Chapter 2

# National Circumstances

During the 1990s, greenhouse gas emissions per unit of gross domestic product (GDP) declined steadily due to continued investments in new energy-efficient technologies and an increase in the portion of GDP attributable to the nonmanufacturing and less energy-intensive manufacturing sectors. However, aggregate U.S. greenhouse gas emissions have continued to increase over the past few years, primarily as a result of economic growth and the accompanying rise in demand for energy.

U.S. energy needs and, hence, emissions of greenhouse gases are also heavily influenced by a number of other factors, including climate, geography, land use, resource base, and population growth. How the nation responds to the issue of climate change is affected by U.S. governmental, economic, and social structures, as well as by the availability of technologies and wealth, which allows such technologies to be employed. All of these factors also affect the nation's vulnerability to climate change and its ability to adapt to a changing natural environment.

Global climate change presents unique challenges and opportunities for the United States. This chapter describes U.S. national circumstances as they relate to climate change: historical developments, current conditions, and trends in those conditions.

## CLIMATE PROFILE

The diverse U.S. climate zones, topography, and soils support many ecological communities and supply renewable resources for many human uses. The nature and distribution of these resources have played a critical role in the development of the U.S. economy, thus influencing the pattern of U.S. greenhouse gas emissions.

U.S. climate conditions are representative of all the major regions of the world, except the ice cap. Average annual temperatures range from –1 to +4°C (30–40°F) in the North to 21–27°C (70–80°F) in the South, and have significant implications for energy demand across the country. In the North, heating needs dominate cooling needs, while the reverse is true in the South. The number of heating and cooling degree-days across U.S. regions illustrates this climatic diversity (Figure 2-1). Because of this diversity of climate and ecological zones, describing the effects of climate change on the nation as either positive or negative overall is an oversimplification.

U.S. baseline rainfall levels also vary significantly by region, with most of the western states being arid. Although the eastern states only rarely experience severe drought, they are increasingly vulnerable to flooding and storm surges as sea level rises, particularly in increasingly densely populated coastal areas. In recent years, although deaths due to tornadoes, floods, and tropical storms have declined substantially, insurance losses have increased. If extreme weather events of this kind were to occur with greater frequency or intensity (which may or may not happen), damages could be extensive.

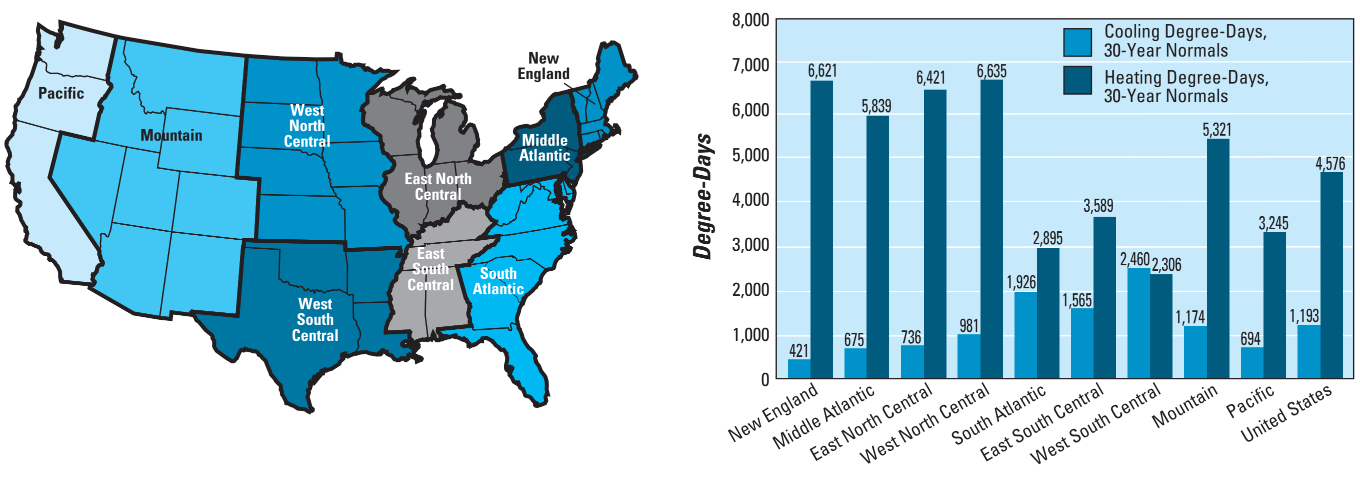
## GEOGRAPHIC PROFILE

The federal government owns slightly more than 20 percent of the total U.S. land area of nearly 920 million hectares (over 2 billion acres). By contrast, the federal government owns over 65 percent of Alaska's nearly 150 million hectares (370 million acres), the state government owns nearly 25 percent, private ownership accounts for about 10 percent, and lands held in trust by the Bureau of Indian Affairs account only for about one-third of 1 percent.

The private sector plays a primary role in developing and managing U.S. natural resources. However, federal, state, and local governments also manage and protect these resources through regulation, economic incentives, and education. Governments and private interests also manage lands set aside for forests, parks, wildlife reserves, special research areas, recreational areas, and suburban and urban open spaces. Table 2-1 and Figure 2-2 illustrate the composition and share of the individual components of U.S. land resources in 1997. This snapshot is discussed in greater detail later in this chapter.

FIGURE 2-1 **Climatic Diversity in the Contiguous U.S.**

Regions of the country with cooler climates may benefit from climate change through reduced demand for heating, while energy consumption for cooling may increase in warmer regions, which could result in higher emissions of greenhouse gases.




*Notes:*

- *Cooling and heating degree-days represent the number of degrees that the daily average temperature is above (cooling) or below (heating) 65°F. The daily average temperature is the mean of the maximum and minimum temperatures for a 24-hour period. For example, a weather station recording a mean daily temperature of 40°F would report 25 heating degree-days.*
- *Degree-day normals are simple arithmetic averages of annual degree-days from 1961 to 1990.*
- *Data for the Pacific region exclude Alaska and Hawaii.*

*Source: U.S. DOE/EIA 2000a.*

## POPULATION PROFILE

Population levels and growth rates drive a nation's consumption of energy and other resources, as more people require more energy services. The population dispersion in the United States increases the need for transportation services, and population density and household size influence housing sizes. Settlement patterns and population density also affect the availability of land for various uses.

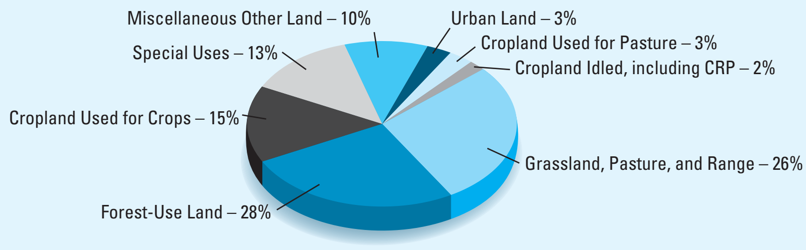
With a population of just over 280 million in 2000, the United States is the third most populous country in the world, after China and India. U.S. population density, however, is relatively low (Figure 2-3). Population density also varies widely within the United States, and those patterns are changing as people move not only from rural to metropolitan areas, but also from denser city cores to surrounding suburbs. In addition, populations in the warmer parts of the country—the Sunbelt in the South and Southwest—are growing more rapidly than in other parts, showing a preference for warmer climates.

Overall, the annual rate of U.S. population growth has fallen from slightly over 1 percent in 1990 to about 1 percent in 2000. But this is still high by the standards of the Organization of Economic Cooperation and Development (OECD)—about five times the rate in Japan, and more than three times the

### TABLE 2-1 AND FIGURE 2-2 U.S. Land Use: 1997

Land is used in many different ways in the United States. Much of the land is forested or used for agricultural purposes.

| Land Use | Hectares (in millions) | Acres (in millions) |
|---|---|---|
| **Urban Land**<br>Residential, industrial, commercial, and institutional land. Also includes land for construction sites; sanitary landfills; sewage treatment plants; water control structures and spillways; and airports, highways, railroads, and other transportation facilities. | 25 | 65 |
| **Forest-Use Land**<br>At least 10 percent stocked by single-stemmed forest trees of any size, which will be at least 4 meters (13 feet) tall at maturity. When viewed vertically, canopy cover is 25 percent or greater. | 260 | 640 |
| **Cropland Used for Crops**<br>Areas used for the production of adapted crops for harvest. | 140 | 350 |
| **Cropland Idled, including Conservation Reserve Program**<br>Includes land in cover and soil improvement crops, and completely idle cropland. Some cropland is idle each year for various physical and economic reasons. Acreage diverted from crops to soil-conserving uses under federal farm programs is included in this component. For example, cropland enrolled in the Federal Conservation Reserve Program is included. | 15 | 40 |
| **Cropland Used for Pasture**<br>Generally considered as being tilled, planted in field crops, and then reseeded to pasture at varying intervals. However, some cropland pasture is marginal for crop uses and may remain in pasture indefinitely. Also includes some land that was used for pasture before crops reached maturity and some land that could have been cropped without additional improvement. | 30 | 70 |
| **Grassland Pasture and Range**<br>Principally native grasses, grasslike plants, forbs or shrubs suitable for grazing and browsing, and introduced forage species that are managed with little or no chemicals or fertilizer being applied. Examples include grasslands, savannas, many wetlands, some deserts, and tundra. | 235 | 580 |
| **Special Uses**<br>Includes national and state parks and wildlife areas, defense installations, and rural transportation. | 115 | 285 |
| **Miscellaneous Other Land**<br>Includes rural residential, marshes, open swamps, deserts, tundra, and other areas not inventoried. | 95 | 235 |
| **TOTAL LAND, 50 STATES** | **915** | **2,265** |




*Note: Individual land uses may not sum to total land due to rounding.*
*Source: USDA/NRCS 2001.*

rate in the European Union. Among the OECD countries, the United States has been and continues to be one of the largest recipients of immigrants (in absolute terms). Net immigration contributes about one-third of the total annual population growth, and natural increase (births minus deaths) contributes the remaining two-thirds.

The U.S. population is aging. The current median age is about 35 years, compared to about 33 in 1990 and 28 in 1970. This change in median age has been a result of both an increase in life expectancy, which now stands at 77 years, and reduced fertility rates. Along with an aging population, trends also indicate a steady reduction in average household size, as people marry later, have fewer children, are more likely to divorce, and are more likely to live alone as they age. Thus, between 1970 and 2000, while the population has grown by nearly 40 percent, the number of households has grown by over 65 percent.

Although the average household size has declined, the average size of housing units has been increasing. Between 1978 and 1997, the proportion of smaller housing units (with four or fewer rooms) has decreased from about 35 to 30 percent, and the proportion of large housing units (with seven or more rooms) has increased from about 20 to nearly 30 percent. In general, larger housing units result in increased demands for heating, air conditioning, lighting, and other energy-related needs.

The share of the total U.S. population living in metropolitan areas of at least one million people has increased to nearly 60 percent in 2000, up from nearly 30 percent in 1950. This growth has been concentrated in suburbs, rather than in city centers. In fact, most major cities have experienced declines in population, as crime, congestion, high taxes, and the desire for better schools have led people to move to the suburbs. As a result, population densities in the U.S. metropolitan areas are far lower than in metropolitan areas around the world, and they continue to decline. For example, the ten largest European cities, on average, have population densities four times greater than the ten largest U.S. cities. The increased concentration of the U.S population in the suburbs has resulted in both greater reliance on decentralized travel modes, such as the automobile, and relatively high per capita energy use.

Another factor leading to higher emissions is the increasing mobility of the U.S. population. The average U.S. citizen tends to move more than ten times in his or her lifetime. According to the 1990 census, nearly 40 percent of U.S. residents do not live in the state where they were born, as compared to about 30 percent in 1980 and about 25 percent in 1970. Families are often dispersed across the country for education, career, or personal reasons. All of these factors have led to an ever-growing need for transportation services.

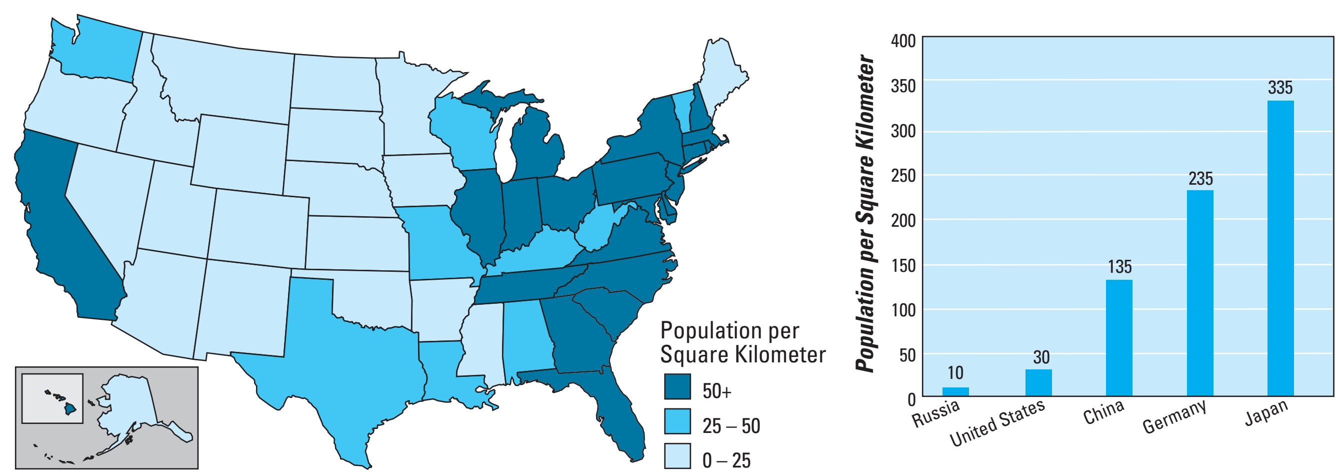
## GOVERNMENT STRUCTURE

The U.S. political and institutional systems participating in the development and protection of environmental and natural resources are as varied as the resources themselves. These systems span federal, state, and local government jurisdictions, and include legislative, regulatory, judicial, and executive institutions.

The U.S. government is divided into three separate branches: the executive branch, which includes the Executive

**FIGURE 2-3 U.S. Population Density: 2000**

Though the United States is the third most populous country in the world, U.S. population density is relatively low. This combination tends to have negative implications for energy and automobile use and, hence, emissions of greenhouse gases.




*Note: International population density comparisons have been rounded.*

*Sources: U.S. DOC/Census 2000 and World Bank 2000.*

Office of the President, executive departments, and independent agencies; the legislative branch (the U.S. Congress); and the judicial branch (the U.S. court system). The distinct separation of powers in this tripartite system is quite different from parliamentary governments.

## Federal Departments and Agencies

The executive branch is comprised of 14 executive departments, 7 agencies, and a host of commissions, boards, other independent establishments, and government corporations. The traditional functions of a department or an agency are to help the President propose legislation; to enact, administer, and enforce regulations and rules implementing legislation; to implement Executive Orders; and to perform other activities in support of the institution's mission, such as encouraging and funding the research, development, and demonstration of new technologies.

No single department, agency, or level of government in the United States has sole responsibility for the panoply of issues associated with climate change. In many cases, the responsibilities of federal agencies are established by law, with limited administrative discretion. At the federal level, U.S. climate change policy is determined by an interagency coordinating committee, chaired from within the Executive Office of the President, and staffed with members of the executive offices and officials from the relevant departments and agencies, including the Departments of Agriculture, Commerce, Defense, Energy, Justice, State, Transportation, and Treasury, as well as the U.S. Environmental Protection Agency and the U.S. Agency for International Development.

## The U.S. Congress

As the legislative branch of the U.S. government, Congress also exercises responsibility for climate change and other environmental and natural resource issues at the national level. It influences environmental policy through two principal vehicles: creation of laws and oversight of the federal executive branch. Thus, Congress can enact laws establishing regulatory regimes for environmental purposes, and can pass bills to appropriate funds for environmental purposes. Under its constitutional authority, Congress ratifies international treaties, such as the United Nations Framework Convention on Climate Change.

The U.S. Congress comprises two elected chambers—the Senate and the House of Representatives—having generally equal functions in lawmaking. The Senate has 100 members, elected to six-year terms, with two representatives for each of the 50 states. The House has 435 members, elected to two-year terms, each of whom represents an electoral district of roughly equal population. The less populated but often resource-rich regions of the country, therefore, have proportionately greater representation in the Senate than in the House.

Environmental proposals, like most other laws, may be initiated in either chamber of the U.S. Congress. After their introduction, proposals or "bills" are referred to specialized committees and subcommittees, which hold public hearings on the bills to receive testimony from interested and expert parties. After reviewing the testimony, the committees and subcommittees deliberate and revise the bills, and then submit them for debate by the full membership of that chamber. Differences between bills originating in either the House or the Senate are resolved in a formal conference between the two chambers. To become a law, a bill must be approved by the majorities of both chambers, and then must be signed by the President. The President may oppose and veto a bill, but Congress may override a veto with a two-thirds majority from each chamber.

As a rule, spending bills must go through this process twice. First, the committee responsible for the relevant issue must submit a bill to authorize the expenditure. Then, once both chambers pass the authorization bill, the Appropriations Committee, in a separate process, must submit a bill appropriating funds from the budget. The funds that are actually appropriated often are less than the authorized amount.

## States, Tribes, and Local Governments

States, Native American tribal organizations, localities, and even regional associations also exert significant influence over the passage, initiation, and administration of environmental, energy, natural resource, and other climate-related programs. For example, the authority to regulate electricity production and distribution lies with state and local public utility commissions. In addition, the regulation of building codes—strongly tied to the energy efficiency of buildings—is also controlled at the state and local levels.

Although the federal government promulgates and oversees environmental regulations at the national level, the states and tribes often are delegated the authority to implement some federal laws by issuing permits and monitoring compliance with regulatory standards. The states also generally have the discretion to set environmental standards that are more stringent than the national standards. Individual states also enjoy autonomy in their approach to managing their environmental resources that are not subject to federal laws. In addition to regulation, some states and localities have developed voluntary and incentive programs that encourage energy efficiency and conservation, and/or mitigate greenhouse gas emissions.

Local power to regulate land use is derived from a state's power to enact legislation to promote the health, safety, and welfare of its citizens. States vary in the degree to which they delegate these "powers" to local governments, but land use is usually controlled to a considerable extent by local governments (county or city). This control may take the form of authority to adopt comprehensive land-use plans to enact zoning ordinances and subdivision regulations or to restrict shoreline, floodplain, or wetland development.

### The U.S. Court System

The U.S. court system is also crucial to the disposition of environmental issues. Many environmental cases are litigated in the federal courts. The role of the courts is to settle disagreements on how to interpret the law. The federal court system is three-tiered: the district court level; the first appellate (or circuit) court level; and the second and final appellate level (the U.S. Supreme Court). There are 94 federal district courts, organized into federal circuits, and 13 federal appeals courts.

Cases usually enter the federal court system at the district court level, though some challenges to agency actions are heard directly in appellate courts, and disputes between states may be brought directly before the U.S. Supreme Court. Generally, any person (regardless of citizenship) may file a complaint alleging a grievance. In civil enforcement cases, complaints are brought on behalf of the government by the U.S. attorney general and, in some instances, may be filed by citizens as well.

Sanctions and relief in civil environmental cases may include monetary penalties, awards of damages, and injunctive and declaratory relief. Courts may direct, for example, that pollution be controlled, that contaminated sites be cleaned up, or that environmental impacts be assessed before a project is initiated. Criminal cases under federal environmental laws may be brought only by the government—i.e., the attorney general or state attorneys general. Criminal sanctions in environmental cases may include fines and imprisonment.

## ECONOMIC PROFILE

The U.S. is endowed with a large and dynamic population, bountiful land and other natural resources, and vibrant competition in a market economy. These factors have contributed to making the U.S. economy (in terms of its real GDP) the largest in the world, accounting for over one-fourth of the global economy.

### Government and the Market Economy

A number of principles, institutions, and technical factors have played a role in the evolution of the U.S. market economy. The first of these is the respect for property rights, which includes the right to own, use, and transfer private property to one's own advantage. The U.S. economic system is also underpinned by a reliance on market forces, as opposed to tradition or force, as the most efficient means of organizing economic activity. In other words, in a well-functioning market, relative prices are the primary basis on which economic agents within the U.S. economy make decisions about production and consumption. Ideally, the price system, combined with a system of well-defined and well-protected private property rights, allocates the resources of an economy in a way that produces the greatest possible economic welfare.

However, in some cases, due to imperfect information, lack of clearly defined property rights for public goods (such as air and water), and/or other market imperfections, the production of goods and services creates externalities (i.e., costs or benefits) that are not borne directly by the producers and consumers of those goods and services. For example, if the production of a good has environmental costs that are not borne by its producers or consumers, that product may be priced too low, thereby stimulating excess demand and pollution. Alternatively, research and development (R&D) may produce benefits to society beyond those that accrue to the firm doing the research, but if those benefits are not captured in the price, firms will underinvest in R&D. Under such circumstances, the U.S. government intervenes to alter the allocation of resources.

Government intervention may include limiting the physical quantity of pollution that can be produced, or charging polluters a fee for each unit of pollution emitted. As a practical matter, however, accurately establishing the cost of the externality to be internalized by a fee, a tax, or a regulation can be very difficult. There is also a risk that government intervention could have other, unintended consequences. For these reasons, the U.S. government tends to be cautious in its interventions, although it does take actions necessary to protect the economy, the environment, human health, natural resources, and national security.

In addition, many government interventions are intended to correct market imperfections and facilitate smooth functioning of markets. By protecting property rights, producing public goods such as roads and other types of infrastructure, formulating policies that internalize external costs (e.g., environmental policies), and enacting legislation to ensure a minimum standard of living for all of its citizens, the U.S. government fosters an environment in which market forces can function effectively. Finally, the government inevitably influences the economy through regulatory and fiscal processes, which in turn affect the functioning of markets.

### Composition and Growth

Robust economic growth typically leads to higher greenhouse gas emissions and degradation of environmental resources in general. Nonetheless, it is often the case that as the health of the economy improves and concerns about unemployment and economic growth lessen, greater emphasis is placed on environmental issues.

From 1960 to 2000, the U.S. economy grew at an average annual rate of over 3 percent, raising real GDP from about $2 trillion to over $9 trillion (in 1996 constant dollars). This implies that, with population growth averaging about 1 percent over the same period, real GDP per capita has increased at an average annual rate of over 2 percent to about $32,800 in 2000 from nearly $13,300 in 1960 (all in 1996 constant dollars).

Between 1960 and 2000, the labor force more than doubled from slightly over 65 million to about 135 million, as the influx of women into the work force raised the overall labor participation rate from nearly 60 percent to over 65 percent. The rapid growth in the size of the labor force has been led by the service sector (which includes communications, utilities, finance, insurance, and real estate), as shown in Figure 2-4. While the size of the service sector labor force more than doubled between 1970 and 2000, its sectoral share in the U.S. labor force increased by more than 40 percent over the same period. Employment in several other industries, such as construction, trade, and finance also increased significantly, along with their sectoral shares in the U.S. labor force. In contrast, employment in agriculture, along with its sectoral share in the U.S. labor force, declined during the same period.

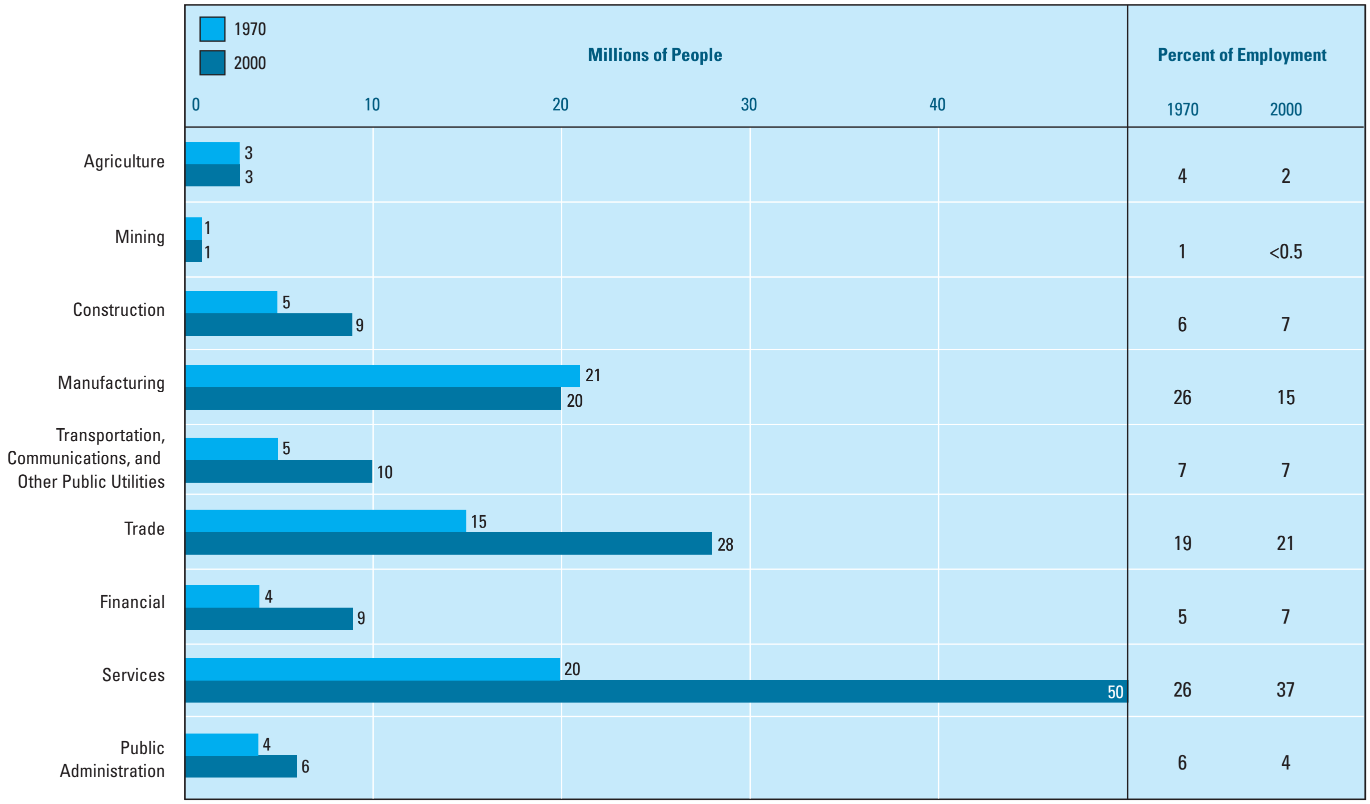
From the latter part of 1991 through 2000, the United States experienced the longest peacetime economic expansion in history. The average annual U.S. economic growth (in terms of real GDP) was about 3 percent per year between 1991 and 1995 and more than 4 percent per year between 1996 and 2000. During the second half of 2000, the economy, nonetheless, showed signs of moderating, with real annual GDP growth registering at a little over 3 percent in 2000, relative to the previous year. Overall, unemployment was reduced to about 4 percent in 2000, while producing healthy increases in real wages and real disposable income. Both personal consumption and industrial production have increased as a result of this economic growth and have, therefore, contributed to greater energy consumption and fossil fuel-related carbon dioxide emissions. Much of this economic growth, however, has occurred in sectors of the economy that are less energy-intensive (e.g., computer technologies), which in turn has lowered the energy intensity of the U.S. economy.

## ENERGY PRODUCTION AND CONSUMPTION

The United States continues to be the world's largest energy producer and consumer. The nation's patterns of energy use are determined largely by its economic and population growth, large land area, climate regimes, population dispersion, average size of household, other population characteristics, and availability of indigenous resources. Much of the infrastructure of U.S. cities, highways, and industries was developed

### FIGURE 2-4 U.S. Employment by Industry: 1970–2000

Between 1970 and 2000, employment rose most rapidly in the construction, trade, financial, utilities, and services sectors. The service sector is by far the largest in the United States, employing more than one-third of the population.




*Note: All numbers are rounded to the nearest integer.*

*Sources: U.S. DOC/Census 1999 and U.S. DOL/BLS 2000.*

in response to abundant and relatively inexpensive energy resources. Figure 2-5 provides a comprehensive overview of the energy flows through the U.S. economy in 2000.

Different regions of the country rely on different mixes of energy resources (reflecting their diverse resource endowments) to generate power and meet other energy needs. For example, the Pacific Northwest and Tennessee Valley have abundant hydropower resources, while the Midwest relies heavily on coal for power generation and industrial energy needs.

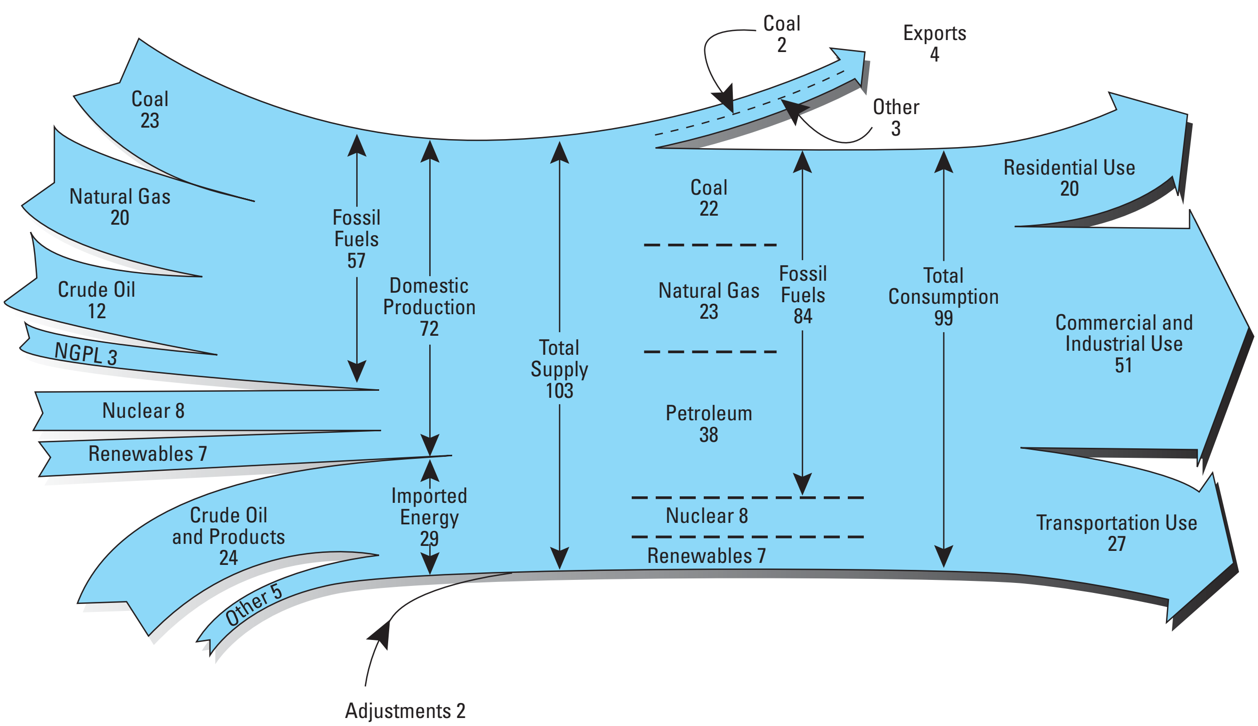
## Resources

The vast fossil fuel resources of the United States have contributed to low prices and specialization in relatively energy-intensive activities. Coal, which has the highest emissions of greenhouse gases per unit of energy, is particularly abundant, with current domestic recoverable reserves estimated at nearly 460 billion metric tons (about 503 billion short tons)—enough to last for over 460 years at current recovery rates. Recent gains in mining productivity, coupled with increased use of less-expensive western coal made possible by railroad deregulation, have led to a continual decline in coal prices over the past two decades. As a result, the low cost of coal on a Btu basis has made it the preferred fuel for power generation, supplying over half of the energy consumed to generate electricity.

Proved domestic reserves of oil (nearly 4 trillion liters or over 20 billion barrels at the start of 2000) have been on a downward trend ever since the addition of reserves under Alaska's North Slope in 1970. Restrictions on exploration in many promising but ecologically sensitive areas have constrained additions to reserves. Reserves of natural gas were nearly 5 trillion cubic meters (nearly 170 trillion cubic feet) at the start of 2000. The estimated natural gas resources of nearly 37 trillion cubic meters (nearly 1,300 trillion cubic feet) are expected to last for more than 65 years at current rates of production. U.S. energy resources also include over 120 million kg (about 270 million pounds) of uranium oxide, recoverable at about $65 per kilogram ($30 per pound) or less (in 2000 current dollars). Hydroelectric resources are abundant in certain areas of the country, where they have already largely been exploited.

**FIGURE 2-5 Energy Flow Through the U.S. Economy: 2000 (Quadrillion Btus)**

The U.S. energy system is the largest in the world and is composed of multiple energy sources and end users. Most of the energy is produced and consumed domestically, although imports constitute a significant portion, and a small fraction of energy is exported.




*Note: Shares may not sum to totals due to rounding.*
*Source: U.S. DOE/EIA 2000a.*

## National Energy Policy Goals

In May 2001, the Bush Administration published the *National Energy Policy* (NEP). This long-term, comprehensive strategy was primarily designed to assist the private sector, states, and local governments in promoting "dependable, affordable, and environmentally sound production and distribution of energy for the future" (NEPD Group 2001). The NEP seeks to promote new, environmentally friendly technologies to increase energy supplies and to encourage cleaner, more efficient energy use. It also seeks to raise the living standards of Americans by fully integrating national energy, environmental, and economic policies. The following goals are the NEP's guiding principles.

**Modernize Conservation**

This NEP goal seeks to increase energy efficiency by applying new technology, which is expected to raise productivity, reduce waste, and trim costs. Some of the recommendations include: increased funding for renewable energy and energy efficiency research and development programs; income tax credits for the purchase of hybrid and fuel cell vehicles; extension of the ENERGY STAR® efficiency program; and tax incentives and streamlined permitting to promote clean combined heat and power (CHP) technology.

**Modernize Energy Infrastructure**

This NEP goal seeks to modernize and expand the national energy infrastructure such that energy supplies can be safely, reliably, and affordably transported to homes and businesses. Some of the recommendations include: improving pipeline safety and expediting pipeline permitting; expanding research and development on transmission reliability and superconductivity; and enacting comprehensive electricity legislation that promotes competition, encourages new generation, protects consumers, enhances reliability, and promotes renewable energy.

**Increase Energy Supplies**

This NEP goal seeks to increase and diversify the nation's traditional and alternative fuel sources so as to provide "families and businesses with reliable and affordable energy, to enhance national security, and to improve the environment." Some of the recommendations include: environmentally regulated exploration and production of oil using leading-edge technology in the Arctic National Wildlife Refuge (ANWR); regulated increase in oil and natural gas development on other federal lands; fiscal incentives for selected renewable power generation technologies; and streamlining the relicensing of hydropower and nuclear facilities.

**Accelerate Protection and Improvement of the Environment**

This NEP goal seeks to integrate long-term national energy policy with national environmental goals. Some of the recommendations include multi-pollutant legislation to establish a flexible, market-based program to significantly reduce and cap emissions of sulfur dioxide, nitrogen oxides, and mercury from electric power generators; land conservation efforts; and new guidelines to reduce truck-idling emissions at truck stops.

**Increase Energy Security**

This NEP goal seeks to lessen the impact of energy price volatility and supply uncertainty on the American people. Some of the recommendations include increasing funding for the Low-Income Home Energy Assistance Program; preparing the Federal Emergency Management Administration for managing energy-related emergencies; and streamlining and expediting permitting procedures to expand and accelerate cross-border energy investment, oil and gas pipelines, and electricity grid connections with Mexico and Canada.

## Production

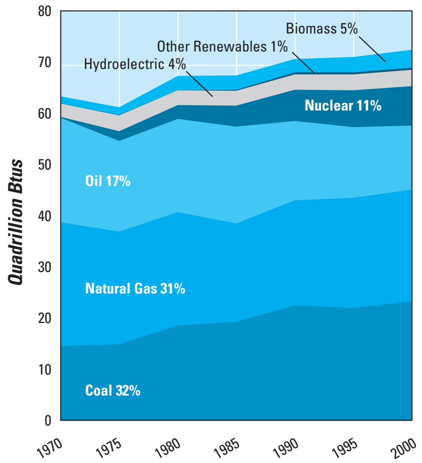
Coal, natural gas, and crude oil constitute the bulk of U.S. domestic energy production. In 1960, these fossil fuels accounted for nearly 95 percent of production. By 2000 their contribution had fallen to about 80 percent, with the nuclear electric power displacing some of the fossil fuel production (Figure 2-6). Further displacement will most likely be limited, however, due to uncertainties related to deregulation of the electric industry, difficulty in siting new nuclear facilities, and management of commercial spent fuel. Renewable resources contribute a small but growing share.

### *Crude Oil*

Before 1970, the United States imported only a small amount of energy, primarily in the form of petroleum. Beginning in the early 1970s, however, lower acquisition costs for imported crude oil and rising costs of domestic production put domestic U.S. oil producers at a comparative disadvantage, leading to a divergence in trends of energy production and consumption. In 2000, the United States produced over 70 quadrillion Btus of energy and exported 4 quadrillion Btus, over 35 percent of which was coal. Consumption totaled nearly 100 quadrillion Btus, requiring imports of nearly 30 quadrillion Btus. Domestic crude oil production is projected to remain relatively stable through 2003 as a result of a favorable price environment and increased success of offshore drilling. A decline in production is projected from 2004 through 2010, followed by another period of projected stable production levels through 2020 as a result of rising prices and continuing improvements in technology. In 2020, the projected domestic production level of slightly over 5 million barrels per day would be almost one million barrels per day less than the 1999 level. In 2000, net imports of petroleum accounted for over 60 percent of domestic petroleum consumption. Continued dependence on petroleum imports is projected, reaching about 65 percent in 2020.

FIGURE 2-6 U.S. Domestic Energy Production: 1970–2000

Coal is the largest source of domestic energy, followed by natural gas and oil. Since 1970, the production of coal, nuclear, and renewables has risen to offset the decline in oil and natural gas production.




*Notes: Fuel share estimates correspond to 2000 data. Shares may not sum to 100 percent due to rounding*

*Source: U.S. DOE/EIA 2000a.*

### *Coal*

Coal is the largest source of domestically produced energy. As the only fossil fuel for which domestic production exceeds consumption, coal assumed a particularly important role in the wake of the oil shocks in the 1970s. Between 1991 and 2000, U.S coal production increased by about 8 percent. However, more recently (between 1998 and 2000), coal production has declined by nearly 4 percent from slightly over one billion metric tons in 1998. This decline was primarily attributed to a large drop in coal exports and a smaller than usual growth in coal consumption for power generation.

From 1996 to 2000, U.S. coal exports have declined by about 35 percent. In particular, they declined sharply between 1998 and 2000, from over 70 million metric tons (over 77 million short tons) to nearly 55 million metric tons (nearly 61 million short tons). U.S. coal exports declined in almost every major world region. The decline in coal exports to Canada, Europe, and Asia was primarily attributed to competition from lower-priced coal from Australia, South Africa, Columbia, and Venezuela. Coal exports are projected to remain relatively stable, settling at slightly more than 50 million metric tons by 2020.

### *Natural Gas*

Regulatory and legislative changes in the mid-1980s led to market pricing of natural gas. These changes heightened demand and boosted natural gas production, reversing the decline it had experienced in the 1970s and early 1980s. This increased production is projected to continue and even accelerate in the early decades of the 21st century. Nonetheless, growth in consumption is expected to outstrip that of production, leading to an increase in net imports, from the 1999 level of more than 85 billion cubic meters (3 trillion cubic feet) to a projected level of nearly 170 billion cubic meters (6 trillion cubic feet) in 2020.

### *Renewable Energy*

Renewable sources currently constitute about 9 percent of U.S. energy production, and hydropower contributes 4 percent. Projected growth in renewable electricity generation is expected from biomass (currently at nearly 5 percent) and from solar, wind, and geothermal energy (currently at less than 1 percent). The largest increase in renewable electricity generation is projected for biomass, from more than 35 billion kilowatt hours in 1999 to over 65 billion in 2020.

## Electricity Market Restructuring

The U.S. electric power generation industry is evolving from a regulated to a competitive industry. In many jurisdictions, wholesale markets have already become competitive, while retail markets have been slow to follow. Where power generation was once dominated by vertically integrated investor-owned utilities (IOUs) that owned most of the generation capacity, transmission, and distribution facilities, the electric power industry now has many new companies that generate and trade electricity. Although vertically integrated IOUs still produce most of the country's electrical power today, this situation is rapidly changing.

Competition in wholesale power sales received a boost from the Energy Policy Act of 1992 (EPAct), which expanded the Federal Energy Regulatory Commission's (FERC's) authority to order vertically integrated IOUs to allow nonutility power producers access to the transmission grid to sell power. In 1996, the FERC issued its Orders 888 and 889, which established a regime for nondiscriminatory access by all wholesale buyers and sellers to transmission facilities. More recently, in December 1999, FERC issued Order 2000, calling for the creation of regional transmission organizations (RTOs)—independent entities that will control and operate the transmission grid free of any discriminatory practices. Electric utilities were required to submit proposals to form RTOs by January 2001.

In addition to wholesale competition, for the first time in the history of the industry, retail customers in some states have been given a choice of electricity suppliers. As of July 1, 2000, 24 states and the District of Columbia had passed laws or regulatory orders to implement retail competition, and more are expected to follow. The introduction of wholesale and retail competition to the electric power industry has produced and will continue to produce significant changes in the industry.

In 2000, coal-fired power plants generated more than 50 percent of electricity produced in the United States, followed by nuclear power (nearly 20 percent), natural gas (a little over 15 percent), conventional hydropower (nearly 10 percent), petroleum (3 percent), and other fuels and renewables (2 percent). Over the past few years, and in near-term projections, natural gas has been the fuel of choice for new electricity-generating capacity. The restructuring of the electric power industry may accelerate this trend, due to the fact that natural gas generation is less capital-

### The U.S. Energy Policy and Conservation Act

Several titles of the U.S. Energy Policy and Conservation Act of 1992 continue to be extremely important to the overall U.S. strategy of reducing greenhouse gas emissions. Important provisions of this Act were reauthorized in the Energy Conservation Reauthorization Act of 1998. Relevant titles of the original Act are summarized below.

**Title I—Energy Efficiency**

This title establishes energy efficiency standards, promotes electric utility energy management programs and dissemination of energy-saving information, and provides incentives to state and local authorities to promote energy efficiency.

**Titles III, IV, V, and VI—Alternative Fuels and Vehicles**

These titles provide monetary incentives, establish federal requirements, and support the research, design, and development of fuels and vehicles that can reduce oil use and, in some cases, carbon emissions as well.

**Titles XII, XIX, XXI, and XXII—Renewable Energy, Revenue Provisions, Energy and Environment, and Energy and Economic Growth**

These titles promote increased research, development, production, and use of renewable energy sources and more energy-efficient technologies.

**Title XVI—Global Climate Change**

This title provides for the collection, analysis, and reporting of information pertaining to global climate change, including a voluntary reporting program to recognize electric utility and industry efforts to reduce greenhouse gas emissions.

**Title XXIV—Hydroelectric Facilities**

This title facilitates efforts to increase the efficiency and electric power production of existing federal and nonfederal hydroelectric facilities.

**Title XXVIII—Nuclear Plant Licensing**

This title streamlines licensing for nuclear plants.

intensive than other technologies, and the cost of capital to the industry is expected to increase.

### Consumption

On the consumption side, rapid economic and population growth, combined with the increasing energy demands of the transportation and buildings sectors, resulted in an 80 percent increase in energy demand from 1960 to 1979. Most of the increased demand was met by oil imports and by increased consumption of coal and natural gas. Total energy demand dampened during and after the international oil price shocks in 1973–74 and 1979–80, and overall energy consumption actually fell through the early 1980s. Energy consumption resumed its upward trend in the latter half of the 1980s, in response to declining oil and gas prices and renewed economic growth.

Another lingering effect of the oil price shocks was a shift in consumption away from oil. Power generation shifted toward natural gas, coal, and nuclear power, and space heating became more dependent on natural gas and electricity. Most of the shift away from oil to natural gas, however, occurred after the second oil price shock.

From 1949 to 2000, while the U.S. population expanded by nearly 90 percent, the amount of electricity sold by utilities grew by over 1,200 percent. Average per capita consumption of electricity in 2000 was seven times as high as in 1949. The growth in the economy, population, and distances traveled has contributed to increased U.S energy consumption. However, by 2000, energy use per dollar of GDP (or energy intensity) had decreased by nearly 45 percent from its peak in 1970. Most of these energy intensity improvements are due to an increase in the less energy-intensive industries and a decrease in the more energy-intensive industries. The household and the transportation sectors also experienced significant gains in efficiency. Today U.S. energy intensity is just slightly above OECD's average energy intensity (at 0.43 kg of oil equivalent per dollar of GDP, versus 0.41 kg for the OECD).

## SECTORAL ACTIVITIES

In 2000, end users consumed about 75 quadrillion Btus (quads) of energy directly, including over 10 quads of electricity. In addition, about 25 quads of energy were used in the generation, transmission, and distribution of electricity. Industry and transportation consumed three-quarters of this direct energy, while the residential and commercial sectors used one-quarter. However, because most electricity is delivered to residential and commercial users, total primary energy consumption of nearly 100 quads is distributed fairly evenly among final users (Figure 2-7).

The remainder of this section discusses energy use by and emissions from industry, residential and commercial buildings, transportation, and the U.S. government, as well as waste. Agricultural and forest practices are addressed elsewhere in this chapter.

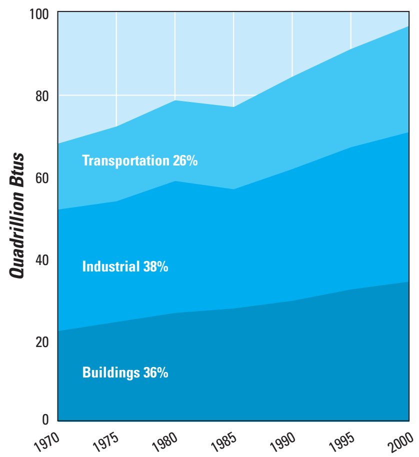
### Industry

Comprised of manufacturing, construction, agriculture, and mining, the industrial sector accounted for more than 35 percent of total U.S. energy use in 2000 and slightly over 30 percent of total U.S. greenhouse gas emissions. Industry's energy consumption rose steadily until the early 1970s, and then dropped markedly, particularly in the early 1980s, following the second oil shock. Since the late 1980s, industrial energy consumption has resumed a gradual upward trend.

Similarly, from 1978 to 1999, industrial energy intensity (energy consumed by the individual sector per unit of

### Figure 2-7 Energy Consumption by Sector: 1970–2000

Energy consumption is divided fairly evenly among the three sectors, with industrial being the largest and the buildings sector close behind. The rate of growth in energy consumption since 1970 has been highest in the buildings and transportation sectors.




*Notes: Sectoral share estimates correspond to 2000 data. Shares may not sum to 100 percent due to rounding.*

*Source: U.S. DOE/EIA 2000a.*

industrial output) fell by about 25 percent. Approximately two-thirds of this decline is attributable to structural shifts, such as the changing array of products that industry produced during the period, while roughly one-third is attributable to efficiency improvements.

Over 80 percent of the energy consumed in the industrial sector is used for manufacturing (including feedstocks), with the remainder of the energy consumed by mining, construction, agriculture, fisheries, and forestry. In 1998, fuel consumption for manufacturing amounted to nearly 25 quadrillion Btus, an increase of nearly 10 percent since 1994. Of this, four subsectors accounted for nearly 80 percent of the total manufacturing fuel consumption: chemicals and allied products (25 percent), petroleum and coal products (over 30 percent), paper and allied products (over 10 percent), and primary metal industries (over 10 percent). Natural gas was the most commonly consumed energy source in manufacturing.

Natural gas and electricity together comprised nearly 45 percent of all energy sources (in terms of Btus). Over the past two decades energy intensity in the manufacturing sector has declined, although the rate of decline has slowed since energy prices fell in 1985. Of the 20 major energy-consuming industry groups in the manufacturing sector, most continued to reduce their energy intensity between 1985 and 1994.

## Residential and Commercial Buildings

The number, size, and geographic distribution of residential and commercial buildings, as well as the market penetration of heating and cooling technologies and major appliances, all combine to influence the energy consumption and greenhouse gases associated with residential and commercial activities.

Residential and commercial buildings together account for roughly 35 percent of the U.S. carbon emissions associated with energy consumption. Commercial buildings—which encompass all nonresidential, privately owned, and public buildings—account for slightly over 15 percent of U.S. carbon emissions. Total energy use in the buildings sector has been increasing gradually, rising from more than 20 quadrillion Btus in 1970 to nearly 35 quadrillion Btus in 1998. The sector's share of total energy consumption relative to other end-use sectors has remained roughly stable over this period.

In 1997 the United States had more than 100 million households, approximately half of which lived in detached, single-family dwellings. Demographic changes have led to a steep decline in the average number of people per residence—from 3.3 in 1960 to 2.6 in 1990—and the sizes of houses have also increased. Since then, that number has remained fairly stable through 1996. The average heated space per person had increased to nearly 65 square meters (nearly 680 square feet) in 1990, compared to nearly 60 square meters (nearly 630 square feet) in 1980.

In addition, major energy-consuming appliances and equipment came into widespread use during this period. By 1990, essentially all U.S. households had space and water heating, refrigeration and cooking appliances, and color television sets. In 1997, over 70 percent of the households had some form of air conditioning, over 75 percent had clothes washers, over 70 percent had clothes dryers, and about 50 percent had dishwashers (Figure 2-8).

New products have continued to penetrate the market. For example, in 1978, only 8 percent of U.S. households had a microwave oven; by 1997, nearly 85 percent had a microwave oven. Similarly, household survey data on personal computers were first collected in 1990, when slightly over 15 percent of households owned one or more PCs. By 1997 that share had more than doubled to 35 percent.

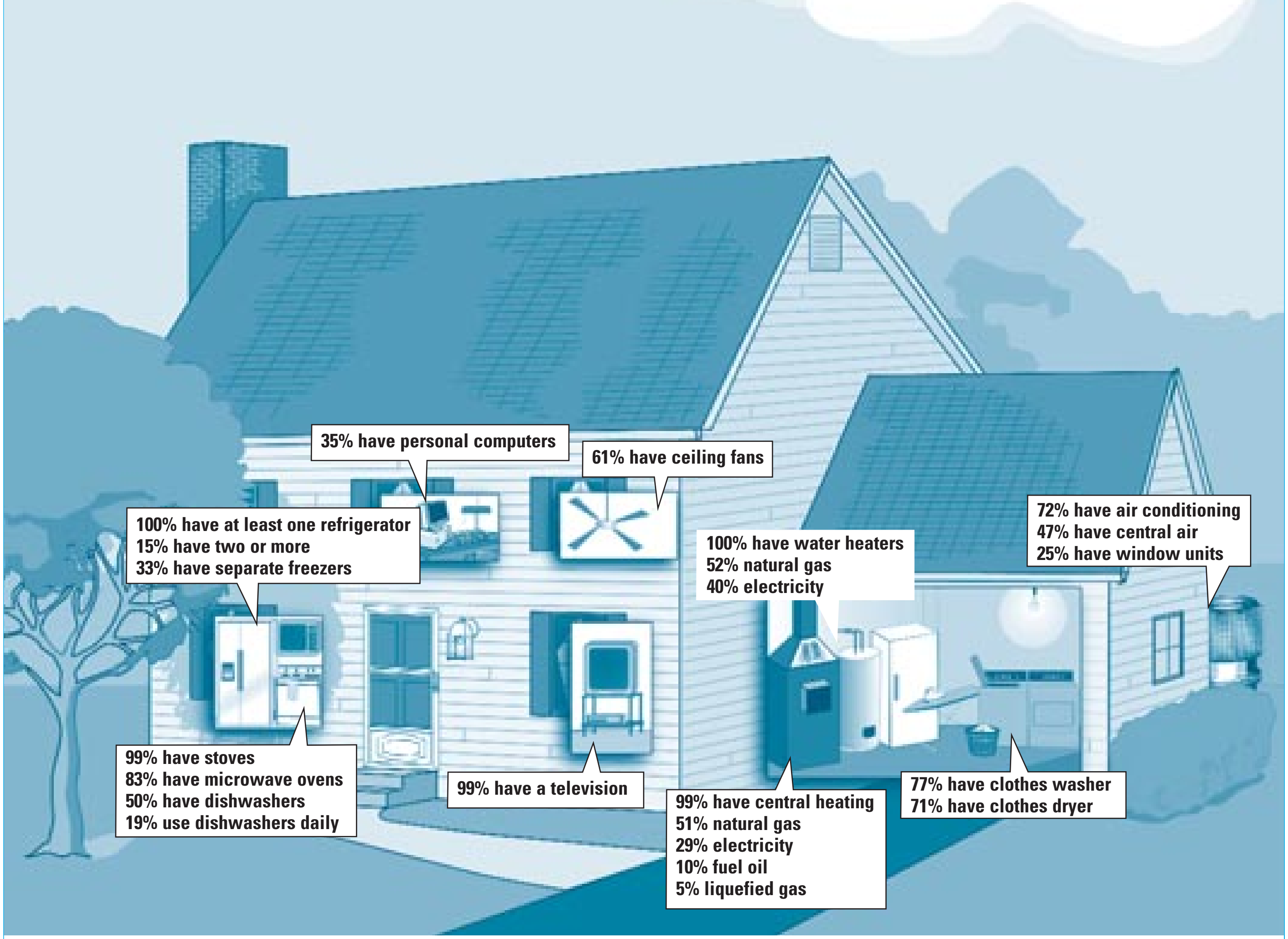
Despite this growth in appliances, products, and per capita heating and cooling space, large gains in the energy efficiency of appliances and building shells (e.g., through better insulation) have resulted in a modest decline in residential energy use per person and only modest increases in total U.S. energy demand in the residential sector. The increased use of nontraditional electrical appliances, such as computers and cordless (rechargeable) tools, is expected to drive a gradual (one half of 1 percent per year) rise in per-household residential energy consumption between 1990 and 2015.

The type of fuel used to heat U.S. homes has changed significantly over time. More than one-third of all U.S. housing units were warmed by coal in 1950, but by 1997 that share fell to less than one-half of 1 percent. During the same period, distillate fuel oil lost just over half of its share of the home-heating market, falling to 10 percent. Natural gas and electricity gained as home-heating sources. The share of natural gas rose from about a quarter of all homes in 1950 to over half in 1997, while electricity's share shot up from less than 1 percent in 1950 to nearly 30 percent in 1997.

In recent years, electricity and natural gas have been the most common sources

FIGURE 2-8 **Energy Characteristics of U.S. Households**

In 1997, household energy consumption was 10.25 quadrillion Btus. The primary energy source was natural gas, followed by electricity and oil. The graphic below depicts the percentage of households with a variety of energy-consuming appliances.




*Source: U.S. DOE/EIA 2000a.*

of energy used by commercial buildings as well. Commercial buildings house the rapidly growing financial and services sectors. Accordingly, their number and their total square footage have increased steadily. Over 85 percent of all commercial buildings are heated, and more than 75 percent are cooled. In addition, the past decade has seen a major increase in the use of computers and other energy-consuming office equipment, such as high-resolution printers, copiers, and scanners.

Rapid growth in the financial and services sectors has substantially increased the energy services required by commercial buildings. However, as in the residential sector, substantial efficiency gains have reduced the net increases in energy demand and carbon emissions. The widespread introduction of efficient lighting and more efficient office equipment, such as ENERGY STAR® labeled products, should help to continue this trend. The entry into the market of energy service companies, which contract with firms or government agencies to improve building energy efficiency and are paid out of the stream of energy savings, has aided the trend toward greater energy efficiency in the commercial buildings sector.

## Transportation

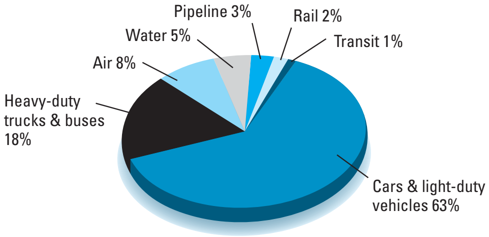
Reflecting the nation's low population density, the U.S. transportation sector has evolved into a multimodal system that includes waterborne, highway, mass transit, air, rail, and pipeline transport, capable of moving large volumes of people and freight long distances. Automobiles and light trucks dominate the passenger transportation system. In 1997, the highway share of passenger miles traveled was nearly 90 percent, while air travel accounted for 10 percent. In contrast, transit and rail travel's combined share was only 1 percent (Figure 2-9).

## FIGURE 2-9 U.S. Transportation: Characteristics and Trends

The U.S. transportation system relies heavily on private vehicles. Although fuel efficiency in automobiles has been rising steadily, there has also been a trend toward larger vehicles, such as light trucks and sport utility vehicles. Coupled with an increase in vehicle miles traveled, overall energy consumption has been increasing. Air travel has also experienced impressive growth, and the performance of freight modes has not offset these increases in consumption.

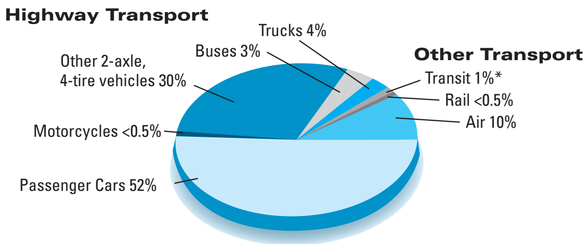
### Energy Use by Transportation Mode: 1998

In 1998 the transportation sector consumed nearly 26 quadrillion Btus. Highway vehicles accounted for about 80 percent of this consumption.




### Passenger Miles Traveled: 1998

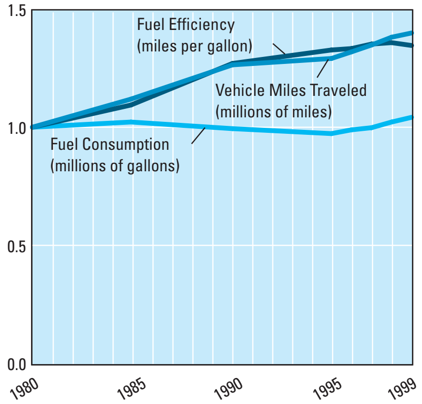
Of the nearly 5 trillion passenger miles traveled in 1998, passenger cars accounted for the single largest mode of transportation.




**Includes motor and trolley buses; light, heavy, and commuter rail; and ferry boats.*

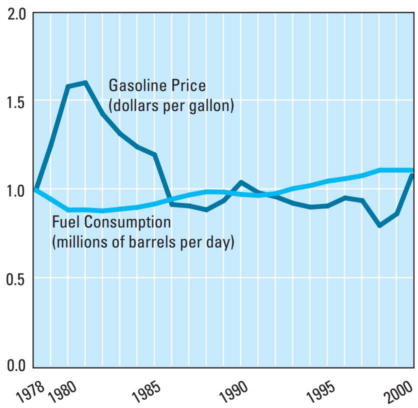
### Passenger Car Use Index: 1980 = 1

Generally, although fuel efficiency has been improving as a result of CAFE standards, fuel consumption continues to rise due to increased U.S. vehicle miles traveled.



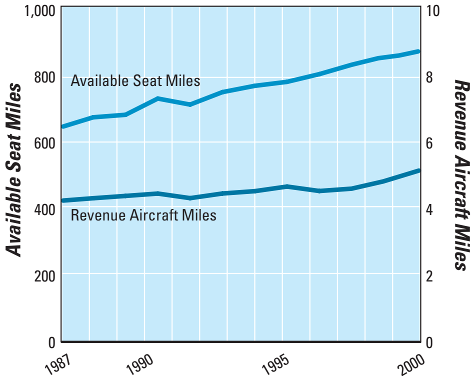

### Gasoline Prices and Fuel Use Index: 1978 = 1

As real gasoline prices declined in the early 1990s, fuel consumption on our nation's highways increased.




### Air Transport (Billions of Miles)

Air transport has been rising over the past decade: revenue aircraft miles and available seat miles have been increasing at average annual rates of nearly 4 and 3 percent, respectively.




### Efficiency of Freight Modes

The fuel efficiency of U.S. freight transportation is steadily improving. Most notably, the energy intensity of railroads decreased by nearly 45 percent during 1970–98.

| Year | Trucks (mpg) | Class I Freight Railroads (Btus per Ton Mile) | Domestic Waterborne Commerce (Ton Miles per Barrel) |
|---|---|---|---|
| 1970 | 5.5 | 645 | 4,820 |
| 1980 | 5.4 | 590 | 3,680 |
| 1990 | 6.0 | 420 | 3,370 |
| 1995 | 6.2 | 370 | 3,580 |
| 1996 | 6.2 | 365 | 3,580 |
| 1997 | 6.4 | 370 | 3,770 |
| 1998 | 6.1 | 360 | 3,660 |

*Note: Totals may not sum due to rounding.*
*Sources: U.S. DOE/EIA 2000a, U.S. DOT/BTS 2000a and 2000b, U.S. DOT/FAA 1998.*

Because of the dominance of motor vehicles in the U.S. transportation system, motor vehicle ownership rates, use, and efficiency drive energy consumption and greenhouse gas emissions in the transportation sector. Between 1960 and 1998, the number of cars and trucks registered in the United States almost tripled, from nearly 75 million to more than 210 million. Overall, the transportation sector consumed slightly over 25 quadrillion Btus in 1998, accounting for approximately one-third of U.S. greenhouse gas emissions. Rising incomes, population growth, and settlement patterns were the primary factors in this trend.

Both the number of vehicles on the road and the average distance they are driven have increased. In 1999, on average, passenger cars were driven over 19,000 kilometers (nearly 12,000 miles) per year, compared to approximately 16,000 kilometers (about 10,000 miles) in 1970. The distance traveled per car has increased steadily over the last two decades, interrupted only by the oil shocks in 1974 and 1979. Total U.S. vehicle miles traveled have increased by nearly 140 percent since 1970.

These increases have been significantly offset by enhanced efficiency. This can be attributed to a combination of factors, including the implementation of Corporate Average Fuel Economy (CAFE) standards for new cars, and improved average fuel consumption per kilometer—from a low of 18 liters per 100 kilometers (slightly over 13 miles per gallon) for the on-road passenger car fleet in 1973, to 11 liters per 100 kilometers (slightly over 21 miles per gallon) in 1999. Between 1998 and 1999, the fuel efficiency of passenger cars declined by about 1 percent, halting the growth trend in improvement of energy efficiency.

The fuel economy of light trucks and sport utility vehicles has also improved, although the increased share of light trucks in the total light-duty-vehicle fleet has diminished these overall gains. Thus, as in other sectors, efficiency improvements moderated the increase in motor fuel consumption (including air, water, pipeline, and rail) in the transportation sector from nearly 8 million barrels per day in 1970 to about 12 million barrels per day in 1999.

The causes for the rapid rise in vehicle miles traveled are numerous, although their relative importance is unclear. In 1997, there was slightly over one vehicle per licensed driver—an increase of about 25 percent over 1970. This increase in ownership translates into a decrease in the use of carpools and public transportation, and an accompanying increase in personal vehicle use. Increased vehicle ownership and use are related to a host of factors, including changing patterns of land use, such as location of work and shopping centers; the changing composition of the work force, such as the growing number of women in the work force; and the reduced marginal costs of driving.

U.S. freight transportation, measured in ton-miles, grew at an average of 2 percent annually from 1970 to 1997, when it reached nearly three trillion ton-miles. In 1997, the predominant mode of freight transportation was trucks, followed closely by rail, then waterways, pipelines, and air.

- Heavy trucks account for most of the freight sector's energy use. From 1970 to 1997, their energy consumption more than doubled. While their fuel efficiency increased slightly, U.S. ton-miles of freight transported on intercity trucks nearly tripled between 1970 and 1997.
- Between 1970 and 1997, the number of railroad cars in use declined. However, they carried more freight for greater distances, resulting in nearly a 1 percent reduction in total fuel consumed for rail freight service since 1970, and nearly a 50 percent improvement in energy consumed (in terms of Btus) per freight ton-mile.
- Ton-miles shipped by air increased rapidly—by over 6 percent a year from 1970 to 1997.
- Water-transport and oil-pipeline shipments grew steadily over that same period.

## Government

The U.S. government is the nation's single largest energy consumer. It uses energy in government buildings and operations widely dispersed across the entire nation and every climate zone, providing services to the U.S. population. Based on reports submitted to the Department of Energy by 28 federal agencies, the U.S. government consumed slightly over one quad of energy during fiscal year 1999 (about 1 percent of U.S. energy consumption), when measured in terms of energy actually delivered to the point of use. This total net energy consumption represented a 30 percent decrease from 1990. Based on these figures, the federal government was responsible for nearly 25 million metric tons of carbon emissions in 1999—a reduction of nearly 9 million metric tons, or over 25 percent, from 1990. The largest contribution to this reduction was from vehicle and equipment end-uses, which reduced their carbon emissions by nearly 35 percent.

The Department of Defense is the federal government's largest energy consumer, accounting for just over 80 percent of total federal energy use. The Postal Service is the second largest consumer of federal energy, and accounted for nearly 4 percent of total federal energy use. Overall in 1999, energy consumption by vehicles and equipment accounted for 60 percent of the total, buildings for 34 percent, and energy-intensive operations for 7 percent. In terms of energy use by fuel type, jet fuel accounted for nearly 55 percent; fuel oil, nearly 20 percent; electricity, more than 10 percent; natural gas, 10 percent; and other fuels, 6 percent.

## Waste

In 1999, the United States generated approximately 230 million tons of municipal solid waste (MSW). Paper and paperboard products made up the largest component of MSW generated by weight (nearly 40 percent), and yard trimmings comprised the second largest material component (more than 10

## Energy Savings in Federal Agencies

Initially in response to the energy crises of the 1970s, and later because it just made good financial sense, federal agencies have been steadily pursuing energy and cost savings in their buildings and operations. Under the Federal Energy Management Program, federal agencies have invested several billion dollars in energy efficiency over the past 20 years and have substantially reduced their energy consumption. In federal buildings, the primary focus of the program, 1999 energy consumption was down nearly 30 percent from 1985 levels and nearly 25 percent from 1990 levels. Within the same sector, carbon emissions have decreased by nearly 20 percent since 1990. This has been partly due to a 10 percent reduction in gross square footage since 1990 and about an 8 percent reduction in primary energy intensity (in terms of Btus per gross square footage).

The Energy Policy Act of 1992 and Executive Order 13123 further challenge federal energy managers to reduce energy use in federal buildings by 35 percent by 2010 from 1985 levels. With declining federal resources available, the Federal Energy Management Program is emphasizing the use of private-sector investment through energy-saving performance contracting and utility financing of energy efficiency to meet these goals. The combination of federal funding and the anticipated private-sector funding of about $4 billion through 2005 should make these goals attainable. In addition, agencies are making cost-effective investments in renewable-energy and water-conservation projects, and further savings are being pursued through an energy-efficient procurement initiative.

percent). Glass, metals, plastics, wood, and food each constituted between 5 and over 10 percent of the total MSW generated. Rubber, leather, and textiles combined made up about 7 percent of the MSW, while other miscellaneous wastes made up approximately 2 percent of the MSW generated in 1999.

Waste management practices include source reduction, recycling, and disposal (including waste combustion and landfilling). Management patterns changed dramatically in the late 1990s in response to changes in economic and regulatory conditions. The most significant change from a greenhouse gas perspective was the increase in the national average recycling rate, which rose from over 15 percent in 1990 to nearly 30 percent in 1999 (nearly 65 million tons). Of the remaining MSW generated, about 15 percent is combusted and nearly 60 percent is disposed of at landfills. The number of operating MSW landfills has decreased substantially over the last decade, from about 8,000 in 1988 to under 2,000 in 1999, while the average landfill size has increased.

Overall, waste management and treatment activities accounted for about 260 teragrams of carbon dioxide equivalent (Tg $CO_2$ Eq.), or nearly 4 percent of total U.S. greenhouse gas emissions in 1999. Of this, landfill emissions were over 210 Tg $CO_2$ Eq. Waste combustion, human sewage, and wastewater treatment constituted the rest of the emissions.

## AGRICULTURE

Despite their decreased acreage, U.S. grazing lands are sustaining more animals, and agricultural lands are feeding more people. Enlightened land management policies and improved technologies are major contributors to their enhanced productivity.

### Grazing Land

U.S. grazing lands—both grassland pasture and range and cropland used for pasture—are environmentally important. They include major recreational and scenic areas, serve as a principal source of wildlife habitat, and comprise a large area of the nation's watersheds. These ecosystems, like forest ecosystems, are vulnerable to rapid changes in climate, particularly shifts in temperature and moisture regimes. However, range ecosystems tend to be more resilient than forest ecosystems because of their ability to survive long-term droughts.

Grassland pasture and range ecosystems can include a variety of different flora and fauna communities, usually denoted by the dominant vegetation. They are generally managed by varying grazing pressure, by using fire to shift species abundance, and by occasionally disturbing the soil surface to improve water infiltration.

In contrast, cropland used for pasture is a grazing ecosystem that relies on more intensive management inputs, such as fertilizer, chemical pest management, and introduced or domesticated species. U.S. cropland used for pasture includes native grasslands, savannas, alpine meadows, tundra, many wetlands, some deserts, and areas seeded by introduced and genetically improved species.

Grassland pasture and range accounted for nearly 240 million hectares (580 million acres), or over 25 percent of major land uses in 1997 (see Figure 2-2). However, the area of grassland pasture and range has declined since 1945, when it was nearly 270 million hectares (nearly 660 million acres). One reason for this decline is that farmers have improved the productivity of grazing lands. A second reason is that some of these land areas were also converted to cropland, rural residential, suburban, and urban land uses, as demand for grazing lands declined in recent years due to the decrease in the number of domestic animals—particularly sheep and draft animals—raised on grazing lands.

### Agricultural Land

The United States enjoys a natural abundance of productive agricultural lands and a favorable climate for producing food crops, feed grains, and other agricultural commodities, such as oil seed crops. The area of the U.S. cropland used for crop production declined by 10 percent during the 16-year period between 1981 and 1997, from nearly 160 million hectares (nearly 390 million acres) to about 140 million hectares (nearly 350 million acres). During this same period, conservation programs for the most environmentally sensitive and highly erodible lands have removed nearly 15 million hectares

(35 million acres) from cropping systems.

Although the United States harvests about the same area as it did in 1910, it feeds a population that has grown two and one-half times since then, and its food exports have also expanded considerably. Agricultural productivity increases are due primarily to technological change in the food and agricultural sectors. In the absence of these improvements in productivity, substantially more land would need to be cultivated to achieve today's level of productivity.

The increase in no-till, low-till, and other erosion control practices reduced erosion on cropland and grazing land by 40 percent between 1982 and 1997. These practices also have helped to conserve carbon associated with those soils, protect soil productivity, and reduce other environmental impacts, such as pesticide and nutrient loadings in water bodies.

Although the number of cattle and sheep has been declining, greenhouse gas emissions from agricultural activities have been steadily rising, largely due to growth in emissions of nitrous oxides from agricultural soil management and methane emissions from manure management.

### Principles for Conservation

In September 2001, the U.S. Department of Agriculture presented its long-term view of the nation's agriculture and food system and a framework to foster strategic thinking and guiding principles for agricultural policies, including policies for environmental conservation. These Principles for Conservation were identified as key policy directives.

***Sustain past environmental gains.*** Improvements in losses from soil erosion and wetlands benefit farmers and all Americans. These and other gains resulting from existing conservation programs should be maintained.

***Accommodate new and emerging environmental concerns.*** Conservation policy should adapt to emerging environmental and community needs and incorporate the latest science. These new and emerging issues include the need for sources of renewable energy and the potential for reducing greenhouse gas emissions.

***Design and adopt a portfolio approach to conservation policies.*** Targeted technical assistance, incentives for improved practices on working farms and forest lands, compensation for environmental achievements, and limited dedication of farmland and private forest lands to environmental use will provide a coordinated and flexible portfolio approach to agri-environmental goals.

***Reaffirm market-oriented policies.*** Competition in the supply of environmental goods and services and targeted incentives ensure the maximum environmental benefits for each public dollar spent.

***Ensure compatibility of conservation, farm, and trade policies.*** Producer compensation for conservation practices and environmental achievements should be consistent with "green box" criteria under World Trade Organization obligations.

***Recognize the importance of collaboration.*** Nonfederal government agencies as well as private for-profit and not-for-profit organizations are playing an ever-increasing role in the delivery of technical assistance and in incentive programs for conservation.

*Source: USDA 2001.*

## Forests

U.S. forests vary from the complex juniper forests of the arid interior West to the highly productive forests of the Pacific Coast and the Southeast. In 1997, forests covered about one-third (about 300 million hectares, or nearly 750 million acres) of the total U.S. land area. This includes both the forest-use lands and a portion of the special-use lands listed in Table 2-1 and Figure 2-2.

Excluding Alaska, U.S. forestland covers about 250 million hectares (620 million acres). Of this, nearly 200 million hectares are timberland, most of which is privately owned. However, much of the forested land is dedicated to special uses (i.e., parks, wilderness areas, and wildlife areas), which prohibits using the land for such activities as timber production. These areas increased from about 9 million hectares (over 20 million acres) in 1945 to nearly 45 million hectares (about 100 million acres) in 1997. As a result, land defined as "forest-use land" declined consistently from the 1960s to 1997, while land defined as "special uses" increased.

Management inputs over the past several decades have been gradually increasing the production of marketable wood in U.S. forests. The United States currently grows more wood than it harvests, with a growth-to-harvest ratio of nearly 1.5. This ratio reflects substantial new forest growth; however, old-growth forests have continued to decline over the same period.

# OTHER NATURAL RESOURCES

Climate change significantly affects other U.S. natural resources, including wetlands, wildlife, and water.

## Wetlands

Wetland ecosystems are some of the more biologically important and ecologically significant systems on the planet. Because they represent a boundary condition ("ecotone") between land and aquatic ecosystems, wetlands have many functions. They provide habitats for many types of organisms, both plant and animal; serve as diverse ecological niches that promote preservation of biodiversity; are the source of economic products for food, clothing, and recreation; trap sediment, assimilate pollution, and recharge ground water; regulate water flow to protect against storms and flooding; and anchor shorelines and prevent erosion. The United States has a broad variety of wetland types, ranging from permafrost-underlain wetlands in Alaska to tropical rainforests in Hawaii.

Wetland ecosystems are highly dependent upon upland ecosystems.

Therefore, they are vulnerable to changes in the health of upland ecosystems as well as to environmental change brought about by shifts in climate regimes. Wetlands, including riparian zones along waterways and areas of perennial wet soils or standing water, are both sources of and sinks for greenhouse gases.

Since the nation's settlement in the 18th century, the continental United States has lost about 40–45 million hectares (about 100–110 million acres) of approximately 90 million hectares (over 220 million acres) of its original wetlands. Most wetland conversion in the 19th century was originally for agricultural purposes, although converted land subsequently was often used for urban development. A significant additional share of wetlands was lost as a result of federal flood control and drainage projects.

The pace of wetland loss has slowed considerably in the past two decades. For example, while net wetland losses from the mid-1950s to the mid-1970s averaged 185,400 hectares (458,000 acres) a year, they fell to about 117,400 hectares (290,000 acres) a year from the mid-1970s to mid-1980s. Between 1982 and 1992, the net average rate of wetland conversion further dropped to about 32,000 hectares (80,000 acres) a year. During 1992–97, net wetland losses fell even further to roughly 13,000 hectares (32,600 acres) a year. Urban development accounted for nearly half of these losses, while agricultural conversion accounted for about one-quarter.

The reduced rate of wetland loss since the mid-1980s is attributable to a number of factors. Both government policies for protecting wetlands and low crop prices have decreased conversions of wetlands to agricultural uses. In addition, the majority of wetland restorations have occurred on agricultural land. Government programs, such as the Wetland Reserve Program, which provides funds and technical assistance to restore formerly drained wetlands, have aided such gains. Thus, agricultural land management has most likely contributed to overall gains in wetland areas, as losses to agricultural conversion are greatly reduced and previously drained areas are restored. Future losses are likely to be even smaller, because the United States has implemented a "no net loss" policy for wetlands.

Alaska's over 70 million hectares (175 million acres) of wetlands easily exceed the 45–50 million hectares (over 110–125 million acres) of wetlands in the continental United States. Many of these areas are federally owned. Total wetland losses in Alaska have been less than 1 percent since the mid-1800s, although in coastal areas, losses have been higher.

## Wildlife

During the past 20 years, the United States has become more aware of the reduction in the diversity of life at all levels, both nationwide and worldwide. To better understand and catalog both previous and future changes, the United States is conducting a comprehensive, nationwide survey of its wildlife and biodiversity, referred to as the National Biological Survey.

Information on endangered species is already available through other sources. As of November 2000, over 960 species were listed as endangered, of which about 590 are plants and 370 are animals. In addition, over 140 plant and nearly 130 animal species were listed as threatened, for a total of nearly 1,240 threatened or endangered species. The United States continues to work to conserve species diversity through programs and laws like the Endangered Species Act.

## Water

The development of water resources has been key to the nation's growth and prosperity. Abundant and reliable water systems have enabled urban and agricultural centers to flourish in arid and semiarid regions of the country. For instance, between 1959 and 1997, irrigated agricultural land increased by nearly 70 percent, from less than 15 million hectares (nearly 35 million acres) to over 20 million hectares (55 million acres).

Currently, most of the nation's freshwater demands are met by diversions from streams, rivers, lakes, and reservoirs and by withdrawals from ground-water aquifers. Even though total withdrawals of surface water more than doubled from 1950 to 1980, withdrawals remained at about 20 percent of the renewable water supply in 1980. However, some areas of the country still experience intermittent water shortages during droughts.

There is increasing competition for water in the arid western sections of the country, not only to meet traditional agricultural and hydropower needs, but also for drinking water in growing urban areas; for American Indian water rights; and for industry, recreation, and natural ecosystems. The flows of many streams in the West are fully allocated to current users, limiting opportunities for expanded water use by major new facilities. Several states have adopted a market-based approach to water pricing and allocation, thus offering the potential to alleviate projected shortfalls. Also pertinent is the federal government's insistence that certain minimum-flow requirements be met to preserve threatened and endangered species.

These forces have contributed to a decline in per capita water use in the last two decades. After continual increases in the nation's total water withdrawals for off-stream use from 1950 to 1980, withdrawals declined from 1980 to 1995. The 1995 estimate of average withdrawals, which is over 400 million gallons a day, is 2 percent less than the 1990 estimate and nearly 10 percent less than the 1980 estimate, which was the peak year of water use. This decline in water withdrawals occurred even though population increased by over 15 percent from 1980 to 1995.