and visitors. Other threats include off-road vehicles, introduction of nonnative species that impact biodiversity, and commercial activities such as mining, logging, livestock grazing, and urban development.

There are several solutions to these problems:

- Reducing the amount of private land within national parks through incentives to current owners
- Providing education programs to the public
- Setting quotas on attendance through advanced reservation systems
- Adopting a fee system that covers external costs
- Banning off-road vehicles
- Banning autos and instead provide shuttle buses to control traffic
- Providing tax incentives for property owners near national parks to use land grants
- Conducting periodic and detailed wildlife and plant inventories

RELEVANT LAWS

Yellowstone National Park Act (1872): Preserves the watershed of the Yellowstone River "for the benefit and enjoyment of the people." For the first time, public lands were preserved for public enjoyment and were to be administered by the federal government.

National Park Service Act (1916): Established that national parks are to be maintained in a manner that leaves them unimpaired for future generations and established the National Park Service to manage the parks.

Outdoor Recreation Act (1963): Laid out the Interior Department's role as coordinator of all federal agencies for programs affecting the conservation and development of recreation resources.

Wilderness Act (1964): Wilderness was defined by its lack of noticeable human modification or presence. Federal officials are required to manage wilderness areas in a manner conducive to retention of their wilderness character.

Land and Water Conservation Fund Act (1965): Established a fund, administered by the National Park Service, to assist the states and federal agencies in meeting present and future outdoor recreation demands and needs of the American people.

National Trails System Act (1968): Established a national system of recreational, scenic, and historic trails.

Wild and Scenic Rivers Act (1968): Established a system of areas distinct from the traditional park concept to ensure the protection of each river's unique environment. It also preserves certain selected rivers that possess outstanding scenic, recreational, geological, cultural, or historic values and maintains their free-flowing condition.

Wildlife Refuges

President Theodore Roosevelt designated 4-acre (1.6 ha) Pelican Island, off Florida, in 1903 as the first national wildlife refuge, designed to protect breeding birds. Roosevelt designated another 52 wildlife refuges before he left office in 1909. The early refuges were established primarily to protect wildlife such as the overhunted bison and birds killed by market hunters, such as egrets and waterfowl. During the drought years of the Great Depression, refuges were created to protect waterfowl. The system developed piecemeal largely in response to such wildlife crises. The National Wildlife Refuge System, consisting today of 547 refuges encompassing more than 93 million acres (37 million ha), is managed by the U.S. Fish and Wildlife Service.

Wetlands

Wetlands are areas that are covered by water and support plants that can grow in water-saturated soil. High plant productivity supports a rich diversity of animal life. Countries with the most wetlands are Canada (14% of land area), the Russian Federation (including Siberia), and Brazil. Wetlands were once about 10% of the land area in the United States but have been reduced to about 5%, with most of them in Louisiana and Florida. Most wetland habitat loss—90%—is due to conversion of the land to agriculture with the rest of the loss due to urbanization. Wetlands are

home to a wide variety of species. One-third of all endangered species in the United States spend part of their life span in wetlands. Wetlands serve as natural water purification systems removing sediments, nutrients, and toxins from flowing water. Wetlands along lakes and oceans stabilize shorelines and reduce damage caused by storm surges, reduce the risks of flooding, and reduce saltwater intrusion.

Fens are wetlands characterized by continuous sources of groundwater rich in magnesium and calcium, which makes a fen very alkaline. This groundwater comes from glaciers that have melted, depositing their water in layers of gravel and sand. The water sits upon layers of soil (glacial drift) that are not permeable, thus keeping the water from sinking beneath the surface. The water is then forced to flow sideways along the surface, where it picks up minerals in its path.

A bog is a type of wetland that accumulates acidic peat, a deposit of dead plant material that can be dried and burned for fuel. Bogs are located in cold, temperate climates. They are usually in boreal biomes such as western Siberia, parts of Russia, Ireland, Canada, and the states of Minnesota and Michigan. Bogs are generally low in nutrients and highly acidic. Carnivorous plants have adapted to these conditions by using insects as their nutrient source.

LAND CONSERVATION OPTIONS

Preservation, remediation, mitigation, restoration and sustainable land use strategies are land conservation options. Several principles can be employed in land conservation using a land-use ethic model:

1. Protect biodiversity, wildlife habitats, and the ecological functioning of public land ecosystems through careful monitoring and enforcement.
2. Adopt a user pay approach for extracting resources from public lands. Eliminate government subsidies and tax breaks to corporations that extract publicly owned resources.
3. Institute fair compensation for resources extracted from public land. Instead of the government subsidizing the extraction of resources, the corporations should be paying the government fair market value for natural resources.
4. Require responsibility for any user who damages or alters public land.
5. Adopt uneven-aged management forestry practices that foster maintaining a variety of tree species at various ages and sizes. Uneven-aged management fosters biological diversity, long-term sustainable production of high-quality timber, selective cutting, and the principle of multiple use of the forests for recreation, watershed protection, wildlife, and timber.
6. Include ecological services of trees in estimating valuation.
7. Reduce road building into uncut forest areas. Require restoration plans for those roads that are currently in place, and require such plans for any future roads.
8. Coordinate with the Forest Service on leaving fallen timber and standing dead trees in place to promote nutrient cycling and providing wildlife habitats.

9. Grow timber on longer rotations.
10. Reduce or eliminate clear-cutting, shelter wood cutting, or seed tree cutting on sloped land.
11. Rely on more sustainable tree-cutting methods such as selective and strip cutting.
12. Reduce fragmentation of remaining large forests.
13. Require certification of lumber that is cut according to sustainable forest practices.
14. Use sustainable techniques for tropical forests. These include: educating settlers about sustainable forest practices and their advantages, monitoring and enforcing cutting based on sound ecological principles, and reducing subsidies that encourage tropical deforestation. Other techniques include instituting debt-for-nature and conservation easements, creating subsidies for sustainable practices, and rehabilitating areas that have already been degraded.
15. Solutions to urban land use problems include zoning. Various parcels of land are designated for certain uses but can be influenced by developers. Local governments can limit permits, require environmental impact analyses, require developer fees for services, tax farmland on the basis of its actual (not potential) use, promote compact development and preservation of open space, and establish green spaces, urban boundaries, and land trusts.

The following items describe some land conservation options:

PRESERVATION OR SUSTAINABLE

To keep or maintain intact.

REMEDIATION

The act or process of correcting a fault or deficiency.

MITIGATION

To moderate or alleviate in force or intensity.

RESTORATION

To restore to its former good condition. Ecosystem restoration involves management actions designed to facilitate the recovery or reestablishment of native ecosystems. A central premise of ecological restoration is that restoration of natural systems to conditions consistent with their evolutionary environments will prevent their further degradation while simultaneously conserving their native plants and animals.

MINING

The following table provides an overview of mining.

Overview of Mining

Steps	Descriptions	Environmental Effects and Issues
Mining	Removing mineral resource from the ground. Can involve underground mines, drilling, room-and-pillar mining, long-wall mining, open pit, dredging, contour strip mining, and mountaintop removal.	Mine wastes—acids and toxins. Displacement of native species. Reclamation of land and recycling.
Processing	Removing ore from gangue. Involves transportation, processing, purification, smelting, and manufacturing.	Pollution (air, water, soil, and noise). Human health concerns, risks, and hazards.
Use	Involves distribution to end user.	

Extraction

Before mining begins, economic decisions are made to determine whether a site will be profitable. Factors that enter into the decision include current and projected price, amount of ore at the site, concentration, type of mining required, cost of transporting the ore to a processing facility, and cost of reclamation. After all factors are analyzed, several steps are employed.

SITE DEVELOPMENT

Samples are taken from an area to determine the quality and quantity of minerals in a location. Roads and equipment are brought in.

EXTRACTION

Three main methods of extraction exist: surface mining, underground mining, and *in situ* leaching. Surface mining is a type of mining in which the soil and rock overlying the mineral deposit (known as overburden) is removed and stored (spoilbank). Surface mining is used where deposits of commercially useful minerals are found near the surface, and where the overburden is relatively thin or the area is unsuitable for tunneling. Surface mines are typically enlarged until either the mineral deposit is exhausted, or the cost of removing larger volumes of overburden makes further mining impractical.

There are five main forms of surface mining: (1) Strip mining, the most commonly used method to mine coal or tar sand, is the practice of mining a seam of mineral by first removing a long strip of overburden. Area stripping is used on fairly flat terrain to extract deposits over a large area. As each long strip is exca-

vated, the overburden is placed in the excavation produced by the previous strip. Contour stripping involves removing the overburden above the mineral seam near the outcrop in hilly terrain, where the mineral outcrop usually follows the contour of the land. This method commonly leaves behind terraces in mountainsides. (2) Open-pit mining refers to a method of extracting rock or minerals from the Earth by their removal from an open pit. (3) Mountaintop removal mining is used where a coal seam outcrops all the way around a mountain top. All the rock and soil above the coal seam are removed, and the soil is placed in adjacent lows such as hollows or ravines. Mountaintop removal replaces previously steep topography with a relatively level surface. (4) Dredging is a method often used to bring up underwater mineral deposits. Although dredging is usually employed to clear or enlarge waterways for boats, it can also recover significant amounts of underwater minerals relatively efficiently and cheaply. (5) Highwall mining uses a continuous mining machine driven under remote control into the seam exposed by previous open-cut operations. A continuous haulage system carries the coal from the mine to an open-air installation for stockpiling and transport.

In underground mining, large shafts are dug into the Earth. There is less surface destruction and waste rock produced than in surface mining, but it is unsafe. Subsurface mining often occurs below the water table, so water must be constantly pumped out of the mine in order to prevent flooding. When a mine is abandoned, the pumping ceases and water floods the mine. This introduction of water often results in acid rock drainage, which is caused by certain bacteria accelerating the decomposition of metal sulfide ions that have been exposed to air and water.

Finally, with *in situ* leaching, small holes are drilled into the site. Water-based chemical solvents are used by miners to extract the resources. Advantages of *in situ* mining include: it is a less-expensive method since rocks do not have to be broken up or removed; there are shorter lead times to production; and it requires less surface ground disturbance and less mediation. On the negative side, fluids injected into the Earth are toxic and enter the groundwater supply.

PROCESSING

Processing involves intensive chemical processing during smelting. This is the method by which a metal is obtained from its ore, either as an element or as a simple compound. It is usually accomplished by heating beyond the melting point, ordinarily in the presence of reducing agents such as coke or oxidizing agents such as air. A metal whose ore is an oxygen compound (iron, zinc, or lead oxides) is heated (reduction smelting) in a blast furnace to a high temperature. The oxide combines with the carbon in the coke, escaping as carbon monoxide or carbon dioxide. Other impurities are removed by adding flux, with which they combine to form slag. If the ore is a sulfide mineral (copper, nickel, lead, or cobalt sulfides) air or oxygen is introduced to oxidize the sulfide to sulfur dioxide and any iron to slag, leaving the metal.

In cyanide heap leaching, gold ore is heaped into a large pile. Cyanide solution is then sprayed on top of the pile. As the cyanide percolates downward, the gold leaches out of the ore and collects in pools at the bottom. The gold extracted may be only 0.01% of the total ore processed. Liquid wastes containing cyanide and other toxins are kept in tailing ponds, which eventually leak and enter groundwater supplies.

Tailings are the materials left over after the process of separating the valuable fraction from the ore. Tailings represent an external cost of mining. In coal and oil sands mining, the word "tailings" refers specifically to fine waste suspended in water.

Global Reserves

Two billion tons (1.8 billion m.t.) of minerals are extracted and used each year in the United States (about 10 tons [9.1 m.t.] for every American). At the same time, the United States imports more than 50% of its most needed minerals. As mineral reserves become depleted, lower grades of ore are mined, which causes more processing and consequently more pollution.

The United States, Germany, and Russia represent 8% of the world's population, yet they consume 75% of the most widely used metals, with the United States consuming 20%.

OIL

A large portion of Earth's global crude oil reserve—45% to 70%—has already been depleted. It is estimated that there is a 50-year supply left on Earth, with countries in the Middle East owning about half of what's left. The United States owns 3% of the world's oil reserves but uses 30% of the oil extracted in the world each year. Increased competition for foreign oil by China and India increase the world's cost of oil. Two-thirds of the oil used in the United States is used for transportation (gasoline, diesel, jet fuel, and so on). About one-fourth of it is used in industry (such as plastics, medicines, and cosmetics). Oil imports in the United States increased from 52% in 1996 to a projected 70% by the year 2010.

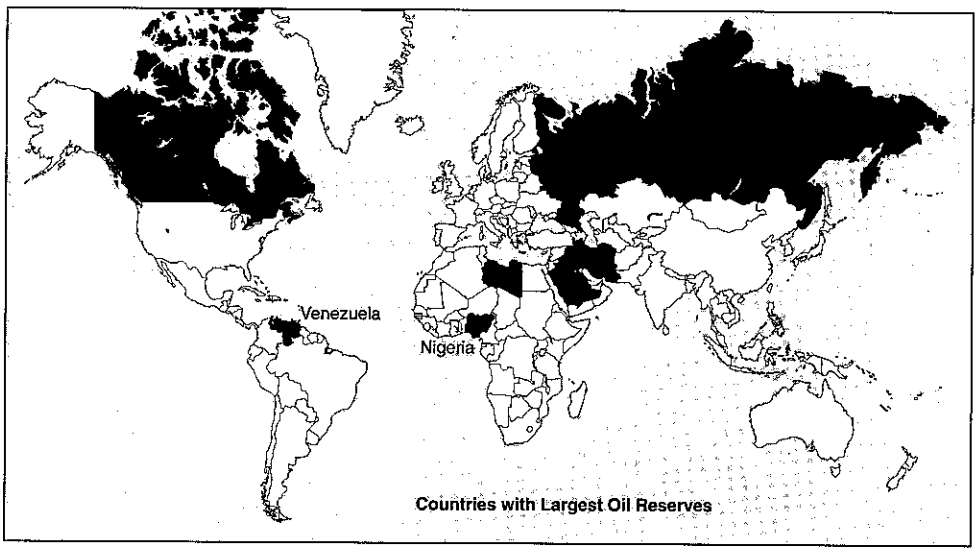


Figure 7.7 Countries with the largest oil reserves

COAL

Coal is currently the world's single largest source of fuel used to produce electricity. China is the world's largest producer. Global coal reserves are estimated to last about 300 years at current levels of extraction.

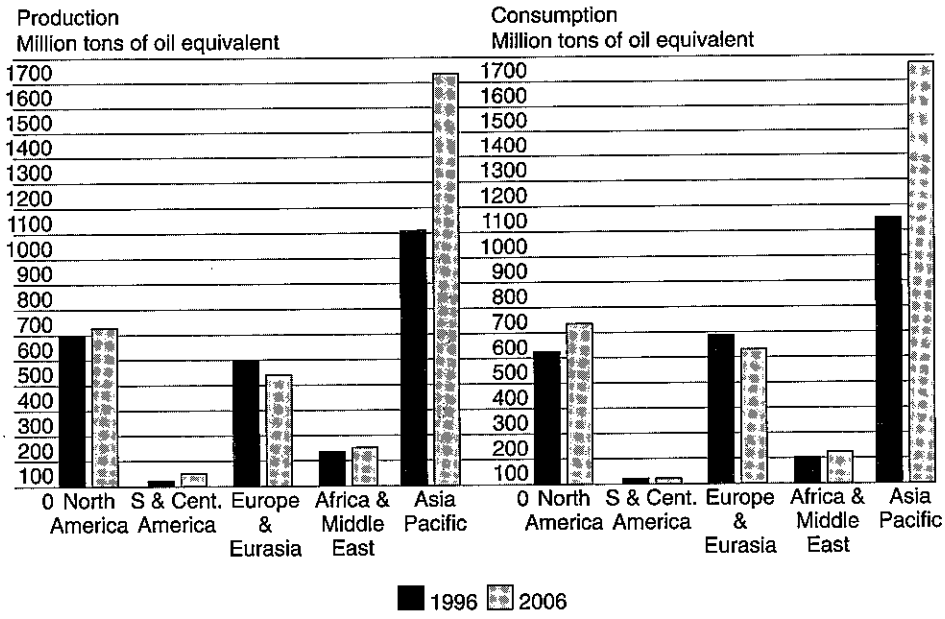


Figure 7.8 Coal production and consumption, 2005

Source: British Petroleum.

NATURAL GAS

Most of the world's natural gas reserves are located in the Middle East (34% of the world total). Europe, the Russian Federation, and the former countries of the U.S.S.R. own 42% of total world reserves. The United States possesses 3% of the world's total natural gas reserves. Given U.S. production levels, there is enough natural gas in the United States to meet approximately 75 years of domestic production. This estimate does not taking into account expected increasing levels of domestic production or the potential opening up of access to currently restricted land such as the Arctic National Wildlife Refuge.

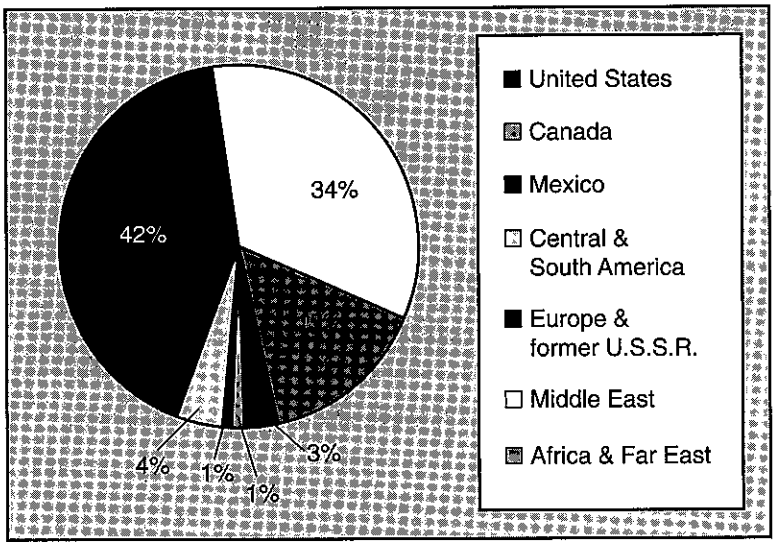


Figure 7.9 Natural gas reserves

RELEVANT LAWS

General Mining Law (1872): Grants free access to individuals and corporations to prospect for minerals in public domain lands and allows them, upon making a discovery, to stake a claim on that deposit.

Mineral Leasing Act (1920): Authorizes and governs leasing of public lands for developing deposits of coal, petroleum, natural gas and other hydrocarbons, phosphates, and sodium in the United States. Previous to the act, these materials were subject to mining claims under the General Mining Act of 1872.

Surface Mining Control and Reclamation Act (1977): Established a program for regulating surface coal mining and reclamation activities.

FISHING

Different techniques are used to fish the planet's waters:

BOTTOM TRAWLING

Uses a funnel-shaped net to drag the ocean bottom. Shrimp, cod, flounder, and scallops. Analogous to clear-cutting forests. Species not wanted is called bycatch.

DRIFT NET

Long expanses of nets that hang down in water. Traps turtles, seabirds, and marine mammals. During the 1980s, 10,000 dolphins and whales and millions of sharks were killed each year by drift nets. 1992 U.N. voluntary ban on drift nets longer than 1.5 miles (2.4 km) has made some progress.

LONGLINE

Placing very long lines with thousands of baited hooks. Swordfish, tuna, sharks, halibut, and cod. Endangers sea turtles, pilot whales, and dolphins.

PURSE SEINE

Surrounds large schools of fish spotted by aircraft with a large net. Net is then drawn tight. Tuna, mackerel, anchovies, and herring.

Overfishing

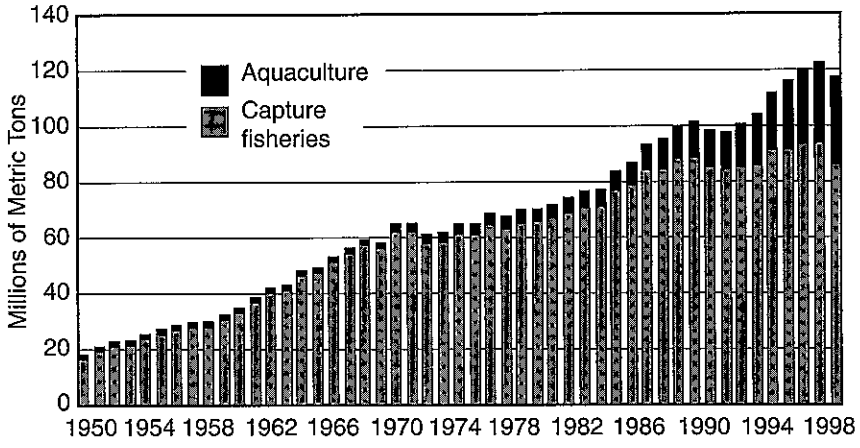
The oceans have been looked on as unlimited resources. Ocean productivity is generally low and results from spatial separation of required plant nutrients. Light is restricted to surface waters.

The oceans supply 1% of all human food and represent 10% of the world's protein source. China is responsible for about one-third of all fish harvesting from the oceans. About one-third of the total catch of fish is used for purposes other than human consumption, such as fish oil, fish meal, and animal feed. Another one-third of global catches consists of bycatch. These are marine mammals, sea turtles, birds, noncommercial fish, and shellfish that are ensnared in fishing nets or dredged up by trawling and discarded.

Maximum sustained yield is the largest amount of marine organisms that can be continually harvested without causing the population to crash. This yield generally occurs when a population is maintained at half the carrying capacity.

Methods to manage fisheries in a sustainable manner include:

1. Regulate locations and numbers of fish farms and monitor their pollution output
2. Encourage the production of herbivorous fish species
3. Require and enforce labeling of fish products that were raised or caught according to sustainable methods
4. Set catch limits far below maximum sustainable yields
5. Eliminate government subsidies for commercial fishing
6. Prevent importation of fish from foreign countries that do not adhere to sustainable-harvesting methods
7. Place trading sanctions on foreign countries that do not respect the marine habitat, including countries that hunt whales
8. Assess fees for harvesting fish and shellfish from public waters
9. Increase the number of marine sanctuaries and no-fishing areas
10. Increase penalties for fishing techniques that do not allow escape of bycatch, including unwanted fish species, marine mammals, sea birds, and sea turtles
11. Ban the throwing back of bycatch
12. Monitor and destroy invasive species transported through ship ballast



Note: Aquaculture quantities prior to 1984 are estimates.
Source: FAO

Figure 7.10 World fishing and aquaculture production

Several methods can restore habitats suitable for freshwater fish. These include: planting native vegetation on stream banks, rehabilitating in-stream habitats, controlling erosion, and controlling invasive species. Other restsorative methods include restoring fish passages around human-made impediments, monitoring, regulating, and enforcing recreational and commercial fishing; and protecting coastal estuaries and wetlands.

Aquaculture

Aquaculture, commonly known as mariculture or fish farming, includes the commercial growing of aquatic organisms for food. It involves stocking, feeding, protection from predators, and harvesting. Aquaculture is growing about 6% annually and provides 5% of the total food production worldwide, most of it coming from less-developed countries. Currently, the most popular products being produced through aquaculture include seaweeds, mussels, oysters, shrimp, and certain species of fish (primarily salmon, trout, and catfish). Kelp makes up about 17% of aquaculture output and is used as a food product and as a source of various products used in the food industry. Aquaculture is used to raise 80% of all mollusks, 40% of all shrimp, and 75% of all kelp.

Aquaculture offers several advantages over raising livestock in that cold-blooded organisms convert more feed to usable protein. For example, for every 1 million calories of feed required, a trout raised on a farm produces about 35 grams of protein whereas a chicken produces 15 grams of protein and cattle produce 2 grams of protein. For every hectare of ocean, intense oyster farming can produce 58,000 kg of protein while natural harvesting of oysters produces 10 kg of protein.

For aquaculture to be profitable, the species must be marketable, inexpensive to raise, trophically efficient, at marketable size within 1 to 2 years, and disease resistant. Aquaculture creates dense monocultures that reduce biodiversity within habitats and requires large levels of nutrients in the water.

Aquaculture offers possibilities for sustainable protein-rich food production and for economic development to local communities. However, aquaculture on an industrial scale may pose several threats to marine and coastal biological diversity. It creates wide-scale destruction and degradation of natural habitats and leaves nutrients and antibiotics in aquaculture wastes. Accidental releases of alien or modified organisms into native waters, transmission of diseases to wild stocks, and displacement of local and indigenous human communities are also side effects.

CASE STUDY

Polychlorinated biphenyls (PCBs) were banned in the U.S. in the late 1970s and are slated for global phase-out under the United Nations treaty on persistent organic pollutants. PCBs are highly persistent and have been linked to cancer and impaired fetal brain development. Salmon farming has made salmon the third most popular fish in America and comprises 22 percent of all retail seafood counter sales. Many consumers eat more salmon today to avoid over-consumption of beef and poultry, and to benefit from anti-cancer and anti-heart disease properties of oily fish. However, analysis of U.S. government data found that farmed salmon are likely the most PCB-contaminated protein source in the current U.S. food supply. Approximately 800,000 U.S. adults have an increased cancer risk by eating PCB-contaminated salmon. Farmed salmon are fattened with ground fishmeal and fish oils that are high in PCBs. As a result, salmon farming operations that produce inexpensive fish unnaturally concentrate PCBs. Furthermore, farmed salmon contains 52 percent more fat than wild salmon, according to the U.S. Department of Agriculture.

RELEVANT LAWS

Fish and Wildlife Act (1956): Established a comprehensive national fish and shellfish resource policy directed primarily to industry.

Anadromous Fish Conservation Act (1965): Authorizes the Secretary of the Interior to enter into agreements with states and other non-federal interests to conserve, develop, and enhance the anadromous fish (fish that migrate from the sea to fresh water to spawn) resources of the United States.

Marine Mammal Protection Act (1972): Prohibits, with certain exceptions, the taking of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States.

Magnuson Fishery Conservation and Management Act (1976): Governs marine fisheries management in United States federal waters. Aids in the development of the domestic fishing industry by phasing out foreign fishing. To manage the fisheries and promote conservation, the Act created eight regional fishery management councils. The 1996 amendments focused on rebuilding overfished fisheries, protecting essential fish habitat, and reducing bycatch.

Fish and Wildlife Coordination Act (1980): Assistance in training of state fish and wildlife enforcement personnel and assistance to states in the development and revision of conservation plans for nongame fish and wildlife.

United Nations Treaty on the Law of the Sea (1982): Defines the rights and responsibilities of nations in their use of the world's oceans, establishing guidelines for businesses, the environment, and the management of marine natural resources.

GLOBAL ECONOMICS

The economy and the environment are intrinsically linked such that both are simultaneously causes and effects and are inputs and outputs of each other. The environment contains all the resources that can be used in the economy. The use of resources for economic purposes continuously creates new environmental situations. For example, while some resources are depleted and transformed from usable to unusable states, economic resources are used to expand additional resources. This occurs through increasing the available supply of materials, opening land to agricultural production, transporting resources from locations where they are in surplus to areas of shortage, and so on.

Increased levels of economic activity and improvements in living standards have occurred since the end of World War II. People in the wealthiest countries constitute 15% of the global population and enjoy average levels of income that are about 20 times greater than the 85% of the global population that live in poorer countries.

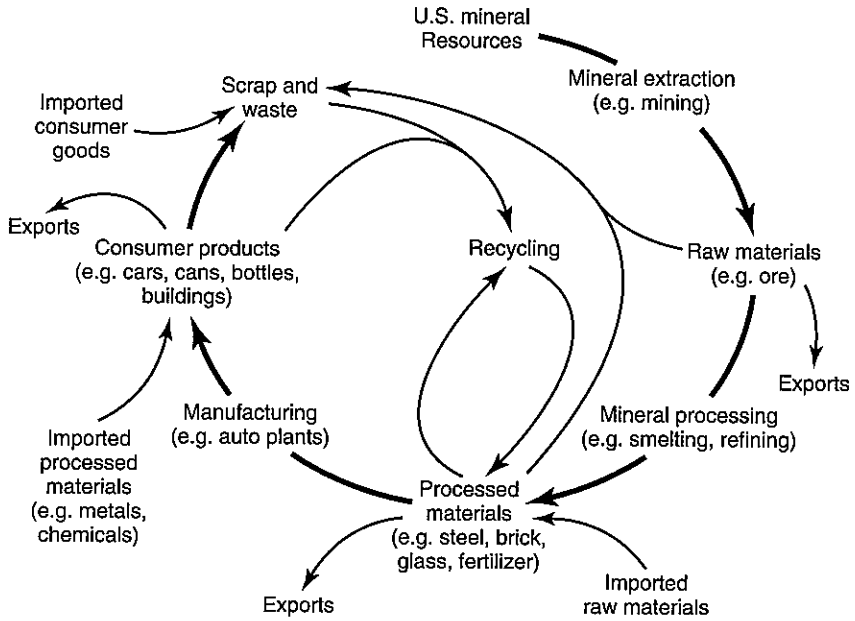


Figure 7.11 Resources cycle

If the income of the poorest 85% were raised to only one-third that of the richest countries, the level of total world production and consumption would have to double, with a similar increase in the use of Earth's resources. The conclusion is that continued increases in living standards in poorer countries will increase pressure on the carrying capacity of the planet.

Until recently, developments in local economies and local environments were dispersed and, to a great extent, isolated. They did not typically result in cumulative processes that had widespread or global impact. However, as with the economy, over the past century or so, the growth of human populations throughout the world (and the greater vigor with which these populations have assaulted the environment in their pursuit of higher production and consumption levels) has led to a significant increase in global environmental disruption. The effects of these disruptions have become increasingly interlinked. A global environment—a set of interrelated processes, causes and effects, not simply a group of unrelated ecological events—has come into being.

World Bank

The World Bank is a source of financial and technical assistance to developing countries around the world. The World Bank (owned by 184 member countries) provides low-interest loans, interest-free credit, and grants to developing countries for education, health, infrastructure, communications, and environmental issues. In 2001, the World Bank Board of Directors endorsed an environment strategy to guide the bank's actions in environmental areas. The strategy emphasizes three objectives: improving the quality of life, improving the quality of growth, and protecting the quality of the regional and global commons through the "greening" of investments in agriculture, water sanitation, and other environmental projects. The World Bank in 2005 has distributed $13.8 billion in public and private funds in the areas of biodiversity, conservation, climate change, and international waters; funded $740 million in projects to phase out ozone-depleting substances; and funded $1.6 billion into projects that reduce greenhouse gas emissions.

The World Bank is also the greatest single source of funds for large dam projects, having provided more than $50 billion for construction of more than 500 large dams in 92 countries. Since 1948, theses large dam projects have forcibly displaced approximately 10 million people from their land.

The following diagram shows how the World Bank distributes economic resources to less-developed countries:

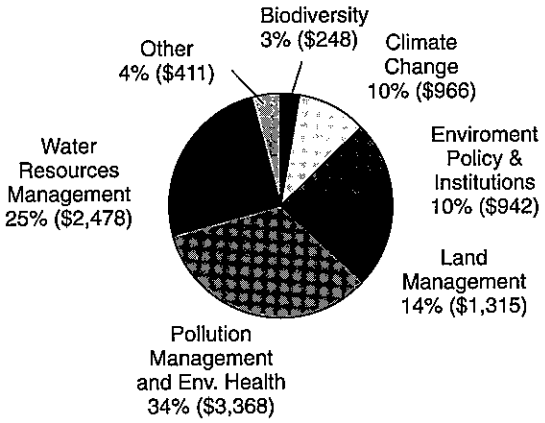


Figure 7.12 World Bank environmental investments (in millions)

"Tragedy of the Commons"

Garrett Hardin wrote the "Tragedy of the Commons" in 1968, and it appeared in the journal *Science*. The story parallels what is happening worldwide in regard to resource depletion and pollution. The seas, air, water, animals, and minerals are all the commons. They are there for humans to use. Those who exploit them become rich. The price of depleting the resources of the commons is an external cost paid by all people on Earth. Limits to the "Tragedy of the Commons" include the following:

- Economic decisions are generally short term, based on reactions in the world market. Environmental decisions are long term.
- Land that is privately owned is subject to market pressure. For example, if privately owned timberland is increasing in value at an annual rate of 3% but interest rates on loans to purchase the land are 7%, this could result in the land being sold or the timber being harvested for short-term profits.
- Some commons are easier to control than others. Land, lakes, rangeland, deserts, and forests are geographically defined and easier to control than air or the open oceans that do not belong to any one group. This is the problem with the United States passing the Kyoto Protocol.
- Incorporating discount rates into the valuation of resources would be an incentive for investors to bear a short-term cost for a long-term gain.
- Breaking a commons into smaller, privately owned parcels fragments the policies of governing the entire commons. Different standards and practices used on one parcel may or may not affect all other parcels.